Proceedings of the
26th European Conference on Knowledge Management
Hosted by Lappeenranta – Lahti University of Technology (LUT), Finland
4-5 September 2025



Prof. Dr. Aino Kianto
Dr. Ilona Toth

Volume 2

A conference managed by ACI, UK

Proceedings of the

26th European Conference on Knowledge Management

ECKM 2025

4-5 September 2025

Hosted By

Lappeenranta–Lahti University of Technology (LUT)

Finland

Volume 2

Edited by

Aino Kianto and

Ilona Toth

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Volume 1 E-Book ISBN: 978-1-917204-48-4
Volume 2 E-Book ISBN: 978-1-917204-50-7
ECKM E-Book ISSN: 2048-8971
Volume 1 Print version ISBN: 978-1-917204-47-7
Volume 2 Print version ISBN: 978-1-917204-49-1
ECKM Print Version ISSN: 2048-8963
Published by Academic Conferences International Limited

Reading, UK
+44 (0) 118 324 6938

www.academic-conferences.org

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About the 26th European Conference on Knowledge Management, 2025

The European Conference on Knowledge Management (ECKM) is a highly respected academic conference that has been held annually for 26 years, making it one of the longest-standing conferences in its field. ECKM provides an important platform for academics, researchers, practitioners, and industry leaders from around the world to exchange ideas, present research, and discuss developments in knowledge management (KM). The conference is dedicated to advancing the theory and practice of knowledge management across a wide range of sectors and disciplines.

The Proceedings of the 26th ECKM, 2025 includes academic research papers, PhD research papers and Master's research papers as well as work-in-progress papers, which have been presented and discussed at the conference. The proceedings are of an academic level appropriate to a research audience including graduates, post-graduates, doctoral and post-doctoral researchers. All papers have been double-blind peer reviewed by members of the Review Committee.

Aims and Scope

The primary aim of ECKM is to foster a deeper understanding of knowledge management processes, practices, and technologies, and to explore their impact on organizational effectiveness and innovation. The conference seeks to bridge the gap between theory and practice by encouraging the exchange of ideas between academics and practitioners. It also aims to promote interdisciplinary collaboration by bringing together experts from various fields such as business, information technology, education, and public administration.

ECKM's scope is broad, encompassing all aspects of knowledge management, from the creation and sharing of knowledge within organizations to the role of technology in enabling KM processes. The conference addresses both the strategic and operational dimensions of knowledge management, emphasising its importance in enhancing organizational learning, innovation, and competitive advantage.

Topics Covered

ECKM covers a wide range of topics related to knowledge management, reflecting the evolving nature of the field and its application in different contexts. The call for papers asked for contributions that considered the following topics. In addition, the committee welcomed papers on a number of specialist mini-tracks which can be seen at the end of this list.

Knowledge Creation and Sharing:

- Tacit and Explicit Knowledge
- Knowledge Sharing Practices.

Knowledge Management Systems and Technologies:

- KM Tools and Platforms
- Artificial Intelligence and KM
- Big Data and Knowledge Analytics.

Organizational Learning and Innovation:

- Learning Organizations
- Innovation Management
- Communities of Practice.

Strategic Knowledge Management:

- KM and Competitive Advantage
- Knowledge Strategy Development
- Intellectual Capital Management.

KM in Specific Contexts:

- KM in Public Administration
- KM in Education
- KM in Healthcare.

Knowledge Management and Organizational Culture:

- Cultural Barriers to KM
- Leadership and KM
- Change Management in KM Initiatives.

Ethics and Knowledge Management:

- Ethical Issues in KM
- Sustainability and KM.

Emerging Trends and Challenges in KM:

- Digital Transformation and KM
- Globalization and KM
- AI's role in KM
- The integration of KM with other business disciplines
- The evolving role of knowledge managers.

Mini Tracks

Experts in the field proposed mini tracks on the following topics. Papers accepted on these topics after the double-blind peer review process were presented as mini tracks at the conference and are also published in these proceedings.

- Challenges and Solutions for Sustainable Knowledge Management
- How to … Lessons Learned
- Age of Digitalisation
- Knowledge Management in Different Cultural Contexts

The programme from the 2025 conference can be downloaded from the publishing portal and full details about the conference can be seen from the conference website: https://www.academic-conferences.org/conferences/eckm/

ECKM 2025 Editorial

These proceedings represent the work of contributors to the 26th European Conference on Knowledge Management (ECKM 2025), hosted by Lappeenranta-Lahti University of Technology (LUT), in Lahti, Finland on 4-5 September 2025. The Conference Chair was Prof. Dr. Aino Kianto, from LUT Business School, LUT University, Lahti, and the Programme Chair is Dr. Ilona Toth, from LUT Business School, Lappeenranta, Finland.

ECKM is now a well-established event on the academic research calendar and now in its 26th year the key aim remains the opportunity for participants to share ideas and meet the people who hold them. The scope of papers will ensure an interesting two days. The subjects covered illustrate the wide range of topics that fall into this important and ever-growing area of research.

The opening keynote presentation was given by Professor Alexeis Garcia Perez, Aston Business School, Aston University, UK, on the topic of *The Knowledge Paradox: Navigating the future of KM with AI.* The Afternoon keynote was given by Professor Paavo Ritala, LUT Business School, LUT University, Lappeenranta, Finland, on the topic *GenAI and knowledge management – A revolution, an evolution, or something else entirely?* The second day of the conference opened with an address by Professor Susanne Durst, Reykjavik University, Iceland, who will talk about *Responsible Knowledge Management in a Polarized World.*

With an initial submission of 300 abstracts, after the double blind, peer review process there are 140 Academic research papers, 13 PhD research papers, 3 Masters Research papers, 4 Non-Academic papers and 4 work-in-progress papers published in these Conference Proceedings. These papers represent research from Australia, Austria, Belgium, Brazil, Bulgaria, Canada, China, Colombia, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Hungary, Iceland, India, Indonesia, Iran, Ireland, Israel, Italy, Japan, Kazakhstan, Latvia, Lithuania, Malaysia, Netherlands, Nigeria, North Cyprus, North Macedonia, Norway, Peru, Poland, Portugal, Romania, Saudi Arabia, South Africa, Spain, Sweden, Switzerland, Thailand, Türkiye, UK, and the USA.

We would like to thank all those who attended the conference this year.

Dr. Aino Kianto
Lappeenranta-Lahti University of Technology (LUT)
Finland
September 2025

Biographies of Chairs and Keynote Speakers

Conference Chair



Aino Kianto, D.Sc. (Econ. & Bus. Adm.) is a Professor in Knowledge Management in the LUT University Business School, Lahti, Finland. Her research focuses on knowledge and innovation management, intellectual capital, and organizational renewal and resilience. She has published close to 200 research papers, approximately 70 of which have appeared in journals, such as Journal of Business Research, Technovation, R&D Management, Human Resource Management Journal, Journal of Knowledge Management, Journal of Intellectual Capital, and Creativity and Innovation Management. Professor Kianto's research has been acknowledged with several international awards, she has delivered keynote speeches in many international conferences and currently serves in the editorial board of five academic journals. She has acted as the PI in eight research projects and other leadership role in six projects, all of which have involved extensive worklife collaboration and most also international collaboration.

Programme Chair



Ilona Toth, D.Sc. (Econ. & Bus. Adm.) is a Post-Doctoral Researcher in Knowledge Management in the LUT University Business School, Lappeenranta, Finland. Previously she has worked for research projects funded by Finnish Work Environment Fund and State Treasury. Her current research focuses especially on individual worker well-being and its relationship to sustainable performance. Dr. Toth's research articles have been published e.g., in VINE Journal of Information and Knowledge Management Systems, in International Journal of Entrepreneurial Behavior and Research, and in Digital Creativity.

Keynote Speakers



Susanne Durst is Full Professor of Management at the Department of Business Administration at Tallinn University of Technology (Estonia). Her research interests include small business management, SME succession/transfers, knowledge (risk) management, and corporate governance. She has been conducting several national and international research projects. Her work has been awarded different awards and has been published in international peer-reviewed journals. Before joining academia, she worked with private enterprises



Paavo Ritala is a Professor of Strategy and Innovation at the Business School at LUT University, Finland. His main research themes include networks, ecosystems, and platforms, the role of data, algorithms, and digital technologies in organizations, business model innovation, and circular and regenerative economy. His research has been published in outlets including Journal of Management, Research Policy, Academy of Management Perspectives, Journal of Product Innovation Management. He is closely involved with business practice through research projects, executive and professional education programs> He is the Co-Editor-in-Chief of R&D Management and serves on the editorial review board of Journal of Product Innovation Management.



Alexeis Garcia Perez is Professor of Digital Business and Society at Aston Business School, Aston University. He is also Visiting Professor at the Centre for Business in Society of Coventry University, and Visiting Research Scholar at the Department of Communication, Culture & Technology of Georgetown University. Alexeis has led teams delivering Information Systems programmes in both Computing and Business environments, including an MBA in Cyber Security. He is Senior Fellow of the Higher Education Academy and member of the executive committee of the International Association for Knowledge Management

Mini Track Chairs



Stephanie Barnes is a seasoned and visionary executive with over 25 years of success helping global organizations to achieve short- and long-term objectives by driving innovation, technology transformation, cultural change, and continuous improvement. An accomplished Knowledge Management leader with strong expertise in designing knowledge management strategies and frameworks, delivering knowledge management initiatives, and providing essential knowledge management toolkits. She is a strategic thinker with proven expertise in shaping long-range knowledge management strategy, roadmap, and process, as well as aligning people, processes, technology, and departments to achieve corporate goals. Stephanie is an engaging communicator with extensive international working experience in Austria, Canada, China, Germany, Nigeria, United Arab Emirates, and the United States.



Cindy Hubert is an APQC inaugural Fellow in Knowledge Management (KM), responsible for building upon the organization's rich legacy as one of the foremost innovators and leaders in the field of Knowledge Management. She has over her 30 years with APQC, during which she has been instrumental in building the organization's intellectual capital in KM through the design and implementation of various tools, methodologies, and research practices. During her tenure, Cindy has provided leadership and oversight to more than 500 client projects around the world involving the transfer of best practices, benchmarking, knowledge management, and process and performance management using APQC's proven methodologies. She has provided subject matter expertise in APQC's extensive KM research program which has completed more than 35 collaborative research projects and ten Advanced Working Groups on various KM topics.



Emeritus professor PhD Marta Christina Suciu is PhD supervisor on Economics 1 Doctoral School, Bucharest University of Economic Studies. She is a senior researcher at the Romanian Academy National Institute of Economic Research Costin C. Kiritescu and Vice-President of an Interdisciplinary Research Group. She is a corresponding member at the Romanian Academy of Scientists, Economics, Law and Sociology section. Her topics of interest are: KM; Cultural and Creative Economy; Creative and Innovative Management; Start-ups, innovative business and PM; Economics of Education; Intellectual Capital & Intangible Assets. She has coordinated eight research projects won on a competitive basis. She obtained the OPERA OMNIA Diploma in 2006.



Dr. Irina Purcarea is an Assistant Professor in the Management and Organizations Department at Rennes School of Business, France. She earned her PhD in business administration, specializing in innovation and small business management, from the Bucharest University of Economic Studies. Her areas of expertise include: project management and organizational behavior. From 2021 to 2024, as Programme Coordinator at Rennes School of Business, she committed to promoting student development programs through hands



Henri Hussinki, D.Sc. (Econ. & Bus.Adm.), is an assistant professor (tenure track) in business analytics at the Business School, LUT University. His research and teaching focus on information systems business value, especially information systems capabilities that firms need to leverage their information technology investments. His research has been published in, e.g., the Journal of Business Models, Measuring Business Excellence, Journal of Knowledge Management, and Journal of Intellectual Capital.



Walter Vesperi is a Research Fellow in Organization Theory and HRM at the University of Palermo, Italy. His research interests are in knowledge transfer, university entrepreneurship and the agri-food sector. His publications have appeared in academic journals, and he has presented his research at several international conferences. He is also a member of the editorial board for several International Journals



Concetta Lucia Cristofaro is an Assistant Professor in Organization Theory and HRM at the E-campus university, Italy. Her Research focuses on public healthcare, Intellectual capital and HRM. She has presented at national and international conference, and she is the author and co-author of several publications. She is also a reviewer for a number of international journals.



Rocco Reina is full Professor in Organization Studies at the University of Catanzaro "Magna Græcia", Italy, He is on the Board of the Italian Association of Management and Organization (ASSIOA) and a member of the regional board of the Italian Association of Personnel Management (AIDP). His research focusses on intellectual capital, small and medium enterprises, knowledge and change management and human resource management. He has presented at national and international conferences and has authored



Associate Professor Ole Jørgen Ranglund lectures in a variety of fields within the scope of organizational learning and theory, including business strategy, service management, leadership and in strategic management at masters level. His research field is diverse ranging from management and leadership to knowledge management issues. He also has a special interest in the delivery of knowledge to students to support relevance of education and has thus involved himself in projects dealing with formative feedback to students, involvement and engagement of students, and hyflex/syncromodal learning.



D.Sc. Sladjana Cabrilo is a Full Professor of Management at I-Shou University in Taiwan. Her research focuses on intellectual capital (IC), knowledge management, innovation, digital transformation, and international business. She is known in the field of IC for insights from emerging economies and for using complexity theory, configurational analysis, and fuzzy set qualitative comparative analysis (fsQCA) techniques to uncover complex relationships and patterns between IC and organizational performance. Her research has been awarded and recognized as 'most prestigious across knowledge clusters' in ranked journals. She is one of the co-editors of the book "Futurizing intellectual capital - Insights on navigating knowledge-based value creation" that will be published by Springer Nature by the end of 2024.



Dr. Liu Gang earned his Ph.D. from The Hong Kong Polytechnic University. Now, he is an associate professor at Business School, Shenzhen Technology University. His research areas include knowledge management and organizational performance, innovation and entrepreneurship, and cross-cultural management. His papers have been published in Journal of Business Research, Industrial management and Data System, Knowledge Management Research & Practice, Proceedings of European Conference on Knowledge Management, etc. He is a committee member of the European Conference on Knowledge Management. He is co-editor of Management & Marketing and associate editor of International Journal of Knowledge Management Studies..

ECKM Review Committee

ECKM is fortunate to have a significant number of international experts in the field willing to review papers. Care is taken to ensure that a fully double-blind peer review process is followed, and reviewers are not selected if they have any research or organisational connection to the author/s.

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Exploring the Interplay Between Tacit and Explicit Knowledge in Organizational Settings: A Systematic Review

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Abstract: This systematic review explores how tacit and explicit knowledge interact in organizational contexts and identifies the factors that facilitate or hinder their integration. The central research question is: *How do tacit and explicit knowledge complement each other in organizations, and what influences their effective integration?* The review addresses the ongoing challenge organizations face in managing these distinct knowledge forms to enhance performance, innovation, and decision-making. Only empirical studies from peer-reviewed journals or top conferences published between January 2011 and April 2025 were included; studies outside this range were excluded. A comprehensive search strategy was applied across multiple academic databases, including Web of Science, Scopus, ABI/INFORM Global, IEEE Xplore, and Business Source Complete. Drawing from both qualitative and quantitative studies, the review examines themes such as knowledge sharing, organizational learning, leadership, and culture. Findings suggest that effective integration relies on trust, supportive leadership, and well-designed knowledge management systems. The review emphasizes a dual approach—fostering informal, tacit knowledge sharing alongside formal mechanisms to capture and disseminate explicit knowledge—and offers practical implications for improving organizational effectiveness**.**

Keywords: Tacit knowledge, Explicit knowledge, Knowledge transfer, Knowledge sharing, Organizational learning, Knowledge management

1. Introduction

1.1 Background and Context

The foundational distinction between tacit and explicit knowledge originates from Michael Polanyi (1966), who argued that "we can know more than we can tell." Tacit knowledge is embodied, experiential, and context-dependent manifested in intuition, skills, and insights that resist articulation. Explicit knowledge is codified, systematic, and easily transferable through formal channels. Digital transformation, knowledge-intensive industries, and hybrid work models have reconfigured how knowledge is produced and shared, blurring traditional boundaries between formal and informal knowledge flows (Ullrich et al., 2023; Santoro et al., 2023). Organizations increasingly recognize that innovation relies not only on structured information but also on leveraging individual expertise, intuition, and collaboration. Tacit knowledge proves especially crucial in contexts involving ambiguity, judgment, and creativity areas where explicit knowledge alone is insufficient. Despite its importance, tacit knowledge is frequently undervalued in formal KM systems due to its intangible nature. While models like Nonaka and Takeuchi's SECI framework (1995) describe dynamic interactions between knowledge types through socialization, externalization, combination, and internalization, empirical validation remains uneven across contexts. This systematic review examines the interplay between tacit and explicit knowledge, investigating how organizational structures, leadership behaviors, digital tools, and social environments mediate this relationship.

1.2 Rationale of the Study

The dynamic and often tacit nature of knowledge presents ongoing challenges for organizations aiming to capture, share, and apply both tacit and explicit forms of knowledge effectively. While explicit knowledge is readily articulated and stored, tacit knowledge remains embedded in individual experience, often transferred informally through observation and practice. In the context of increasingly digitized and dispersed work environments, particularly following the COVID-19 pandemic, organizations are struggling to maintain effective knowledge flows that balance both formal systems and informal, interpersonal mechanisms (Ullrich et al., 2023; Santoro et al., 2023). Existing knowledge management frameworks such as Nonaka's SECI model conceptually address the conversion between tacit and explicit knowledge. However, empirical evidence on how this conversion occurs in practice across different organizational settings remains fragmented. Many studies examine either tacit or explicit knowledge in isolation or are limited by context-specific constraints that reduce generalizability (Seghroucheni et al., 2023). Moreover, the increasing adoption of digital collaboration tools introduces new complexities into the tacit-explicit knowledge interplay that are not yet fully understood. Thus, there is a need to synthesize empirical findings across sectors to understand how these knowledge forms interact and what enables their effective integration in modern organizational settings.

2. Problem Statement

Despite the widespread recognition that tacit and explicit knowledge must be effectively integrated to support innovation, learning, and strategic decision-making, organizations continue to face significant barriers in managing this interplay. These barriers include cultural silos, inadequate technological systems, lack of trust, and misaligned incentives. Moreover, the literature on knowledge management is highly fragmented, with inconsistent terminology, diverse methodological approaches, and studies often limited to specific industries or case studies, making it difficult to form a coherent understanding of best practices (Zhu et al., 2023). Compounding this challenge is the evolving nature of organizational work—characterized by hybrid teams, remote collaboration, and reliance on digital platforms—which impacts how tacit and explicit knowledge are shared and utilized. The traditional boundaries between formal (explicit) and informal (tacit) knowledge-sharing practices are increasingly blurred, yet academic research has not kept pace with these workplace transformations (Santoro et al., 2023). This systematic review aims to fill these gaps by consolidating and analysing recent empirical evidence on the interaction between tacit and explicit knowledge. By doing so, the study seeks to uncover the organizational, technological, and human factors that either facilitate or hinder knowledge integration. The goal is to provide practical insights and theoretical refinements that can inform more effective knowledge management strategies in diverse and evolving organizational environments.

3. Research Objective

This primary research objective is to:

- To investigate the complementary roles of tacit and explicit knowledge within organizations and identify key enablers and barriers to their effective integration.

This objective was selected as the central theme of the review because it provides the necessary foundation for understanding how organizations manage both types of knowledge in practice. It also allows for a focused exploration of the factors that support or hinder integration, which is critical in a fast-evolving digital and organizational landscape.

4. Methodology

Following PRISMA guidelines (Moher et al., 2009; Page et al., 2021), 3,782 articles were identified, and titles and abstracts were screened and included 83 empirical studies. Both qualitative and quantitative designs were considered. Seminal pre-2009 studies were included for foundational framing (e.g., Polanyi, 1966; Nonaka & Takeuchi, 1995). Studies were selected using the SPIDER framework (Cooke et al., 2012) and drawn from major academic databases. Inclusion criteria focused on primary research addressing tacit-explicit knowledge in organizational settings. Data were extracted on study design, context, mechanisms, digital tools, and outcomes. Quality appraisal followed established tools for each research type (CASP, 2018; Hong et al., 2018). Fig 1 presents the PRISMA flow diagram, summarizing the screening process and showing how studies were identified, filtered, and included.

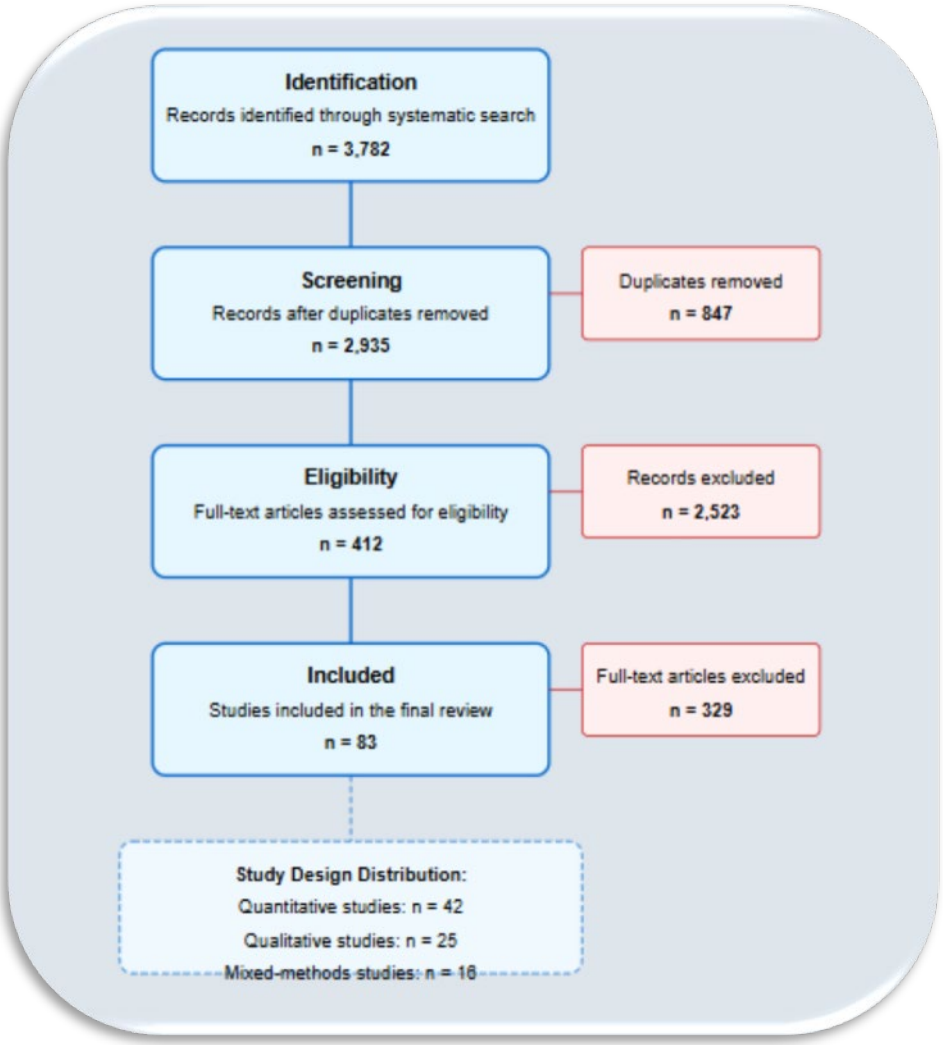
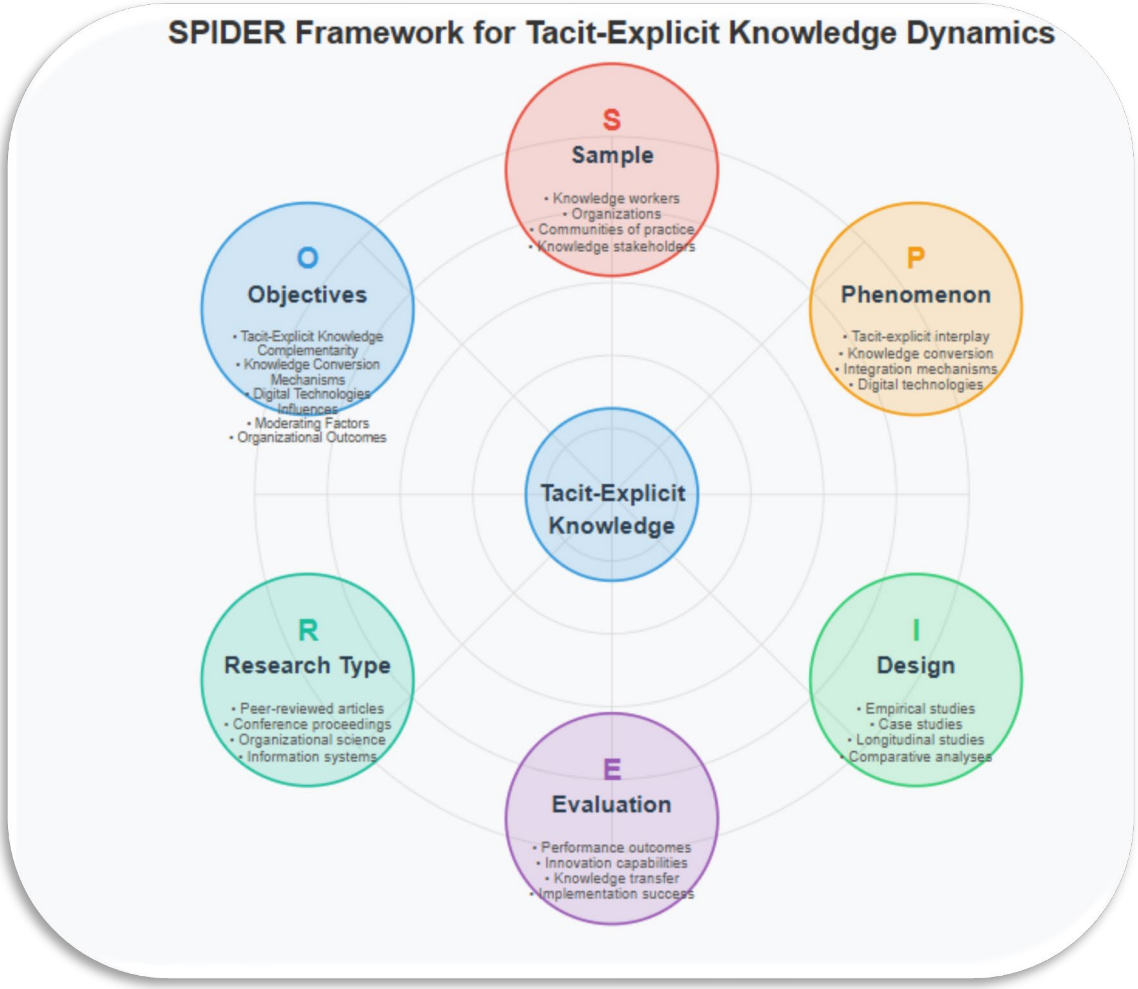


Figure 1: Adapted from the PRISMA workflow diagram (Moher et al., 2009; Page et al., 2021)

4.1 Search Strategy

A comprehensive literature search was conducted using databases including Web of Science, Scopus, ABI/INFORM Global, IEEE Xplore, and Business Source Complete. The strategy followed PRISMA guidelines and focused on keywords related to tacit knowledge, explicit knowledge, and knowledge conversion within organizational settings. Boolean operators—**AND**, **OR**, and **NOT** were used to strategically combine search terms during the literature search process. These operators helped refine and expand search results to ensure both comprehensive coverage and relevance of the retrieved studies.

Figure 2 visually summarizes the SPIDER framework and its application to the study selection process.



Source: Author's own creation (2025)

Figure 2: A summary of the SPIDER framework and its application to the study selection process Data Extraction and Quality Assessment

Following the identification and selection of 83 empirical studies—comprising both qualitative and quantitative research—a systematic and rigorous data extraction and analysis process was undertaken. Key data points were extracted using a standardized template, including research design, organizational context, types of knowledge explored, mechanisms of tacit-explicit knowledge integration, technological enablers, and reported outcomes. To analyse the extracted data, a multi-phase thematic synthesis approach was employed. For quantitative studies, relevant variables and findings were extracted and mapped onto corresponding qualitative categories to facilitate thematic convergence and triangulation. The analytic process was both inductive and deductive: while new themes were allowed to emerge from the data, coding was also guided by key constructs from the SPIDER strategy Sample, Phenomenon of Interest, Design, Evaluation, and Research type (See Fig 4.3). This framework helped organize findings and maintain analytic coherence across studies of varying designs. Quality appraisal of included studies was conducted using established tools appropriate for each methodology: the Critical Appraisal Skills Programme (CASP, 2018) for qualitative studies, and the Effective Public Health Practice Project ((Symonds & Tang, 2024) tool for quantitative studies. This ensured that only methodologically sound evidence contributed to the synthesis.

5. Results

The review incorporated 83 empirical studies from 32 countries, spanning sectors such as healthcare, education, manufacturing, technology, and non-profit organisations. Among these, 42 percent used qualitative methods (such as interviews, ethnographic fieldwork, and case studies), 37 percent employed surveys and quantitative techniques, and the remaining 21 percent implemented mixed-method designs. Most studies anchored their work in established theoretical frameworks including Polanyi's tacit–explicit continuum, Nonaka and Takeuchi's

SECI model, and the knowledge-based view of the firm. Findings consistently indicate that tacit knowledge, embodied in personal experience and intuition, fuels innovation, while explicit knowledge—being formal and codified—supports efficiency and reliability. The reviewed studies surpass simplistic binary classifications by showing that tacit and explicit knowledge operate along a continuum and reinforce one another. For instance, Zhang et al. (2024) emphasized the centrality of trust in facilitating tacit knowledge management and its positive impact on product innovation and organizational performance. Similarly, Gamble, (2020) and other researchers noted that environments characterized by high trust and authentic leadership create psychological safety essential for uncovering and sharing tacit insights. Trust-based environments also lead to higher employee engagement and retention, both of which are essential for preserving organizational knowledge continuity (Zanabazar et al., 2024). The review identified three primary mechanisms for converting tacit into explicit knowledge. The first is social interaction such as mentorship, storytelling, and communities of practice that foster trust and open communication (Kucharska & Bedford, 2024). These social mechanisms function as forms of social capital that enable effective knowledge integration within organizations (Arruda et al., 2024). Second, technological mechanisms particularly advanced AI and natural language processing enable organizations to systematize and codify unstructured data, though such tools require human oversight to preserve contextual nuance (Zhang & Liu, 2021; Seghroucheni et al., 2023). Third, structured frameworks such as Clarke's Tacit Knowledge Spectrum Model (2011) and conceptual schema guide the formalization of complex, experiential knowledge into transferable formats; Clarke's spectrum reveals the many layers within tacit knowledge, demonstrating how reflection and triggers bring deeper tacit elements to the surface. Digital tools including AI analytics, enterprise knowledge repositories, and collaboration platforms were also found to significantly support explicit knowledge creation. NLP-enabled tools help distill insight from text, while synchronous and asynchronous systems like Microsoft Teams and Slack underpin essential socialization and internalization phases of knowledge creation (Seghroucheni et al., 2023). However, studies emphasize that digital tools are most effective when embedded within socio technical systems grounded in trust and continuous interpersonal interaction (Pedersen et al., 2023; Nupap, 2022; Igoa-Iraola & Díez, 2024). Isolated digitization, devoid of human context, was found to yield superficial or misaligned knowledge assets. Analysis also highlighted several moderating factors influencing knowledge conversion at organizational, individual, and environmental levels. Organizational factors such as decentralization, sector-specific norms, and supportive culture particularly prevalent in larger or more dynamic firms accelerate knowledge exchange (Igoa-Iraola & Díez, 2024). The perceived value of knowledge and engagement in organizational citizenship behaviour significantly impact attitudes towards knowledge sharing. These attitudes mediate the relationship between beliefs and sharing intentions, promoting a culture of knowledge exchange (Mahmood et al., 2023). Trust emerges as a critical factor in these organizational dynamics, functioning as social capital that facilitates knowledge integration and enhances overall organizational performance (Arruda et al., 2024). Tacit knowledge sharing (TKS) is shaped by both individual and environmental factors. At the individual level, self-efficacy, intrinsic motivation, and a growth-oriented mindset influence how confidently and willingly individuals articulate and share tacit insights (Juan & Lin, 2020; Nor et al., 2024). Externally, factors such as market competitiveness and regulatory pressures affect whether organizations prioritize open knowledge-sharing mechanisms (Ning et al., 2024; Akrofi, 2023). Organizations operating in highly competitive or regulated environments are more likely to adopt structured TKS strategies to maintain compliance and competitive advantage. Notably, firms that align these individual and environmental elements exhibit stronger, more sustainable knowledge integration. However, this alignment is most effective when supported by an enabling organizational culture and leadership that actively promotes and models knowledge-sharing behaviors. Research indicates that such environments not only facilitate knowledge transfer but also contribute to higher levels of employee engagement and organizational commitment (Zanabazar et al., 2024). Despite these positive trends, persistent challenges were evident. Knowledge hoarding, rigid hierarchical structures, leadership disengagement, and high staff turnover limited institutional learning (Phaladi, 2022; Herlina et al., 2024). Conversely, organizations that cultivated learning-oriented cultures, implemented mentorship programs, and held leaders accountable for KM practices showed stronger knowledge performance, innovation capacity, and continuity of expertise (Makhanya & Vezi-Magigaba, 2023; Schaate, 2023; Sharif et al., 2023).

6. Discussion of Findings

This review highlights the dynamic interplay between tacit and explicit knowledge as central to organizational learning and innovation. Rather than representing binary categories, tacit and explicit knowledge exist along a continuum (Polanyi, 1966), where tacit knowledge embedded in personal experience, intuition, and contextual understanding often serves as the source of novel insights and creative problem-solving in complex

environments. A key finding is the enabling role of trust in facilitating the movement of knowledge along this continuum. Trust not only supports interpersonal collaboration but also functions as social capital, enabling individuals to contribute personal insights to collective organizational learning processes (Arruda et al., 2024; Zhang et al., 2024). Consistent with prior research, psychologically safe environments underpinned by mutual respect and openness were shown to be critical for encouraging the disclosure of tacit knowledge (Kucharska & Bedford, 2024; Shafique et al., 2023). The role of leadership emerged prominently in this context. Leaders who model vulnerability, decentralize authority, and cultivate inclusive cultures reinforce these trust-based dynamics and, in turn, contribute to enhanced knowledge flows and employee engagement (Zanabazar et al., 2024). However, the findings also draw attention to structural and cultural inhibitors of tacit knowledge sharing. Hierarchical rigidity, time pressure, and knowledge hoarding continue to reflect legacy models that treat knowledge as power to be controlled rather than shared. In contrast, organizations that promote mentoring, storytelling, and peer learning practices create more conducive environments for surfacing tacit knowledge and converting it into explicit, reusable organizational assets (Kucharska & Bedford, 2024). These practices not only preserve institutional memory but also drive innovation and adaptability. While technological tools particularly AI and NLP are increasingly integrated into knowledge management systems, the findings suggest their role is largely limited to codifying explicit knowledge (Seghroucheni et al., 2023; Zhang & Liu, 2021). Their effectiveness is significantly enhanced when embedded within socio-technical systems that recognize the value of human judgment, contextual interpretation, and ethical considerations in knowledge use (Medina et al., 2011; Pedersen et al., 2023). Thus, technology should be viewed as an enabler within a broader human-centered framework rather than as a substitute for relational knowledge processes. Moreover, organizational and sector-specific factors were found to shape knowledge management outcomes. Decentralized structures and responsiveness to contextual demands such as industry competition or regulatory compliance were associated with stronger knowledge-sharing behaviors (Igoa-Iraola & Díez, 2024). Importantly, the review also identified individual-level enablers, including self-efficacy, intrinsic motivation, and a growth mindset, as critical drivers of tacit knowledge articulation and participation in knowledge-sharing activities (Plank & Zlomuzica, 2024; Prihandoko et al., 2024; Xu et al., 2021). These personal attributes not only influence willingness to share knowledge but also reinforce organizational commitment and retention (Zanabazar et al., 2024).

7. Interpretations of Results

The results indicate that the transformation of tacit knowledge into organizational value relies on trust-based, psychologically safe environments that act as social capital enablers. Trust not only supports knowledge integration but also promotes engagement and retention, essential for sustaining organizational knowledge over time (Arruda et al., 2024; Zanabazar et al., 2024). Mentoring, storytelling, and peer collaboration emerged as core social learning mechanisms that facilitate the sharing and codification of tacit knowledge. These practices support reflection, deepen understanding, and foster a sense of shared meaning, which are vital for organizational learning (Kucharska & Bedford, 2024; Arruda et al., 2024). Clarke's (2011) Tacit Knowledge Spectrum offers a conceptual basis for how structured reflection surfaces otherwise hidden insights. While digital tools like AI and NLP aid in codifying explicit knowledge (Zhang & Liu, 2021; Seghroucheni et al., 2023), their value is enhanced when embedded within socio-technical systems that preserve context and human meaning (Clarke, 2011; Pedersen et al., 2023). Technology should therefore amplify—not replace—human knowledge processes. Contextual alignment across systems, individual motivations, and leadership is another key determinant of knowledge-sharing effectiveness (Igoa-Iraola & Díez, 2024). Leaders play a catalytic role by embedding knowledge-sharing values into everyday practice, fostering environments where tacit knowledge is seen as a strategic asset (Kucharska & Bedford, 2024; Shafique et al., 2023). Finally, individual psychological resources such as self-efficacy, intrinsic motivation, and growth mindset moderate effective knowledge sharing. These traits enhance both cognitive and emotional engagement in collaborative learning environments, further reinforcing knowledge retention and innovation (Plank & Zlomuzica, 2024; Prihandoko et al., 2024; Xu et al., 2021).

7.1 Limitations and Directions for Future Research

Limitations include the exclusion of non-English and non-academic sources and methodological diversity across studies. Future research should explore the evolving role of technologies like AI and AR in knowledge sharing (Zhou et al., 2025) and examine longitudinal, cross-cultural dynamics.

7.2 Conclusions and Recommendations

This systematic review concludes that the effective management of tacit and explicit knowledge constitutes a vital strategic capability for contemporary organizations. The findings reveal that no single approach—whether

technological, cultural, or structural can independently ensure successful knowledge integration. Instead, organizations must adopt a holistic perspective that recognizes the interdependence of these elements. Tacit knowledge, with its experiential and context-bound nature, complements explicit knowledge to drive innovation and problem-solving. While digital tools can support the codification and dissemination of knowledge, they are most effective when embedded within trust-based, collaborative environments that facilitate informal exchanges. Ultimately, sustained innovation and resilience depend on the organization's ability to integrate knowledge practices across multiple levels, foster a culture of openness, and align leadership behaviour with knowledge-sharing values.

Recommendations for organizations include:

- **Adopting balanced knowledge management approaches** that respect the complementary nature of tacit and explicit knowledge (Nonaka & Takeuchi, 1995; Polanyi, 1966; Clarke, 2011).
- **Promoting leadership models** that incentivize knowledge-sharing behaviours and embed them within performance structures (Zanabazar et al., 2024; Kucharska & Bedford, 2024; Shafique et al., 2023).
- **Implementing digital technologies** with careful consideration of their impact on human interaction and organizational values (Seghroucheni et al., 2023; Pedersen et al., 2023; Zhang & Liu, 2021).

These recommendations are essential for fostering innovation, building organizational resilience, and sustaining competitive advantage in a knowledge-intensive economy.

7.3 Contributions to Literature

This review consolidates global empirical evidence on tacit-explicit knowledge interplay. It identifies leadership, culture, and digital infrastructure as key enablers (Castañeda & Ramirez, 2022; Igoa-Iraola & Díez, 2024) and offers a foundation for advancing knowledge management theory and practice.

Ethics Declaration: This study did not require ethical clearance as it did not involve human participants, personal data collection, or sensitive information.

AI Declaration: AI tools were used solely for language refinement and grammatical improvements. No AI-generated content was included in the research, analysis, or original writing of this paper.

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Sustainability Chronicles: Mapping the Journey of Sustainability Agents

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Abstract: In an era of polycrisis, individuals as part of organizations are required to mobilize knowledge and leadership to drive transformational sustainability change effectively. This paper explores the professional journeys of sustainability agents, tracing their pathways into the field, their experiences while working in sustainability-focused roles, and the systemic boundaries they encounter along the way. By asking, *What shapes the journey of sustainability agents, from entering the field to driving transformations?*, our study sheds light on the interplay between individual agency and broader systemic conditions. More specifically, we look at the agents' sensemaking processes throughout their sustainability journey. For this purpose, we draw on in-depth interview data from 29 participants in the context of a leadership program for societal transformation. We employ a life-course exercise to explore the trajectory of sustainability agency. Our findings reveal three critical stages in the sustainability agent journey. Throughout this process, they engage in sensemaking processes, continuously interpreting and reinterpreting their perception of sustainability within evolving systemic conditions. Their cognitive frames shape how they process complexity, balance competing priorities, and adapt to uncertainty, influencing their capacity for driving transformational change. First, individuals enter the field through diverse pathways, guided by personal values, formal education, or chance opportunities. Second, navigating professional environments, they engage in continuous learning processes while battling limited resources, organizational inertia, and external pressures. Finally, when confronted with systemic boundaries, including entrenched belief systems, funding limitations, and corruption, they adopt one of three strategies: expanding, pivoting, or accepting trade-offs. By framing the sustainability agent experience as a process, this study advances the understanding of how individuals navigate the complexities of sustainable development within organizational contexts. It highlights the importance of development programs and knowledge exchange as mechanisms for supporting agents and organizations to enable transformational action in pursuit of sustainability.

Keywords: Sustainability agents, Sustainability trajectory, Sustainable transformation, Sensemaking, Life-Course

1. Introduction

Sustainability represents one of the most pressing challenges of our time, cutting across organizational, societal, and global contexts. In this paper, we understand sustainability not only as a balancing act between economic, environmental, and social goals, but as a regenerative process that actively restores and enhances the systems on which life depends. This perspective moves beyond minimizing harm or optimizing trade-offs and instead focuses on creating conditions that allow both human and ecological systems to thrive (Buckton *et al.*, 2023). Climate change, resource depletion, inequality, and other interconnected crises demand transformative action, not only through policies and technologies but also through the efforts of individuals who work to drive these efforts (Buhr, Harms and Schaltegger, 2023). In this study, we define sustainability transformations as profound, systemic shifts that reconfigure how societies interact with environmental, economic, and social systems. These transformations go beyond incremental changes, often relying solely on balancing the triple bottom line elements. Instead, in our understanding, actual sustainability transformations aim to establish regenerative structures that contribute positively to both society and the environment (Buckton *et al.*, 2023). While organizations often take center stage in the sustainability discourse, individuals within these organizations play a pivotal role in translating sustainability ideals into meaningful action (Teerikangas *et al.*, 2021). These individuals, whom we refer to as *sustainability agents,* operate at the nexus of personal values, professional responsibilities, and systemic constraints, often pushing the boundaries of what is possible within their respective contexts (Redman and Wiek, 2021; Ayers, Missimer and Bryant, 2023). We regard sustainability agents as individuals who work toward sustainability transformations within their organizations and beyond, occupying decision-making or leadership roles. Despite the growing recognition of sustainability agents as pivotal drivers of transformation, their journey remains underexplored. Current research lacks comprehensive insights into their cognitive processes, creating a gap in understanding the enablers and drivers of transformation, as well as the strategies for overcoming challenges (Ayers, Missimer and Bryant, 2023; Onkila *et al.*, 2023). Particularly in contexts characterized by ambiguity, complexity, and uncertainty, such as

sustainability transformations, cognitive processes significantly influence individual responses (Hahn *et al.*, 2014). In this context, sensemaking and, therefore, knowledge processes are critical to how individuals and groups construct, share, and apply meaning from experiences (Weick, 1995). Sustainability agents must continuously interpret complex information, often amidst ambiguity and competing priorities (Redman and Wiek, 2021). Applying a sensemaking framework provides a deeper exploration of how these agents navigate the sustainability agency space, offering insights into their adaptive strategies and the flow of knowledge that supports transformative action (see Drencheva et al., 2023). Furthermore, exploring who these sustainability agents are is crucial to developing a deeper understanding of how to attract, support, and retain individuals who are both willing and capable of leading in the sustainability space. Consequently, we pose the question: *What shapes the journey of sustainability agents, from entering the field to driving transformations?*

In this research, we adopt a life-course perspective (see Koistinen *et al.*, 2020) to examine sustainability agents' engagement across three stages: entering the sustainability agency space, navigating it, and encountering systemic boundaries. This approach allows us to analyze how personal and professional experiences, shaped by past, present, and relational contexts, influence their trajectories. Through in-depth interviews with 29 sustainability agents, we explore their pathways into the field, strategies for driving transformation, and responses to systemic constraints. Through a sensemaking lens, we examine how agents interpret and respond to these constraints, offering cognitive insights into sustainability practice. Additionally, by identifying key strategies for navigating the sustainability agency space, this study informs leadership development, providing practical guidance for empowering sustainability professionals. Further, this study enriches existing research by including a diverse array of voices that extend beyond predominantly Western settings.

2. Background

2.1 Understanding Sustainability Agents

The concept of agency refers to an individual's ability to shape their circumstances through deliberate actions. Sustainability agents exemplify this by transforming organizational systems towards sustainability. They are variously identified as intrapreneurs, champions, and change agents (Carrington, Zwick and Neville, 2019), all highlighting their vital role in driving transformational change (Buhr, Harms and Schaltegger, 2023). Teerikangas et al. (2021) describe sustainability agency as intentional action aimed at sustainable futures, operating within complex organizational environments. These environments offer both opportunities and challenges due to diverse logics, power dynamics, and structural constraints (Hahn *et al.*, 2010). Navigating these complex environments, key traits of sustainability agents include a strong commitment to environmental and social causes, as well as the capacity to challenge established norms (Russell and Victoria, 2022). While the concept of agency emphasizes individual action, sustainability agents can also act as knowledge brokers, mobilizing and potentially embedding sustainability-related awareness and competence within and across organizational boundaries. The continuous challenge of addressing resistance among organizational members to transformation requires emotional resilience from agents (Ayers, Missimer and Bryant, 2023). While our understanding of sustainability agency is expanding, Onkila et al. (2023) highlight the need for more robust theoretical frameworks to explain how agency is sustained over time and how these capacities develop (Koistinen *et al.*, 2020). The evolution of sustainability agency, particularly in diverse cultural and resource-constrained settings, remains further underexplored. Addressing these gaps is essential for creating comprehensive models that reveal how individuals effectively develop and exercise sustainability agency across varied contexts.

2.2 Sensemaking in Sustainability

Sensemaking is a fundamental concept in organizational studies, focusing on how individuals and groups comprehend and respond to complex, ambiguous environments. Popularized by Karl Weick (1995), it highlights the social and cognitive processes through which people create an understanding of their surroundings. In uncertain and rapidly changing contexts, sensemaking is essential, allowing actors to interpret environmental cues and craft coherent narratives that guide decision-making and action (Hahn *et al.*, 2014). Sensemaking shapes how individuals organize and apply knowledge in uncertain conditions, playing a central role in how sustainability insights are developed and translated into purposeful action. Within sustainability, sensemaking is vital as individuals and organizations tackle multifaceted ecological, social, and economic challenges. Often viewed as “wicked problems” without clear solutions, these challenges require navigating landscapes of competing interests and values (Sharma *et al.*, 2022). Effective sensemaking involves interpreting complex data and reconciling diverse perspectives to foster collaborative action (Penttilä *et al.*, 2020). Sustainability agents must continuously interpret shifts in their environments to align their actions with evolving goals (Quarshie,

Salmi and Wu, 2021). This involves iterative cycles of reflection and adaptation, where past experiences shape current understanding and future actions. Sensemaking also fosters resilience and innovation, encouraging stakeholders to question assumptions and reframe issues as new insights emerge (Calic *et al.*, 2018), therefore laying the foundation for sustainability transformations.

3. Methodology

3.1 Research Context and Data Collection

This study forms part of a broader research project in collaboration with a leadership program designed to foster societal transformation. The program involved 20 participants from diverse organizational and national backgrounds in a 12-month, no-cost training initiative focused on developing and implementing sustainability projects. Participants hailed from non-profits, for-profits, start-ups, and governmental organizations, each responsible for sustainability activities in their workplaces or ventures. This selection ensured the inclusion of individuals actively engaged in sustainability transformations and positioned to effect meaningful change. The study also included nine facilitators who provided expert training sessions. These facilitators, from various institutions and sustainability-focused organizations, enriched the program by fostering co-creation in a non-hierarchical environment. Participant demographics are detailed in Appendix Table 1. In-depth, semi-structured interviews were conducted with all 20 leadership program participants at the start and end of the program, along with life-course exercises. Additionally, single interviews with the nine facilitators included the same exercise. Drawing on life-course research principles, we explored critical periods influencing agents' sustainability engagement, building on work like Koistinen et al. (2020). We utilized a timeline (on paper or via Google Slides) for participants to record key life events, allowing core memories to surface. They then highlighted events shaping their sustainability engagement, such as entry points, challenges, and shifts in motivation. This exercise guided interview discussions, encouraging participants to elaborate on pivotal experiences.

3.2 Life-course Approach and Data Analysis

The life-course perspective examines how individuals' trajectories evolve, shaped by personal experiences and social contexts (Elder, 1994). It highlights that professional and identity development are dynamic, influenced by experiences and social interactions across different life stages. Applying this to sustainability agents helps us understand how they navigate the field amidst systemic boundaries and opportunities. Our analysis used a process-oriented approach to explore three phases: entry into sustainability, challenges encountered, and strategies for sustained engagement. This aligns with process-based qualitative analysis and grounded theory (Langley, 1999). We employed thematic coding as outlined by Braun et al. (2019) to assess participants' career trajectories and key experiences. Please refer to Figure 1 in the Appendix for the data structure.

4. Findings

In the following, we present the three stages of the sustainability agent's journey: entering, navigating, and encountering systemic boundaries within the sustainability agency space. We define this space as the field in which agents operate, encompassing both external structures and personal perceptions. Figure 2 provides a visual representation of the trajectory of sustainability agency.

4.1 Entering the Sustainability Agency Space

The pathways into sustainability agency are shaped by personal background, pivotal experiences, and external circumstances. Building on Koistinen et al. (2020), we identify three distinct entry trajectories: Education and Upbringing, Awakening Moments, and Opportunity-Driven Entry. Throughout these stages, we observe how sustainability agents construct meaning through iterative engagement with their environments, drawing on and reshaping prior knowledge, which informs their strategic and relational choices. While the first two align with prior research, our study extends this framework by highlighting a third pathway, the entry through professional opportunities rather than pre-existing personal commitment.

4.1.1 Education and upbringing

For many agents, early exposure to sustainability values played a foundational role. Participants described growing up in households that prioritized environmental consciousness, social responsibility, or ethical decision-making. Practices such as minimizing waste, engaging in community service, or prioritizing quality over consumption were later recognized as formative, even if not framed as "sustainability" at the time. Formal education reinforced these perspectives, with key teachers, courses, or extracurricular activities introducing

sustainability concepts such as the UN Sustainable Development Goals (SDGs). *"My mom was ahead of her time - everything she did had a sustainable element. We grew up with that without realizing it. If she bought me clothes, they had to last for years. She lived minimally, even before we had a term for it."*

4.1.2 Awakening moments

For others, engagement with sustainability stemmed from critical awakening moments, encounters that deeply altered their perspectives. Adopting Koistinen et al's (2020) terminology, we define awakening moments as experiences that make sustainability challenges tangible and urgent. These included direct personal encounters with environmental harm or social injustice, as well as large-scale events that heightened awareness. Media, activism, and exposure to sustainability narratives, especially following the SDGs' introduction, helped frame these realizations. Cross-cultural experiences also played a role, with study abroad programs or travel offering new perspectives on inequality and environmental degradation. Such moments often became inflection points, prompting shifts in professional paths and priorities. *"Growing up in Sweden, I thought it had a big global influence. Then I went to China and realized sustainability challenges existed on an entirely different scale. That experience changed how I saw the world."*

4.1.3 Opportunity driven entry

Beyond personal values or awakening moments, some agents entered sustainability through professional exposure rather than an initial commitment to the field. These individuals encountered sustainability as part of an existing role, a career shift, or an unexpected opportunity. Over time, engaging in sustainability work deepened their understanding and commitment, demonstrating that sustainability agency can emerge through professional practice rather than pre-existing motivation. *"The SDGs came in 2015; I was already mid-career by then. Sustainability wasn't part of my education; I learned on the job."*

4.2 Navigating the Sustainability Agency Space

Once sustainability agents enter the field, they adopt various strategies to drive transformative changes. Our findings reveal three interrelated strategies: Purpose and Identity, Building Collective Capacity, and Strategy and Adaptation. These are not fixed approaches but dynamic processes of sensemaking and recalibration as agents navigate evolving constraints and opportunities.

4.2.1 Purpose and identity

A strong sense of purpose emerged as a central force in sustainability agency, often rooted in personal values, ethical convictions, and societal aspirations such as social justice. While many agents described fulfillment in their roles, others experienced tensions between their ideals and systemic limitations. Despite this dissonance, agents speak of fulfillment in their work and express hopes and dreams for the future. Continuously rearticulating one's sense of purpose becomes a crucial aspect of sustaining long-term engagement. *"I know my colleagues say, 'Oh, these big ideas again,' but dreaming is what keeps me going."*

4.2.2 Building collective capacity

Recognizing the limits of individual action, agents actively build networks to amplify their impact. These range from informal peer groups to structured collaborations, serving as platforms for shared learning, knowledge exchange, emotional support, and coordinated action. Mentoring, facilitating dialogue, and equipping others with tools to drive transformation reinforce a decentralized model of agency, distributing responsibility rather than relying on a few visible leaders. Advocacy and stakeholder engagement also play a central role. Agents act as intermediaries, bridging businesses, policymakers, and communities to align interests and mobilize support. This requires translating complex sustainability issues into accessible narratives that resonate across diverse audiences. The ability to foster dialogue, navigate tensions, and build coalitions is a defining feature of effective sustainability agency. *"Through regular meetings with stakeholders, we've broken barriers, amplified our voice, and taken leadership over our own health systems."* These practices not only support distributed leadership but also illustrate how knowledge is co-produced, translated, and embedded across multiple sites of action.

4.2.3 Strategy and adaptation

Navigating sustainability requires continuous learning, adaptability, and strategic refinement. Agents describe transformations as a slow, iterative process where setbacks, while frustrating, offer critical learning opportunities. Many leverage their specialized expertise in policy, finance, or innovation to advance sustainability goals. However, technical knowledge alone is insufficient, adaptive leadership is equally critical.

Creativity, resilience, and the ability to inspire others in uncertain or resistant environments emerged as essential skills. Ultimately, sustainability agents are not just managing existing systems but also pushing for transformational change. This means challenging dominant paradigms and advocating for systemic shifts. *"I want to honor my history and use myself as a resource. My identity and liminal experiences are assets - I speak six languages, and there's resilience in that story."*

4.3 Encountering Systemic Boundaries

The third phase in the sustainability agent journey involves encountering systemic boundaries that limit their scope and impact. These boundaries, rooted in cultural, economic, political, and institutional structures, shape sustainability efforts and highlight the constraints on individual agency. Our analysis reveals six interconnected challenges: cultural resistance, weak governance, weak collaboration, awareness gaps, resource constraints, and psychological pressures. Cultural resistance emerged as a major boundary, with agents struggling against entrenched norms and short-term economic priorities that sustain unsustainable practices. Shifting mindsets, whether in communities, organizations, or governments, was seen as one of the most difficult tasks. As one participant put it, *"The real challenge is knowledge and awareness among all of us."* Weak governance also poses significant boundaries. Participants cited fragmented policies, political misalignment, and even corruption as factors that hinder coordinated sustainability efforts. Similarly, weak collaboration limits progress, with agents noting that stakeholders often worked in silos due to competing agendas and a lack of shared networks. As one participant noted, *"People work on similar topics but won't collaborate because of different funding, outputs, and institutional priorities."* Resource constraints, whether financial, human, or technological, were another common challenge, particularly for agents in smaller or underfunded organizations. The psychological toll of sustainability work further compounded these difficulties. Many described the emotional strain and overwhelm of facing resistance. Balancing professional commitments with personal well-being also proved difficult, as reflected in one agent's experience: *"Sometimes you're so engaged that you overlook family time. You come back, and the kids say, 'Dad, you weren't here last week, and now you're traveling again.' It's a real challenge."*

4.3.1 Response strategies

In response to these systemic boundaries, sustainability agents employ a variety of strategies to adapt and continue their work. These strategies reflect the agents' resilience and determination to push for sustainability transformation despite the boundaries they face. The most prominent strategies identified by participants were expanding the space of influence, pivoting to alternative approaches, and balancing trade-offs between personal, organizational, and sustainability goals. Actively broadening their networks, building coalitions, and increasing their influence to overcome resource limitations and governance fragmentation allow agents to expand their agency space. As one participant described, *"We hope that also attracts kind of people of the same mind. So creating a fertile ground for people of the same mind to come together and try to solve this, organize themselves around that purpose around that mission."* Finally, many agents lean on balancing trade-offs between competing priorities. The sustainability agent's role is often fraught with difficult decisions, where long-term sustainability goals must be weighed against short-term pressures. Some agents acknowledged the need to make strategic compromises to ensure that they could continue their work, balancing the ideal of transformation with the pragmatic realities of limited time, resources, and institutional support. This perspective can lead agents to pivot. Faced with boundaries such as limited resources or cultural resistance, agents sometimes adjust their approach, adopting more flexible or new strategies. However, this adaptability may come at the risk of compromising sustainability standards and settling for tradeoffs. *"We have our own priorities because in the sustainable development goal, there are 17 different goals and we cannot contribute to all the goals."*

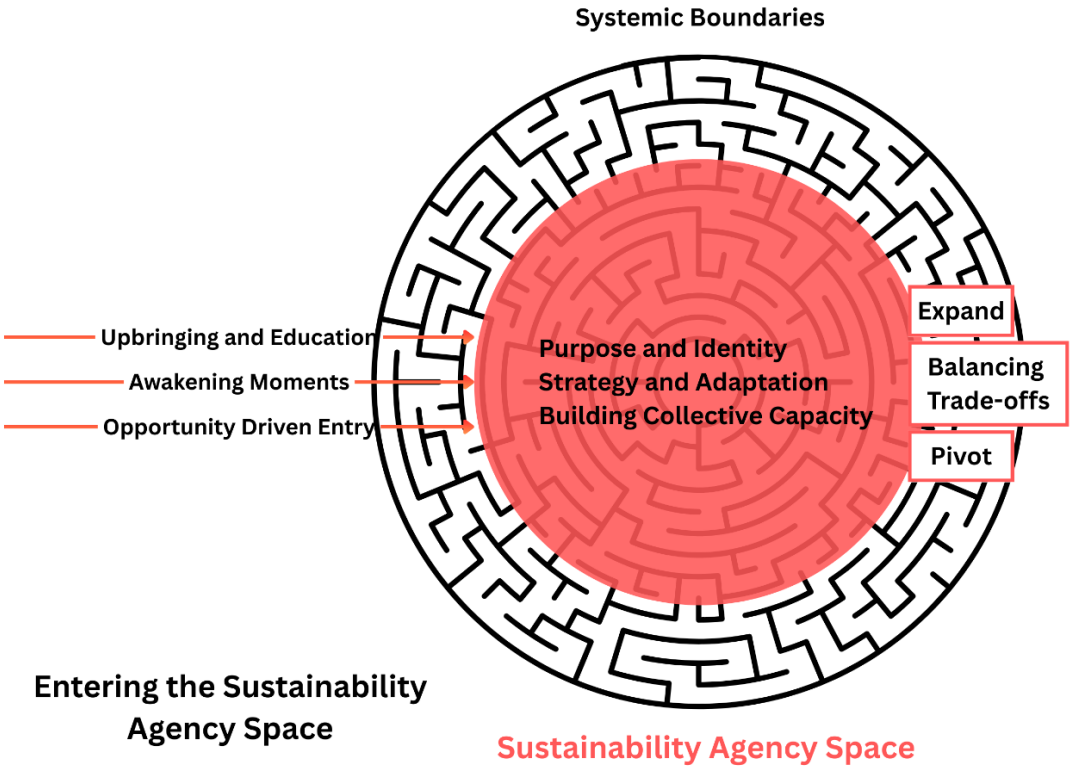


Figure 2: Trajectory of Sustainability Agency

5. Discussion

This study extends Koistinen et al.'s (2020) life-course perspective on sustainability agents by examining their professional trajectories through a sensemaking lens. By analyzing the experiences of 29 agents through three critical stages in their sustainability journey, we show how agency is shaped not only by personal experiences and external structures but also by how agents generate meaning, adapt knowledge, and reframe their roles.

5.1 Entering the Sustainability Space

Agents' entry into sustainability is shaped through sensemaking of formative experiences, opportunities, and sociocultural cues. While some agents are guided by foundational values or awakening moments, others gradually internalize sustainability goals through exposure in professional contexts. These trajectories illustrate how initial interpretations evolve through integrating new knowledge and reflective engagement with practice. Experiences such as witnessing social or environmental injustices can act as moments of dissonance, triggering reorientation, where individuals reinterpret prior experiences in light of sustainability concerns. This process appears iterative. Some agents begin with a clear sustainability commitment, while others develop it through exposure and engagement, demonstrating the evolving nature of sustainability agency, where learning and unlearning unfold over time through reinterpretation and contextual re-evaluation.

5.2 Navigating the Sustainability Agency Space

Once engaged, sustainability agents must sustain momentum while adapting to complex settings. Their sense of purpose provides direction, yet it is continuously shaped through interactions with others and evolving contexts. Building supportive networks can strengthen their agency and facilitate shared interpretation. Through these interactions, agents refine their understanding and adjust their practices in addressing sustainability challenges. This highlights the importance of relational learning and collective sensemaking, showing that sustainability agency involves action alongside the continuous circulation and recontextualization of situated knowledge.

5.3 Encountering Systemic Boundaries

As agents push for sustainability transformation, they confront systemic boundaries. Their responses vary: some prioritize achievable goals, while others diversify their approaches. These adaptations reflect the ongoing, sense-making-driven negotiation between individual agency and structural constraints, involving continuous interpretation and reconfiguration of knowledge within complex systems. Emotional resilience plays a crucial

role, as sustainability work often involves reconciling idealism with reality, leading to cognitive and emotional strain. Recognizing these psychological dimensions is essential for sustaining long-term engagement in the field.

6. Limitations, Implications, and Future Research

This study sheds light on sustainability agents but acknowledges several limitations. Notably, the sample comprises individuals already committed to sustainability, potentially limiting broader applicability. Future research should include participants from less sustainability-focused contexts and wider cultural and geographical backgrounds to enhance relevance. Exploring how knowledge flows and sensemaking processes shape the emergence and persistence of agency in these varied contexts could deepen understanding. The qualitative, retrospective data presents another limitation, as it introduces potential biases. Supplementing interviews with longitudinal observational studies or participant diaries could enrich insights into how agents create, share, and adapt knowledge over time. Additionally, the cross-sectional design restricts insight into long-term changes, emphasizing the need to explore what sustains or hinders sustainability agency through dynamic learning and reinterpretation.

Our findings suggest several ways organizations can better support sustainability agents. A strong sense of purpose drives engagement, yet maintaining motivation amid systemic boundaries is challenging. Organizations can foster purpose by creating spaces for reflection, mentorship, and celebration, connecting individual work with broader goals to sustain direction. Collaboration plays a key role, as agents rely on networks and cross-sector alliances to amplify impact. Developing formal knowledge-sharing platforms and communities of practice can support collective interpretation and innovation around sustainability challenges. Embedding sustainability across organizational structures, rather than relying on individuals, strengthens long-term change. Adaptability is critical as agents adjust strategies to shifting conditions. Providing training in systems thinking, strategic communication, and stakeholder engagement enhances their capacity to navigate uncertainty. Investigating how digital tools and knowledge management systems support these efforts could offer practical benefits. Emotional resilience is also essential, as many agents face psychological pressures. Organizations should acknowledge this with mental health resources, peer coaching, and work-life balance policies. Addressing these structural and individual boundaries is vital for sustaining transformative agency. By integrating sustainability into culture and decision-making, institutions can move beyond dependence on individuals, fostering collective conditions for lasting impact.

7. Conclusion

This study provides insights into the complex, evolving journeys of sustainability agents, highlighting three key stages: entering the field through diverse pathways, navigating professional environments, and responding to systemic barriers. Sustainability agents continuously engage in sensemaking, interpreting, and adapting their roles as systemic conditions evolve. Entry into sustainability is shaped by personal values, education, awakening moments, or professional opportunities. In their work, agents face challenges such as cultural resistance, weak governance, resource limitations, and psychological pressures. They respond by building collective capacity, guided by a strong sense of purpose, and refining their strategies through ongoing learning and knowledge exchange. These findings underscore the importance of both individual development and collaborative processes in sustaining agency. By recognizing the dynamic nature of these journeys and the systemic boundaries agents encounter, organizations can better support the creation, sharing, and application of knowledge needed to drive transformational sustainability change.

Ethics declaration: This study was approved by the RMIT College Human Ethics Advisory Network (approval no. 2024-26566-23156) in February 2024.

AI declaration: AI assistance was used in the preparation and refinement of this manuscript, aiding in language enhancement and content clarity. The authors maintain responsibility for the accuracy and integrity of the research presented.

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Appendix

Table 1: Overview of Participant Demographics and Backgrounds

#	Sex	Country of Work	Type of Organization	Work Sector	Job Title
1	M	Ukraine	Government	Infrastructure	Advisor
2	F	South Africa	Start-up	Agriculture	Founder
3	F	Tanzania	Non-profit	Development work	Consultant
4	F	Tanzania	Non-profit	Development work	Country Director
5	F	India	Government	Innovation	Director
6	F	South Africa	Start-up & Non-profit	Agriculture	Founder
7	F	Seychelles	Government	Tax & Finance	Commissioner General
8	M	Sweden	Business	Innovation	Group Coordinator & Strategist
9	M	Tanzania	University	Development work	Researcher & Project Lead

#	Sex	Country of Work	Type of Organization	Work Sector	Job Title
10	M	India	Government	Innovation	Manager Strategic
11	F	Sri Lanka	Intergovernmental Organization	Development work	National Specialist
12	M	Nepal	Non-profit	Development work	Partner Monitoring Officer
13	F	UK	Non-profit	Development work	Policy Lead
14	F	Ghana	Intergovernmental Organization	Tax & Finance	Program Manager & Advisor
15	F	Somaliland	Government	Health	Program Officer
16	F	Egypt	Non-profit	Development work	Program Officer
17	F	Tanzania	University	Development work	Researcher & Project Lead
18	M	Sweden	Business	Innovation	Innovation Manager
19	F	Somaliland	Government	Health	Technical Advisor
20	M	Nepal	Non-profit	Development work	Technical Coordinator
21	M	Sweden	University	Innovation	Program Director
22	F	Sweden	University	Education & Development	Educational Developer
23	F	Sweden	University	Education	Facilitator
24	F	Sweden	University	Training & Development	Research Officer & Advisor
25	F	Sweden	Business	Innovation	Consultant
26	F	Sweden	University	Health & Training	Researcher
27	F	Sweden	Non-profit	Conservation	Senior Advisor & Project Coordinator
28	M	Sweden	University	Development work	Senior Extension Specialist
29	F	Sweden	University	Education	Program Director

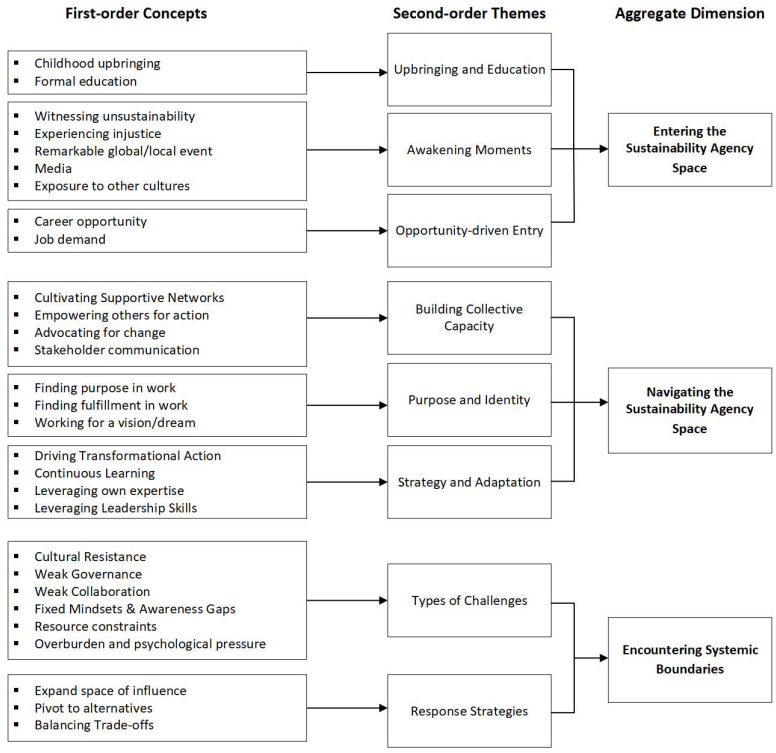


Figure 1: Data Structure

Industrial Project Management Supported by KM Methods: Empirical Results from Polish Enterprises

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Abstract: Organisations that customise products and services to meet individual customer needs, or offer new products to new and existing markets, implement operational processes according to project management standards. In a rapidly changing economic environment, knowledge is a key resource that provides companies with a competitive advantage. The shortening of product and service introduction cycles in many market segments means that orders are won on the basis of generic data and information. One of the symptoms in organisations is that employees perform a variety of tasks outside their area of specialisation. The research questions posed in this article are the following: Does the increased availability of data and information to support employee creativity and the increased use of knowledge management tools in this market group of companies foster an increased ability to carry out interdisciplinary projects? In this group of companies, is the increased use of tools supporting knowledge management accompanied by a positive increase in business development? These questions are part of a broader research project on Industry 4.0 and business opportunity theory, conducted at the Faculty of Engineering Management at Poznan University of Technology. The research was conducted among a group of 300 medium and large companies operating in 19 industries. It was carried out between November 2024 and February 2025 and involved 240 medium and 60 large companies. In the study sample, there is a small but clear linear correlation between an increase in the availability of data and information to support employee creativity and an increase in the ability to carry out interdisciplinary projects.

Keywords: Knowledge management, Project management, Knowledge base, Industry 4.0, Operational excellence

1. Introduction

The article presents selected results from a sample of 300 companies operating in Poland, focusing on the analysis of the impact of knowledge management tools on project management processes. Due to the increasing turbulence of the business environment, the results can be used to build effective models of operational excellence. This article focuses on the business segment of organisations that customise products and services to meet individual customer needs, or offer new products to new and existing markets. The aim of the paper is to answer the following question: Is there a correlation between the increased availability of data and information based on use of knowledge management tools and the level of increased ability to carry out interdisciplinary projects with accompanied by a positive increase in business development. These questions are a part of a wider research project on Industry 4.0 and business opportunity theory, conducted at the Faculty of Engineering Management, Poznan University of Technology. The research explored how organisations can use flexibility, intelligence and cleverness, supported by KM methods and tools, to discover and exploit market opportunities.

2. Research problem

Environment

In a rapidly changing economic environment, knowledge is a key resource that provides companies with a competitive advantage. The rapid pace of change in the business and technology area requires leaders to be agile and adapt effectively. Knowledge management is defined as the systematic process of creating, sharing, using and managing an organisation's knowledge and information (Mirai et al., 2024; Bukowitz, 2000). The modern business environment is characterised by high volatility and complexity of economic processes, among others:

- Labour shortages.
- Increasing amount of outsourced work.
- Increasing product complexity.
- Disintegration of traditional economic chains and emergence of business networks (Małkowska - Borowczyk, 2011).
- Shortening of the product life cycle and reduces profits, (Porter), (Grudzewski, Koźmiński, 1996), (Wang, 2016). Shorter product lifecycles and the growing role of customisation often means that changes in specifications, and consequently in design and technology, often occur during production phase.

- Changing operational objectives by replacing productivity with efficiency, quality and flexibility, understood as the ability of the organisation to adapt to changes in the environment (Volberda, 1998, p. 13), (Krupski, 2008, p. 6).
- Opportunities that grow in a changing environment (Trzcieliński, 2011, pp. 10-12; Trzcieliński, Kałkowska, Pawłowski, Włodarkiewicz-Klimek, 2016, pp. 9 -12; Goldman, Nagel, Preiss, 1995, pp. 8, 42-43).
- Increasing role of using Industry 4.0 methods and tools (Herman, Pentek, Otto, 2015), (Alcácer, Cruz-Machado, 2019), (Kagermann, Lukas, Wahlster, 2011; Kagermann, Wahlster, Helbig, 2013).
- Increasing customisation of products to meet individual customer needs and increasing complexity of products and services. (Salvador, De Holen, Piler, 2009; Gilmore, Pine, 1997; Duray R. 2002). The results of a study conducted on a large group of companies from eight countries (including the US and Japan) indicate that mass customisation is a very important strategic mechanism that can be applied in many manufacturing and service industries (Salvador, De Holen, Piler, 2009, pp. 71-79). Other research shows that SMEs also adapt to economic volatility and market complexity through product customization strategies (Bamiatzi, Kirchmaier, 2014), amongst others, by enabling entry into new submarkets and deterring potential competitors (Bhaskarabhatla, 2016). Organisations that customise products and services to meet individual customer needs, or offer new products to new and existing markets, implement operational processes according to project management standards.

Literature review

Despite the growing interest in knowledge management (KM), the concept remains elusive due to the absence of a universally accepted definition (Ode, Ayavoo, 2020; Nonaka, 1994). The knowledge management literature often focuses on information technology (IT), where knowledge should be codified, systematised and standardised (Al-Zayyat at all, 2010; Davidson and Voss, 2002). Many organizations begin their knowledge management efforts by trying to understand what they know and where that knowledge is. This was primarily due to the emergence of knowledge-based systems, which played a significant role in this development (Barclay, R. and Murray, P., 2004). Academic research has been conducted on the impact of using knowledge management methods on operational project management and performance levels. The majority of research has sought to identify positive relationships between them. The studies described in the literature were often dealt with a single sector of industry e.g. IT (Reich, Gemino, Sauer, 2013; Al-Zayyat at all, 2010; Foote, and Halawi, 2016), or oil and gas industry (Mirai et al., 2024), or space industry (Cocchiara, Nigro, Roma, Ragusa, 2024). In the literature, we can also find work researching the inverse relationship between the use of project management tools and knowledge management (Clemente, Domingues, 2023). However, Ahern, Leavy, Byrne (2014) in their research indicated that complex project management as a form of complex problem solving is a challenge of knowledge management under uncertainty, no less, they based their research on the analysis of two cases.

Research Problem

In spite of the growing interest in the use of knowledge management in project management, few studies have provided empirical evidence on the relationship between knowledge management practices and operational project management. This article focuses on the business segment of organisations that customise customer needs, or offer new products to new and existing markets. The results can be used to build effective models of operational excellence and this paper is part of a broader research project on Industry 4.0 and business opportunity theory. Operational excellence (OpEx) model needs empirical testing with organisations from different industries and sectors. A detailed breakdown and explanation of each element in terms of the underlying logic and laws that guide it is required (Found at all, 2018). With regard to the above this paper concentrates on two issues:

- Does the increased availability of data and information to support employee creativity and the increased use of knowledge management tools in this market group of companies foster an increased ability to carry out interdisciplinary projects?
- In this group of companies, is the increased use of tools supporting knowledge management accompanied by a positive increase in business development?

3. The Proposed Methodology

3.1 Research Sample, Scope and Methods

The research sample comprised 300 medium and large companies, operating in 19 industries, and included 240 medium and 60 large companies. The research was conducted from November 2024 to February 2025. The respondents comprised individuals directly involved in the management of the production and engineering area, including the president/managing director, the technical director, and other persons with similar competencies. The scope of the research encompassed the degree of product customisation, the extent of data and information availability, the utilisation of tools facilitating knowledge management, and the efficency of achieving a positive increase in business development. In the scope of this study, a questionnaire survey was conducted among a sample of 300 medium and large industrial enterprises in Poland. The survey was conducted in the form of an interview. The respondents were invited to respond on a 1–5 (Likert) scale. In addition, the data was partially processed using the Spearman's rank correlation test (Statistica 13.3).

3.2 Data Processing Methodology

The data collected was processed using the following methodology, based on the approach used in ongoing research on the Industry 4.0 project and business opportunity theory (Pawlowski, 2024):

Step 1 – Group of companies that customise products and services to meet individual customer needs was selected from the research sample for further investigation.

Step 2 – Following a comprehensive analysis of the aforementioned group of companies, two subgroups were identified:

- Group A comprises companies with positive growth in business development.
- Group B comprises other enterprises that have not experienced a positive increase in business development.

Step 3 – In research samples A and B, the following indicators were identified:

- Availability of data and information to support employees' creativity indicator.
- Ability to carry out interdisciplinary projects indicator.
- Use of tools to support knowledge management indicator.

These ratios indicate the proportion of enterprises in which respondents indicated the occurrence of a given characteristic at level 4 or 5 on the Likert scale, in relation to the total size of the given sample. In other words, these ratios demonstrate the intensity of a specific characteristic within each survey sample. The values of the individual indicators were analysed in research groups A and B.

Step 4 – Spearman’s rank correlation tests were carried out for some of the features.

3.2.1 Step 1 – Identification of a group of companies that customise products and services to meet individual customer needs

The following two questions was posed with the objective of identifying the group of companies that offer highly customised products, designed to meet the specific requirements of individual customers:

Q1. We adapt (modify) existing products:

Q 1.1. - to the markets in which we are present;

Q 1.2. - to new markets.

Responses on a scale of 4 and 5 to both questions qualified the company to the group of companies offering highly customised products, designed to meet the specific requirements of individual customers. A total of 128 companies from the entire research sample (N=300) offered highly customised products. The research indicates that 43% of the companies in the research sample are customising products, thus confirming the growing trend that has been identified in the literature research.

3.2.2 Step 2 – Identification of groups A and B in relation to the business development trend

In order to identify groups A and B in relation to the business development trend, the following question was asked:

Q 2. The trend in business development over the last 5 years is:

1 - very negative;

2 - negative;

3 - neutral;

4 - positive;

5 - very positive;

Responses on a scale of 4 and 5 classified the enterprise into group A, responses on a scale of 1 to 3 classified the enterprise into group B. Group A comprises 74 companies, while Group B consists of 54 companies.

3.2.3 Step 3 – Determination of indicators: availability of data and information indicator, ability to carry out interdisciplinary projects indicator, use of tools to support knowledge management indicator.

- Availability of data and information (Availability Indicator).

The following research question was posed to determine the lability of data and information to support employees' creativity indicator in group A and B:

Q 3. The availability of data and information to support their employees' creativity is:

1-very low,

2-small,

3-moderate,

4-large,

5-very high.

Thirty-five companies in Group A (74) have reported a high intensity of the bhad trait, which means an (Availability Indicator) value of 47%, in contrast, the value of the (Availability Indicator) in Group B was 30%.

- Ability to carry out interdisciplinary projects indicator (Interdisciplinarity Indicator).

The following research question was posed to determine ability to carry out (Interdisciplinarity Indicator) in group A I B:

Q 4. The company's ability to implement interdisciplinary projects is:

1-very low,

2-small,

3-moderate,

4-large,

5-very high.

29 companies in Group A indicated answers of 4 and 5 on a Likert scale, which means that an indicator of 31% was reached. Group B, on the other hand, had an indicator of 22%.

- Use of tools to support knowledge management indicator (Tools Indicator).

The following research questions was posed to determine (Tools Indicator). The following technologies:

Q 5. Big Data Analytics (BDA) (BDA is the process of analysing very large data sets to uncover hidden patterns, trends and information that can support better business decisions within a company) are used:

1 - not used at all,

2 - to a very small extent,

3 - to a moderate degree,

4 - to a large extent,

5 - to a very large extent.

Q 6. Big Data Analytics (BDA) They affect the working conditions in the company:

1 - Not used at all

2 - To a very small extent;

3 - To a moderate extent;

4 - To a large extent;

5 - To a very large extent.

Twenty-three companies in Group A indicated answers of 4 and 5 on a Likert scale, which means that an indicator of 31% was reached. In contrast, Group B demonstrated an indicator of 20%. However, it is interesting to note that in the entire survey sample (N=300) the indicator is at 29%, i.e. the value of the indicator in group A is slightly higher than in the entire survey sample, while in group B of companies with a low development trend it is definitely lower at 20%. Also, 43% of Group A companies said that using Big Data Analytics tools has a big or very big effect on their employees' working conditions. In Group B, 38 per cent of the companies surveyed said the same.

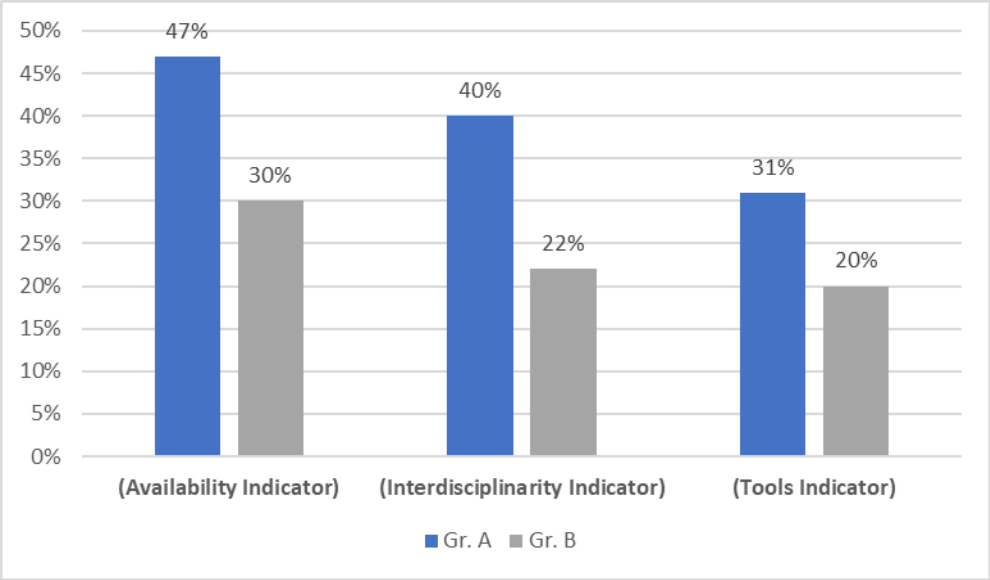


Figure 1: Determination of indicators: availability of data and information to support employees' creativity indicator, ability to carry out interdisciplinary projects indicator, use of tools to support knowledge management indicator

As illustrated in Figure 1, the data provides a comparative summary of the three indicators examined for enterprise groups A and B. The results support the assumption that companies in Group A, which offer highly customised products designed to meet the specific requirements of individual customers and demonstrate a positive or very positive business development trend, achieve significantly higher results for the indicators studied. The increased use of Big Data Analytics tools is combined with greater accessibility to information and an increased ability to carry out interdisciplinary projects.

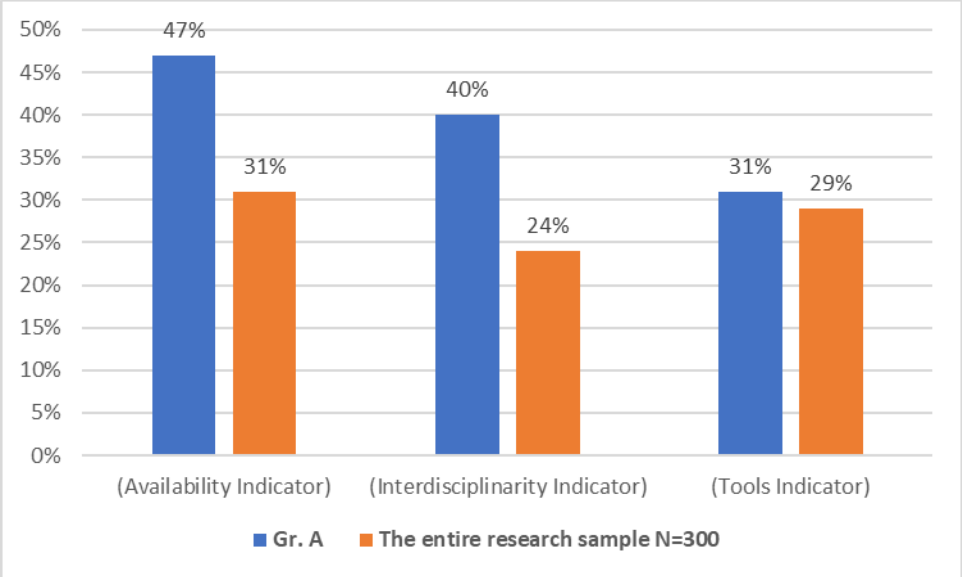


Figure 2: Determination of indicators: availability of data and information to support employees' creativity indicator, ability to carry out interdisciplinary projects indicator, use of tools to support knowledge management indicator in group A and entire research sample N = 300

Figure 2 shows the levels of the indicators studied in enterprise group A relative to the entire research sample N=300. The availability of data and information to support employees' creativity indicator, and the ability to carry out interdisciplinary projects indicator, are significantly higher in research sample A compared to the entire research sample N=300. As indicated earlier, the rate of use of tools to support knowledge management (BDA) is slightly higher in group A enterprises compared to the entire research sample. Analysing Figures 1 and 2, we can therefore assume that in the group of companies adapting products to customer requirements, the increased ability to carry out interdisciplinary projects and the increased availability of information and use of tools (BDA) is conducive to a positive business development trend.

3Step 4 – Spearman's rank correlation tests

Statistical analyses were performed using Statistica 13.1 software. Spearman's rank analysis was performed with a significance level of $p<0.05000$. The strength of the correlations was assessed according to the classification shown below in Table 1. The interpretation of the correlation coefficient does not provide a clear answer on the causal relationship, but it indicates the existence of a certain statistical relationship between the variables studied, which is one of the conditions for the existence of a causal relationship (Małkowska-Borowczyk, 2011).

Table 1: The strength of the correlations

Correlation coefficient value	**Interpretation**
r ≤0.2	Virtually no relationship
0.2< r ≤0.4	Low but clear linear correlation
0.4< r ≤ 0.7	Moderate correlation
0.7< r ≤0.9	Significant correlation
0.9< r ≤1	Very strong correlation

Elaboration based on Ostasiewicz, Rusnak, Siedlecka, (2000) .

Table 2 presents the results of Spearman's Rang correlation between the ability to carry out interdisciplinary projects, availability of data and information to support employees' creativity, use of tools to support knowledge management Big Data Analytics (BDA) and business development trend.

Table 2: Spearman's Rang correlation.

		[1]	[2]	[3]	[4]
[1]	Ability to carry out interdisciplinary projects	x	0,215519	0,067373	0,240773
[2]	Availability of data and information to support employees' creativity	0,215519	x	-0,070026	0,215519
[3]	Use of tools to support knowledge management Big Data Analytics (BDA)	0,067373	-0,070026	x	0,067373
[4]	Business development trend	0,240773	0,215519	0,067373	x

The following conclusions can be drawn from the analysis of Table 2:

- Correlation coefficients marked in red are significant with p <.05000.
- In addition, coefficients circled in yellow indicate low but clear linear correlation (0.2< r ≤0.4). These results were analysed in detail. All of the above statistically significant results are positive, indicating that an increase in one factor is accompanied by an increase in the other.
- An increase in the availability of data and information to support employee creativity is fostered by an increase in the ability to carry out interdisciplinary projects and an increase in the business development trend.

4. Conclusions

In a turbulent environment, the role of product and service customisation is growing. On the operational side, it means implementing processes according to project management methods. One of the symptoms that can be observed in organisations is that employees are required to perform a variety of tasks outside their designated area of specialisation. The aim of the paper was to answer the following question: Is there a correlation between the increased availability of data and information, use of knowledge management tools and the level of increased ability to carry out interdisciplinary projects with accompanied by a positive increase in business development. In a rapidly changing economic environment, knowledge is a key resource that provides companies with a competitive advantage. An analysis of the indicators and Sperman rank correlations indicates a that increase in the availability of data and information is fostered by an increase in the ability to carry out interdisciplinary projects and an increase in the business development trend. In view of the increasing turbulence in the business environment, the results can be used to build effective models of operational excellence.

The analysis of the above results indicates that such a model, in the variant for companies offering customised products or services, should include in its pillars methods supporting project management supported by tools increasing access to information such as Big Data Analytics (BDA).

Of course, the issue of knowledge management in the context of building (OpEx) systems in different business contexts is a broad field for further detailed research.

Ethics Declaration: N/A

AI declaration: AI tool - Elicit.com has been used to search databases for available literature on knowledge management and project management issues. Thanks to the tool, several literature items were identified.

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The Role of Human Resource Management in Building Knowledge Management Capacity in South African Public Sector Enterprises

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Abstract. The study investigated the role of Human Resource Management (HRM) in building Knowledge Management (KM) capacity in South African public sector enterprises. Research shows that HRM divisions' role in building knowledge management capacity in Public Sector Enterprises (PSEs) is underdeveloped and they face common challenges such as tacit knowledge loss risks, leading to criticism of HRM for not effectively fostering knowledge-driven organisational practices and cultures. In order to address this gap, this paper explored the perception of HRM's role in building knowledge management capabilities; the extent to which HRM supports Knowledge Management in PSEs; the close collaboration between HR managers and knowledge management practitioners; and key practices that enhance knowledge management capabilities in these enterprises. The study utilised a qualitative research design, conducting in-depth interviews with 20 human resource (HR) managers from 9 public sector enterprises in South Africa. The interview data was analysed for its thematic content using Atlas.ti. Human Resource Management plays a crucial role in knowledge management, particularly in public sector enterprises in the South African economy, albeit with some serious shortcomings. However, it is often considered last in the process due to a lack of understanding of the philosophy behind knowledge management, as well as a lack of synergy between HRM and KM functions. Nevertheless, on a positive note, HR managers believe that their practices can enhance knowledge management capability in public sector enterprises by facilitating critical processes like knowledge acquisition, application, sharing, and retention, regardless of whether they have a Knowledge Management function. The researcher recommends implementing knowledge-oriented HRM methods in South African public sector enterprises to improve knowledge management efficiency and capacity development. This paper may pave the way for future research in the field of knowledge management on a more thorough examination of the connections between HRM and KM in PSEs in South Africa and, more generally, in developing economies, since the impact or function of HRM on KM capacity has not been extensively empirically studied in the South African public sector.

Keywords: Knowledge management, Knowledge-oriented HRM practices, Human resource management, State-owned enterprises, South Africa

1. Introduction

The efficient management, protection and retention of firm-specific tangible and intangible resources are crucial for success in modern knowledge-intensive business enterprises. Private and publicly-owned enterprises currently utilise various human resource management (HRM) and knowledge management (KM) strategies to enhance their work and business operations in response to intense knowledge-based competition and evolving knowledge economies (Le, 2024; Naqshbandi et al. 2023). Extant literature emphasizes the importance of a robust connection between HRM and KM for business enterprises to effectively utilize their organisation's intangible assets for superior business value, performance and innovation (Murali and Kumar 2014). Public sector enterprises (PSEs) are state-owned instruments that drive economic development in developing and developed nations, including South Africa, where they are seen as catalysts for economic growth, employment and sustainability. The effective management of organisational knowledge in knowledge-intensive enterprises such as PSEs relies heavily on human resources and related practices (Gürlek 2020). In order to ensure the growth and placement of the South African economy in the global knowledge economy, HRM, its managers and its practices should ideally play a critical role in knowledge management, especially in public sector firms. However, research indicates that the role of HRM divisions and their practices in building KM capacity in PSEs is underdeveloped (Phaladi 2024). Further complicating the landscape of knowledge management in PSEs is that they face common challenges in tacit knowledge loss risks. Consequently, HRM has been criticised for not effectively fostering knowledge-driven organisational practices, cultures and structures (Islam, Jasimuddin and Hasan 2015), with South African PSEs exemplifying this trend (Phaladi 2022).

The literature presents complex research issues regarding KM problems, including enterprise knowledge loss and related risks (Durst et al. 2023). Many organisations' performance and sustainability are negatively impacted by these knowledge loss concerns (Zieba et al. 2022). According to Dalkir (2023), knowledge management is greatly aided by HRM techniques, which tackle issues such as knowledge retention and loss. It is imperative that HRM and KM complement one other in order to manage businesses' tacit knowledge vulnerabilities. Nonetheless, some scholars (Dalkir 2020; Gope et al. 2018) bemoan the dearth of case studies and empirical research on the connections between HRM and KM. Given the increasingly crucial role of HRM and KM in key

business outcomes, sustainability and innovation capabilities of public and commercial enterprises, this paper aims to investigate the role of human resource management in enabling the knowledge management capability of public sector enterprises in South Africa. It explores the extent to which HRM supports knowledge management in PSEs; the perception of HRM's role in building knowledge management capabilities; the close collaboration between HR managers and knowledge management practitioners; and key practices that enhance the knowledge management capabilities in these enterprises. Both HRM and KM practices have a positive impact on organisational performance, knowledge driven-culture, innovation and sustainability. However, recent research emerging out of South Africa laments the fact that HRM portfolios in PSEs do not facilitate knowledge sharing and retention despite facing some serious knowledge loss risks (Mthunzi 2024; Phaladi 2024). Furthermore, these authors also point to a lack of empirical research linking HRM to organisational tacit management. Knowledge management (KM) practices as a moderator in the relationship between HRM practices and organisational performance have been minimally empirically explored in public sector enterprises. Much of the focus of extant literature has been largely conceptual or theoretical in nature. Mthunzi (2024) and Phaladi (2023) attest that HRM strategies play a crucial role in facilitating and building organisational culture and capabilities that are knowledge-driven. These firm-specific intangible capabilities assist organisations to minimize potential knowledge risks.

In order to explore the role of HRM in building KM capacity in the public sector enterprises of South Africa, the following research questions are pursued:

RQ1: Is there a role for HRM in the knowledge management processes of public sector enterprises?

RQ2: To what extent does HRM facilitate or support the management of knowledge in PSEs?

RQ3: Do human resource managers see their role in building knowledge management capabilities in South African PSEs?

RQ4: How closely are HR Managers working with knowledge management practitioners in managing organisational knowledge?

RQ5: What do HR managers consider as key practices that enhance knowledge management capabilities in public sector enterprises?

RQ6: Why do they think that these practices or systems enhance knowledge management capability in PSEs?

As the influence or role of HRM in KM capacity has not been widely empirically researched in the South African public sector, this paper may open the KM field for further studies on a deeper investigation of the relationships existing between HRM and KM in PSEs in South Africa and, more generally, in developing economies.

2. The Role of Human Resource Management in Knowledge Management

Sarfraz et al. (2023) and Farr and Hosseingholizadeh (2019) suggest that HRM departments within organisations have the potential to create a knowledge-driven organisational culture and gather the most useful expertise through its numerous practices, such as hiring, rewards and compensation, training and development, performance and retention. However, scholars suggest that effective HRM practices must be knowledge-oriented in their approach, strategy and tactics in order to successfully build KM capacities and related behaviours (Le 2024; Gürlek and Çemberci 2020). Human resources are empowered by the knowledge-based methods of the company, which encourage creativity within the organisation. It is true that knowledge-based HRM practices foster business process innovation and have an impact on organisations' knowledge cultures. The acquisition, development, sharing and retention of important business knowledge may be facilitated directly or indirectly by traditional HRM practices like hiring and selection, learning and development, compensation and rewards systems, organisational design, performance management, and retention systems. For example, knowledge acquisition and absorptive ability are directly linked to HRM recruiting practices through the identification and sourcing of knowledge workers with the necessary knowledge, competences and skillsets (Phaladi 2023). Naturally, one of the key organisational soft infrastructures for the creation of firm-specific knowledge assets is human resource development (HRD), including training and development. Since they help organisations develop a knowledge-oriented culture, knowledge management and innovation capabilities, such activities are regarded as knowledge-driven (Mthunzi 2024; Donate and Guadamillas 2015). Scholars concur that companies that provide learning and development opportunities to their human resources are thought to have a higher retention rate for human capital assets, mostly due to the fact that these chances foster dedication and motivation (Delery and Roumpi 2017). Furthermore, these HRD practices help to support knowledge acquisition and development, as well as building employee commitment and loyalty (Gope et al. 2018).

Additionally, KM benefits greatly from HRM-aligned retention strategies. Retaining human resources will unavoidably result in the preservation and protection of their invaluable knowledge, opening up opportunities for companies such PSEs to incorporate and retain their expertise. From the aforementioned research, it becomes apparent that through hiring (recruitment and selection), training, compensation and rewards, and performance management, HRM could facilitate knowledge exchange and retention by ensuring that the proper people are in the right places or positions, as well as fostering a learning culture, all of which are critical components of KM capability. Few empirical studies have been conducted to explain the potential effects of HRM on building knowledge capability to mitigate against potential knowledge loss risks, particularly in relation to its impacts on knowledge management and its key processes, even though HRM practices are thought to be the main solutions for firms to foster knowledge-oriented activities, behaviours, processes and key outcomes like productivity, sustainability and organisational performance (Kianto et al. 2017; Singh et al. 2021; Phaladi 2024). Furthermore, current research emphasises the value of HRM practices in knowledge management, but states nothing about how these practices might be integrated into public sector business knowledge management. The existing empirical literature integrating HRM strategies, which primarily comes from South Africa, indicates that future research in public enterprises worldwide is necessary to examine knowledge loss risks from strategic HRM and KM perspectives, even though the picture of such integration points is unclear in the current review and reality (Phaladi et al. 2024). Retaining human resources through various HRM practices will unavoidably result in the preservation and protection of their invaluable knowledge, opening up the opportunity for PSEs to incorporate and retain their expertise. However, further empirical study is needed to determine whether HRM-driven strategies support KM in PSEs worldwide and may be regarded as knowledge-oriented.

3. Methodology

The study used a qualitative research methodology, interviewing HR managers at South African public sector enterprises to get detailed qualitative data through non-structured interviews. Twenty (20) managers from the HRM departments of nine PSEs, who were purposively sampled to respond to the study questions, were interviewed by the researcher. In order to assure ethical concerns, the researcher used the interview technique in selected PSEs, obtained informed consent, maintained anonymity and privacy, and obtained approvals. It was determined that the sample size of 20 HRM managers was sufficient for obtaining detailed information and creating a comprehensive picture of the issue being studied. Creswell (2014) states that a small number of instances or interview subjects between one to forty are seen to be sufficient for qualitative research in order for researchers to provide a complete picture of the phenomenon under study. Atlas.ti software was used to conduct a thematic analysis of the qualitative data gathered from the interviews.

4. Research Findings

With regard to the research question: *do human resource managers see their role in building knowledge management capabilities in the South African PSEs*? Human Resource managers did in fact recognise their part in developing knowledge management skills. HR managers realized that in order to develop skills, they needed to work with partners in knowledge management. The HR managers who participated in the interviews all agreed that their job is inextricably linked to the organisation's knowledge management initiatives. Human resource management is responsible for maintaining the human element of knowledge management. This job was described by a PSE5 interviewee as follows:

> *I think we are human resource; we are mostly in the cold front dealing with people on a daily basis. Whether you like it or not, humans will always be part of you. You cannot divorce yourself from dealing with people (HR Manager#20, PSE5).*

This is in line with the opinions of a large proportion (12) of the twenty HR managers who were interviewed. They emphasized that part of their job was to raise awareness of the value of organisational knowledge and its management. The following is how one SOE4 interviewee who works in the compliance and regulatory field described the awareness issue:

> *I think yes. The first thing is that HR needs to be able to bring awareness, because HR and IT are the most important people in this space; IT from a point of view of giving the systems we need, like a repository, but HR must bring that awareness to say when we lose people, sometimes it can impact on the operations. How do we make sure that we keep that repository? Therefore, that is awareness from us (HR Manager#11, PSE4).*

However, the difficulty is that even though they are in charge of people management procedures, some HR managers continue to view IT systems as a way to address knowledge management problems in their companies. Whether or not there is a formalized knowledge management framework, human resource management will always play a part in knowledge management. From three PSEs that had KM formalised through structures, it was intriguing that the KM function was only found in human resources in one specific PSE, suggesting a strong bond between the two disciplines. There was no similar synergy for the other two PSEs, whose KM was situated in the Information Technology division.

Regarding the study topic of *whether HRM plays a part in the organisation's knowledge management procedures*, every HR manager stated that they believe HRM plays a part in assisting KM initiatives. This is true whether or not knowledge management is a function of their organisations. From talent acquisition to talent retention, capacity development in terms of learning and development (training and development), workplace skills gap analysis, coaching and mentoring programs, succession planning, conducting exit interviews, raising awareness of knowledge management, advancing talent management strategy, performance management to organisational culture, they see their role in influencing KM behaviours as beginning with these processes. The following is how an HR manager at PSE1 who has a specialized KM function described that role:

> *Yes, I think it's how we are going to make sure these things are in leadership roles, so we can hold them accountable for their capabilities in their teams, so if I am drawing up a profile for a line manager, that line manager profile should build capabilities in their areas and must build succession and shadowing within the areas. You will see it in my performance contract. I have each line manager has their perspectives in terms of critical staff. The line management needs to build up recruitment and retention plans for critical staff in areas of responsibility. They need to implement and monitor values of the staff in terms of making sure that they are the right culture. I need to identify strategic skills gaps within the operations including succession planning and interim training for all my staff. I need to track and monitor their performance and this is cascaded down for line managers (HR Manager #3, PSE1).*

Currently, certain PSEs that have not institutionalized knowledge management in their procedures and frameworks appear to be at the margins when it comes to HRM's involvement in developing knowledge management skills. It is noteworthy that only three of the nine PSEs that took part in the study had a fully functional Knowledge Management unit within their organisational structure. Without a specific KM unit within the organisational framework, one of the PSE9 interviewees hinted that:

> *I do, but it is not central but more on the periphery and in a supportive way, but like I said: we have not really articulated how we will support and respond (HR Manager#16, PSE9).*

The following question had a mixed response: As an HR manager, how closely do you collaborate with knowledge managers or other practitioners in the field of managing organisational knowledge? The results showed that there was some degree of close contact and collaboration in the instance of three PSEs where the management of knowledge was explicitly institutionalized, even if there was still space for development. According to one interviewee, it was as follows:

> *We do not work with them that much because they extract the knowledge from the business. They have their processes in place and we have our processes in place. It integrates more along the line, for example if we are doing an operating line review, the operational line review was to take the bank to a higher level of performance in terms of what they are going to deliver, they will then come to us and say "okay, what are the lessons learned?" What are the skills we need to retain? And so on, so where HR is involved they will come and work with us (HR Manager #3, PSE1).*

The following is how another respondent described the cooperation between the KM unit and human resource managers:

> *We work with in collaboration with the knowledge management unit. When they do brown bag sessions, we are part of those brown bag sessions. Some of them they lead and some of them we work together. However, we are there because that is part of the knowledge management (HR Manager#2, PSE1).*

Visible frustrations were on the 'bad' side of the mixed bag. This was especially true in one organisation where the KM role was poorly conceived within the organisational structure, leading to misunderstandings on matters pertaining to the management of organisational knowledge. For example, there used to be a post called General Manager, IT and Knowledge Management, but not many knowledge management initiatives emanated from

there. However, one of the group's executives was assigned the responsibility of promoting KM. The following is how the two PSE5 HR managers conveyed their frustrations:

> *According to me, I do not see it, I do not feel it. We have individuals; I know that we have a GM, IT and Knowledge Management. What that means, for me that is a library and records. Therefore, it ends there. That is why I am saying that for him to be called GM: IT and Knowledge Management, for me it is very confusing. Hence, I want to clarify on that. And I even think that it is situated at the wrong place. Maybe if we can partner capacity building and knowledge management to be in one area, to be within the strategic human capital (HR Manager#18, PSE5).*

To these frustrations, another HR manager responded as follows:

> *I know that there is somebody at the group strategy level who is dealing with knowledge management [but] he does not even engage with us in terms of whatever initiatives or whatever objectives he needs to do in his line of thoughts so that, maybe, we can assist and form a value chain. I even think that knowledge management is situated at the wrong place. Maybe, if we can partner capacity building and knowledge management to be in one area, to be within the strategic human capital (HR Manager#19, PSE5).*

The aforementioned assertions point to the fact that in some PSEs, KM is poorly conceptualised structurally and those in charge do not understand the science behind KM. Strong relationships between the pertinent role-players are necessary for knowledge management to succeed within the organisation. However, according to two HR managers from two distinct organisations with KM units within their organisational structures, there is no synergy. One area of concern was a lack of cohesion. One human resource manager from a separate PSE using a knowledge management system highlighted a lack of coordination in the following ways:

> *We are far. We are far. Like I said, that we come in at the tail end, and it is just a tick-box exercise, which I do not think does much justice to the process (HR Manager#8, PSE2).*

In order to assist Knowledge Management initiatives in the PSEs, this section lists particular HRM strategies that may be applied to influence people's attitudes and behaviours. The following question was posed to HR practitioners: *What important HRM practices do you think improve the organisation's knowledge management capabilities?* HR managers identified several key practices that enhance an organization's knowledge management capabilities, including hiring, learning and development, talent management, culture management, organizational design, succession planning, compensation, retention, on-job boarding, job rotation and performance management. These practices are central to the HRM system across public sector enterprises, and understanding how people develop knowledge management behaviours and competencies is crucial.

Regarding the research question: *why do HR managers think that these practices or systems enhance knowledge management capability in public sector enterprises*? All participants agreed that these practices are crucial for facilitating critical KM processes like knowledge acquisition, application, sharing and retention, regardless of whether they have a Knowledge Management function.

5. Discussion of the Findings

The findings of the study showed an empirical confirmation relating to the connection and role of HRM in building, influencing and shaping KM capacities, processes and behaviours. Data revealed that human resource management played a key strategic and operational partnering role in public enterprises' establishment of knowledge capacities and the management of organisational knowledge. Nonetheless, this research offered factual data regarding the connection and function of HRM practices in creating and moulding KM behaviours and procedures, thus enhancing the capability of knowledge management. In the qualitative interviews, every human resource manager emphasised how important it is for HRM to support knowledge management initiatives within their companies. A large portion of the data also revealed that many PSEs' use of HRM to develop knowledge management capabilities is mostly peripheral. This is particularly true for PSEs whose organisational structures have not institutionalised knowledge management and procedures. Remarkably, of the nine PSEs that participated in the study, only three had an operational knowledge management unit within their organisational structure. One of the PSE9 interviewees intimated that in the absence of a dedicated KM unit within the organisational structure, PSE9 has not really stated how they will assist and respond. Where they do have KM, it is more peripheral and supporting than core.

Human Resources managers recognize their role in enhancing knowledge management capabilities and collaborate with KM partners. They understand that their role is integral to organisational knowledge management activities as HRM is responsible for people and the process of knowledge management. The study also discovered that knowledge management and human resource management go hand-in-hand. People's knowledge is the foundation of Knowledge Management, whilst individuals and the guardianship of those individuals are the focus of Human Resource Management. This illustrates that HRM and Knowledge Management are inevitably inter-dependent, if not inseparable. However, it is interesting to note that the role of HRM in facilitating KM capability was constrained by the non-existence of a close nexus or synergy between HRM and KM in most of PSEs which did not have KM roles and functions within their organisational structural configurations. In other words, those PSEs needed to have fully institutionalised KM in order to have a full appraisal of the role of HRM in such practices. Hence, much of the role that HRM played in the management of enterprise knowledge was mainly limited due to a lack of appreciation of the science behind KM. It is interesting that even in the few (three) PSEs that had KM institutionalised, the absence of synergy between KM and HRM remains a problematic area. The study found that the KM function was only structurally located in Human Resources in one PSE, indicating a strong bond, unlike the two other PSEs with KM in the Information Technology division. This explains why KM capabilities and capacities are underdeveloped in many PSEs in South Africa. The insufficient capacity for KM, particularly in terms of knowledge sharing and retention, exposes organisations to the potential risk of knowledge loss.

Indications are that HRM's contribution to the creation and enhancement of knowledge management skills was mostly restricted to hiring procedures and employee training and development programmes. Positively, human resource managers in public sector enterprises recognized and viewed their responsibility to mould employees' attitudes toward knowledge management. From recruitment to talent retention, capacity building, workplace skills gap analysis, coaching and mentoring, succession planning, conducting exit interviews, career development, KM awareness, driving human capital strategy, performance management, and organisational culture and design are all part of their role in forming KM behaviours, according to them. However, because they lacked retention strategies, HR departments' ability to assist KM was restricted vis a vis human retention policies.

The study also shown that hiring and training procedures have an impact on the ability to absorb new information and improve existing expertise. The PSEs provided excellent facilitation for the following activities: The process of finding candidates who possess the necessary expertise and abilities, then preparing them with pertinent knowledge-based training interventions and knowledge absorption abilities. The fact that a large number of public sector enterprises had problems retaining employees indicates that they were ineffective in creating and maintaining knowledge protection capability.

Regarding HRM strategies that improve KM capacity in PSEs, HR managers identified hiring, learning and development, talent management, succession planning, culture management, organisational design, remuneration, retention and performance management as key HRM practices to improve an organisation's knowledge management capabilities. Regardless of whether they have a Knowledge Management function or not, all participants concurred that these practices are essential for supporting important knowledge management activities such as knowledge acquisition, application, sharing and retention. They also highlighted the importance of understanding how people develop knowledge management behaviours and competencies.

5.1 Limitations and Future Research Studies

The qualitative study conducted in nine South African public enterprises highlights the importance of HRM in Management and Organisational Knowledge research. However, its findings may not be universally applicable to other PSEs. Future research could explore these issues from various perspectives, including interdisciplinary, multidisciplinary and mixed methods, to provide a more comprehensive understanding of the phenomenon. Furthermore, it would also benefit future research and praxis if the research findings could be quantitatively tested in other similar public enterprises.

6. Conclusion and Recommendations

The researcher concludes that Knowledge Management critically depends on Human Resource Management. The study's conclusions provided empirical support for the hypothesis that human resource management plays a crucial role in establishing and modifying knowledge management practices. While KM primarily focuses on managing the knowledge that is ingrained in people, HRM is involved in all facets of human resource oversight since HR departments are the guardians of People Management techniques. As such, human resources are the source of information and knowledge. As a result, the researcher draws the conclusion that KM and HRM are

intertwined. In the few public sector enterprises where knowledge management was institutionalized, it is evident that HRM was crucial in enhancing knowledge management capabilities, despite some shortcomings. The results of the study make it abundantly evident that HRM in public sector enterprises plays a part in creating and modifying knowledge management practices and cultures. It is impossible to overstate this role. Knowledge management skills within organisations may be improved by human resource management developing, moulding and enforcing the appropriate KM behaviours. In public sector enterprises, there should be a synergy between KM and human resource management. During exit interviews, HRM should not be the last step in the knowledge management process. According to the research, knowledge retention should begin at the outset of the process of finding qualified candidates to close the gaps in knowledge and skills that have been discovered, and should continue all the way through employee engagement, capacity development and knowledge worker retention (Le 2024; Mthunzi 2024). Therefore, the researcher suggests that the organisation's HRM practices, including hiring, training and development, organisational design, management of organisational culture, remuneration, retention, career management and performance management, should all have a knowledge-based bent. In summary, the researcher suggests that knowledge-oriented HRM methods be implemented in South African PSEs with the aim of enhancing their ability to facilitate the efficient and effective management of organisation tacit knowledge. Knowledge-oriented HRM strategies enhance knowledge capacity, culture, sharing and retention, thus acting as a buffer against potential knowledge loss vulnerabilities.

Ethics and AI Declarations: The paper, a part of a larger doctoral study, acknowledges the use of Microsoft Artificial Intelligence in Word for editing of the paper. The University of South Africa granted ethical clearance for the doctoral study.

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Knowledge Management in Distance Education: Challenges Related to Learning Motivation

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Abstract: This article addresses the challenges of knowledge management in distance education at higher education institutions. Remote teaching has necessitated changes in knowledge delivery methods. Closely linked to the new digitalized environment, online teaching has transitioned to a new educational paradigm. The article presents research findings on the challenges of maintaining motivation in distance learning and examines whether there is a relationship between motivation and factors such as gender and study level. The aim is to identify the challenges faced by students and provide recommendations to effectively support student engagement and assist them in the learning process. The first part outlines the theoretical foundations of distance education. The subsequent section explores the challenges students encounter during independent distance learning. A social research method using a questionnaire (CAWI) was employed. Respondents included full-time and part-time undergraduate (bachelor's/engineering) and graduate (master's) students. The study was conducted between July and December 2024, with 230 students participating. The results concerning the analyzed variables are presented and discussed.

Keywords: Education, Knowledge, Learning environment, Higher Education, Motivation

1. Introduction

The rapid implementation of modern technologies compels society to continually update and expand knowledge across various fields of science and technology. In a world of constant change and advancing technological globalization, the challenges facing education are multifaceted. The contemporary generation of the academic community, especially in technical universities, has increasingly demanding expectations regarding educational materials: they seek dynamic content, digital approaches, and high-quality visuals. The knowledge imparted should be presented in an engaging manner that utilizes the latest technologies. Distance education is not merely a technological issue but fundamentally concerns the organization of the educational process, requiring active engagement from both students and lecturers (Kabus, Samek-Wojtyla, 2024). Maintaining motivation in this model poses significant challenges. While technology facilitates access to educational materials, self-organization, engagement, and participant interaction often require additional support. This is particularly true in online learning environments, where flexibility in format and scheduling exists; here, motivation is crucial for sustaining activity and achieving student outcomes. In this context, knowledge management plays a vital role by aiding in the effective collection, processing, and sharing of information in ways that are engaging and tailored to student needs.

This article aims to address the following research questions:

RQ1: What are the primary challenges associated with maintaining motivation in distance education?

RQ2: Are there correlations between student motivation and their gender and degree of study? Two hypotheses were put forward to verify the question. H1 - motivation for self-directed learning varies significantly across different study levels, H2 - there are significant differences in the level of motivation for self-directed learning depending on gender

RQ3: What recommendations can be made to enhance the distance learning process?

Answering these questions seeks to deepen the understanding of factors influencing student motivation in distance learning and to develop strategies that support the effectiveness of this educational model.

2. Literature Review

Distance education is not a new phenomenon; its origins trace back nearly a century. In the 1920s, "educational radio" was utilized, and from 1945 onwards, "educational television" expanded through initiatives like those at Iowa State University (Kossobucka, 2011). Earlier forms of distance learning involved mailing instructional materials, textbooks, and specialized journals, though these methods lacked interactive engagement between teachers and students. The first correspondence school was established in England in 1840, followed by similar institutions in Berlin in 1856, the United States in 1860, and Poland in 1916. Norway introduced the first legal regulations for distance education in 1914 (Dziewulak, 2020). The 1950s marked a

pivotal shift with the advent and widespread adoption of the Internet, significantly enhancing communication capabilities. This technological advancement eliminated geographical barriers, making distance education more accessible and leading to its rapid expansion.

These changes have fostered a new learning paradigm that views knowledge acquisition as a lifelong process. Educational institutions are increasingly implementing modern courses and training programs that leverage computers and the Internet, seeking innovative solutions to enhance teaching effectiveness. Contemporary educational technologies have transformed participants from passive recipients to active, engaged learners (Piersiala, 2024). The development of Virtual Learning Environments (VLEs) has added significant value to modern teaching methods (Biernacka, Patalas, 2006).

Distance education has become the most technologically advanced form of education today, offering benefits such as cost reduction, accelerated learning processes, easier access to training, and efficient monitoring and assessment of learners. Additionally, e-learning enables educators to enhance educational quality by utilizing rapidly evolving global educational resources (Yahiaoui et.al, 2022).

Organizations characterized as knowledge-based focus on creating value through effective knowledge utilization. According to Grudzewski and Hejduk (2004), a knowledge-based organization is one whose structure is focused on creating added value based on the application of knowledge use. The decision to use a knowledge-based organization primarily concerns the following features:

- they produce Knowledge Rich Products, i.e. those whose value is over 50% knowledge, or they provide common services based more on access to knowledge than on physical work,
- they employ high-class specialists, the so-called Knowledge Workers, who constitute the core of all employees,
- about their values resulting from the high value of the intellectual value that determines it.

Applying this definition, higher education institutions are prime examples of knowledge-based organizations, as they leverage knowledge to gain competitive advantages and assist others in acquiring it (Krawczyk, 2024). To meet evolving demands, universities are becoming more open and flexible.

The prevalence of e-learning in higher education is increasing. Terms such as e-learning, distance education, distance learning, distance teaching, correspondence study, open education, teaching by network, online learning, m-learning, Computer-Aided Learning, Computer-Based Training oraz Web-Based Training and others are used interchangeably to describe this educational modality (Kisielnicki, 2008; Kaźmierska, 2019; Looi, 2021). In the United States, the educational market segment for e-learning is expanding rapidly. For instance, funding for online education grew from $550 million in 1998 to $9.3 billion in 2003. E-learning has become an integral part of university operations not only in the U.S. but also globally (Carr, Chellman 2004). Observing trends in the U.S. and Western Europe, it's anticipated that the demand for e-learning will continue to rise in Poland in the coming years. Ongoing technological advancements provide higher education institutions with opportunities to enhance e-learning experiences, making it a crucial strategy for universities (Adnan andAnwar, 2020; Fadillah et.al., 2020)..

In the case of distance learning, students work without physical, direct contact with the lecturer and other students, and therefore need to be more engaged and motivated to learn. Traditional learning provides opportunities for direct contact, informal relationships, conversations in the hallway, and spending time together. Motivation to learn is considered a key factor for success in distance learning (Akram, Li., 2024; Wei et.al., 2023; Çebi, Güyer, 2020; Koyuncuoglu, 2021). However, evidence suggests that student motivation is not a static characteristic that changes with various factors as the course progresses, including emotional states, economic conditions, personal problems, and course content. In addition, studies have shown that factors such as students' age, gender, cultural background, and socioeconomic status can have a significant impact on learning motivation (Ishida, Sekiyama, 2024; Sigmundsson et.al., 2022; Maghrifani, 2024). For example, students from different cultural or social backgrounds may exhibit different types of motivation in the learning process, which may be related to their educational expectations, values, and personal life experiences (Sigmundsson et.al., 2022). In particular, students from lower socioeconomic status may face greater challenges in learning, which may affect their motivation and learning strategies (Maghrifani, 2024). Therefore, understanding the impact of these factors on learning motivation is crucial for designing more personalized and targeted didactic courses. Motivation has been identified as the most important factor that determines students' choices about what to learn, how to learn, and when to learn (Hartnett, 2016). Motivation is an essential aspect of any educational process, especially in relation to e-learning (Yahiaoui et.al,

2022). For example, Elshareif and Mohamed (2021) analyzed data on student learning during COVID-19 to investigate the relationships between key aspects of e-learning and learning motivation. The study identified key aspects of e-learning (i.e., e-learning materials, e-assessments, e-discussions, etc.) in relation to students' learning motivation. However, this relationship was identified based on the data at the end of the course, which partially shows that the authors took student learning into account. In contrast, in Xu's (2017) study, the author identified behaviors such as coping with distractions, organizing the learning environment, time management, emotional engagement, motivation monitoring, and cognitive reappraisal. Kotarba (2024) also identified a set of challenges and factors that academic e-learning faces, indicating, among others: time management, comprehensibility and curiosity of course content, interactions with the lecturer or student group. In turn, Pei (2025) analyzed the quantification of students' motivation to learn and detect their learning dynamics in virtual learning environments. Several studies have shown that students' motivation has a direct impact on students' performance. Therefore, the literature claims that there is a correlation between these two variables (Richardson et al., 2012; Azizoğlu et al., 2015).

3. Research Methodology

The subjects of this study are students who grew up in the digital age, in a world saturated with technology. Their lifestyle is based on digital solutions, and they are characterized by their ease in navigating educational platforms and various online tools. Their method of acquiring knowledge differs from previous generations, which in turn implies a new approach in academic didactics.

This study was conducted to determine the challenges faced during distance learning and how it affects motivation to study. The research was carried out in the form of a survey, and data were collected using a structured questionnaire distributed among students at all levels (both undergraduate – bachelor's and engineering, as well as graduate – master's). The initial sample consisted of 230 students, with 205 correctly completed questionnaires collected, resulting in a response rate of 89%, which is considered highly acceptable according to Sekaran and Bougie (2019). A purposive sampling method was applied. The questionnaire included questions designed for quantitative analysis. Measurement items were expressed using a five-point Likert scale, defined as follows: 1 = strongly disagree, 2 = disagree, 3 = somewhat agree, 4 = agree, and 5 = strongly agree. The questionnaire encompassed two main constructs, in addition to demographic data, also examining the student's motivation for distance learning. Calculations were performed using SPSS software (version 29).

4. Results

The study involved 205 participants: 96 women and 109 men. The largest group consisted of individuals aged between 20 and 25, while the smallest group comprised those over 35 years old. Respondents' ages were recorded from 17 upwards, as the Częstochowa University of Technology enrolls students from Ukraine who often begin their studies earlier than their Polish counterparts. The demographic breakdown by age and gender is presented in Table 1.

Table 1: Demographic Characteristics of Respondents

Characteristic		Frequency	Percentage
Gender	Women	96	47%
	Men	109	53%
Age	17–20 years	21	10%
	21–25 years	79	39%
	26–30 years	53	26%
	31–35 years	40	20%
	Over 35 years	12	6%
Study Programme	Full-time Bachelor's	5	2%
	Part-time Bachelor's	17	8%
	Full-time Engineering	58	28%
	Part-time Engineering	19	9%
	Master's	106	52%

Initially, digital competencies related to distance learning were assessed. The distribution of responses is shown in Figure 1.

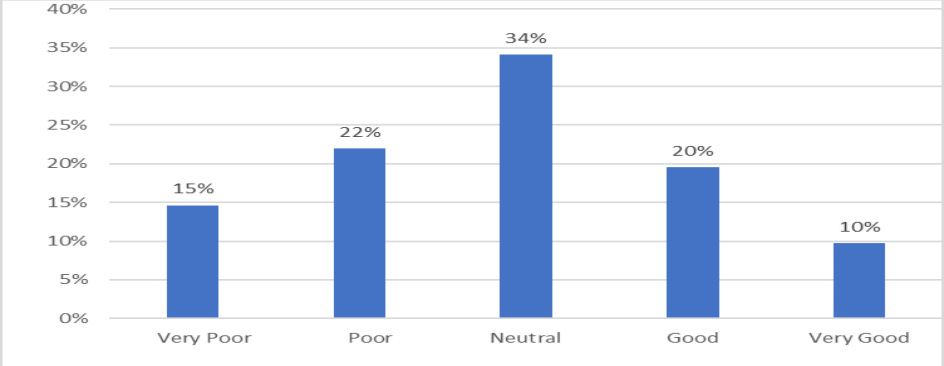


Figure 1: Self-assessment of Digital Competencies for Distance Learning

Description of response categories for the question "How do you assess your digital competencies related to distance learning?" on a scale from "very poor" to "very good":

- Very Poor: The participant feels their digital competencies in the context of distance learning are very low, experiencing difficulties with educational tools, e-learning platforms, online communication, or other related technologies.
- Poor: The participant rates their digital skills as low, managing basic functions but lacking confidence in using advanced features, possibly requiring additional support or training.
- Neutral: The participant is unsure about their digital competencies, possibly due to limited experience with online learning.
- Good: The participant feels competent in using educational tools, e-learning platforms, and managing digital learning materials effectively.
- Very Good: The participant possesses high digital skills, efficiently using advanced features of educational technologies and managing their learning process innovatively.

Subsequently, challenges faced during distance learning were examined using a five-point Likert scale ranging from strongly disagree to strongly agree (RQ1). Table 2 presents the mean scores for various challenges associated with distance learning.

Table 2: Challenges in Distance Learning

Challenge	Mean	Standard Deviation
Motivation for self-directed learning	3,1512	1,35095
Working at one's own place	2,4829	1,41627
Time management	3,1854	1,18188
Technical difficulties	2,9366	1,33610
Limited contact with lecturers	3,1317	1,46100
Maintaining concentration	2,6244	1,40391
Accessibility of educational materials	3,1561	1,43998
Difficulties in assessing progress	3,7317	1,23321
Feeling overwhelmed	2,4341	1,28407
Lack of direct contact with peers	3,5317	1,31925
Difficulty separating study and rest time	1,9805	1,07540

High standard deviation for "limited contact with lecturers" suggests varied experiences among students, while lower variability for "difficulty separating study and rest time" indicates more consistent opinions.

The study also assessed students' motivation for self-directed learning, with responses summarised in Table 3.

Table 3: Motivation for Self-Directed Learning

Response	Frequency	Percentage
Strongly Disagree	32	15,6
Disagree	37	18,0
Neutral	44	21,5
Agree	52	25,4
Strongly Agree	40	19,5
Total	205	100,0

Over one-third of respondents reported difficulties with motivation for self-directed learning, potentially due to lack of support, organizational challenges, or low engagement with online teaching. Nearly a quarter were undecided, suggesting variable motivation influenced by study conditions, course content, or institutional support. Almost half expressed motivation for self-directed learning, indicating that many students adapt well to this teaching mode despite challenges.

The study tested the hypothesis (H1) that motivation for self-directed learning varies significantly across different study levels. ANOVA results (Table 5) showed a significant difference ($p < 0.001$), leading to the rejection of the null hypothesis. This indicates that motivation levels differ among students at various study stages.

Table 5: ANOVA Results for Motivation by Study Level

	Sum of Squares	df	Mean Square	F	Significance
Study Level	35,600	4	8,900	5,286	<,001

The significance value ($p < 0.001$) is much smaller than the standard significance level (0.05), so we reject the null hypothesis. This means that there are statistically significant differences in the level of motivation for self-directed learning between students at different levels of study. The results suggest that motivation for learning is not uniform across different levels of study. According to the cross-table (Table 6), full-time engineering students demonstrated the highest motivation for self-directed learning. Part-time bachelor's students (SN) also showed relatively high motivation. The largest lack of motivation was found among master's students, which may indicate a need for intervention to increase their engagement. Both engineering (ST) and master's students showed the largest group of "undecided" individuals, suggesting that their motivation may be variable and dependent on various factors.

Table 6: Do you have motivation to study?

Motivation	Study Level					Total
	1	2	3	4	5	
Strongly Disagree	4	1	8	2	17	32
Disagree	0	1	6	3	27	37
Neutral	0	3	11	5	25	44
Agree	0	3	19	5	25	52
Strongly Agree	1	9	14	4	12	40
Total	5	17	58	19	106	205

Explanation of table: 1 = Full-time Bachelor's, 2 = Part-time Bachelor's, 3 = Full-time Engineering, 4 = Part-time Engineering, 5 = Master's

In order to answer the research question RQ2: Are there any connections between students' motivation and their gender?, an analysis of variance (ANOVA) was conducted, the results of which are presented in Table 7. The research hypothesis H2, which assumed the existence of significant differences in the level of motivation for independent learning depending on gender, was verified.

Table 7: ANOVA Results for Motivation by Gender

	Sum of Squares	df	Mean Square	F	Significance
Gender	0,115	1	0,115	0,063	0,802

Based on the presented ANOVA analysis results table, there is no statistically significant difference in motivation between genders. Therefore, there is no basis to claim that motivation depends on gender. The p value (0.802) significantly exceeds the assumed level of significance (e.g. $\alpha = 0.05$), which means there is no basis to reject the null hypothesis. Therefore, the existence of a relationship between students' motivation and their gender was not confirmed. Hypothesis H2 was not confirmed by the results of the study.

5. Conclusions

Analysis of the presented data identifies key challenges faced by students during remote learning. Difficulties in assessing progress (3.73) and the lack of direct contact with peers (3.53) are among the most significant issues. This highlights challenges in monitoring personal development and limited opportunities for social interaction, which can negatively impact motivation and self-discipline. The variability in results points to the need for individualized support and improvements in remote teaching methods.

Nearly 45% of students report having motivation for independent study, while a significant group (21.5%) remains undecided, suggesting external factors may influence their motivation, such as the quality of educational materials, teaching methods, and interaction with instructors. Approximately one-third of respondents face challenges in self-motivated learning, indicating a need for additional support, such as better access to educational resources, motivational strategies, and mentoring.

There is a correlation between the type of study program and motivation for independent learning. Full-time engineering students exhibit the highest motivation, while master's students show the most negative responses, potentially due to academic burnout, lack of challenges, or increased external responsibilities. No significant relationship was found between motivation and gender.

To enhance motivation for distance learning, several recommendations can be considered:

- Quality of Educational Materials: Implement interactive resources such as short videos, quizzes, and simulations. Organize online courses with clear structures to facilitate easier comprehension. Offer diverse learning formats, including independent work, group consultations, and practical exercises.
- Extracurricular Support: Conduct workshops on effective study techniques, self-discipline, and motivational strategies. Encourage students to adopt planning methods to manage their studies effectively.
- Enhancing Interactions: Establish regular online meetings with instructors, such as Q&A sessions or individual mentoring. Create virtual study groups to foster peer motivation and support. Introduce gamification elements, like leaderboards and activity-based contests, to increase engagement.
- Assessment Methods: Consider replacing traditional tests with practical projects and problem-solving tasks that actively involve students. Provide clear guidelines on academic progress to help students understand their current standing. Offer constructive feedback to boost student engagement in the learning process.

In summary, while a substantial portion of students are motivated for independent study, many face challenges that require targeted interventions. Improving the quality of educational materials, providing robust support for study management, enhancing interactions with educators and peers, and refining assessment methods are crucial steps toward fostering a more effective and motivating learning environment.

6. Summary

The conducted study has certain limitations. First, it is based on data collected from the Czestochowa University of Technology in Poland, which may limit the generalizability of the proposed quantitative analysis method. To confirm its universality, further research on various educational platforms and at other higher education institutions is necessary.

Moreover, while the study takes into account students' educational behaviors and demographic data, it does not consider other factors influencing motivation to learn, such as emotional states or external factors. To gain a more comprehensive understanding of student motivation, future research should include these additional elements.

AI can motivate students to learn. AI can adapt materials and pace of learning to the individual needs of the student, which increases self-efficacy – a key factor of motivation. Thanks to quick feedback, students can see progress more quickly, which strengthens intrinsic motivation. Many AI applications use game mechanisms, which increase engagement and motivation to continue learning. Students can independently explore content and choose what they learn, which promotes autonomous motivation. Generative AI (gen AI) has revolutionized the workplace by enabling professionals to do high-quality work in less time, according to research published in Harvard Business Review (2025). Whether it's developing a performance review, brainstorming a new session, or crafting a marketing email, people working with gen AI produce results that are both more efficient and often of higher quality. But our research reveals a hidden tradeoff: While gen AI collaboration increases immediate task efficiency, it can undermine employees' intrinsic motivation and increase boredom when they turn to tasks for which they don't have this technological help. The dependence of AI on motivation may be an interesting topic for further research on student motivation to learn.

In the future, it would be valuable to focus on developing personalized intervention strategies tailored to different motivational types, conduct longitudinal studies monitoring changes in motivation over time, expand the analysis with additional demographic data, and develop analytical tools that enable real-time feedback and interventions. Studying alternative motivational theories and testing the scalability of motivation indicators in different educational environments will enhance our understanding of student motivation and improve personalized teaching methods.

Ethics declaration: Ethical clearance was not required for the research

AI declaration: AI tools were not used the creation of the paper

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Preserving Knowledge and Culture: Exploring the Relationship Between Intellectual Capital and Intangible Cultural Heritage

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Abstract: This paper explores the relationship between intellectual capital and intangible cultural heritage, two interconnected yet distinct concepts. Intellectual capital refers to the intangible assets of organizations, encompassing human capital, structural capital, and relational capital, where IC contribute to value creation and competitive advantage. In contrast, intangible cultural heritage represents the collective cultural expressions, traditions, and knowledge passed down through generations within communities. While intangible cultural heritage may be considered a form of intellectual capital in a broader sense, key distinctions exist in terms of ownership, purpose, evolution, and protection mechanisms. Intellectual capital is typically owned by organizations and protected by intellectual property rights, whereas intangible cultural heritage belongs to communities and is characterized by its dynamic and evolving nature. Despite these differences, both concepts share common ground in knowledge preservation, value creation, and innovation. The study further examines the fields in which intangible cultural heritage is part of intellectual capital and the intersections where intangible cultural heritage could contribute to cultural capital and economic benefits, using Latvia's national intangible cultural heritage list and Upīte cultural space as a case study. In order to achieve this, a literature analysis will be conducted beforehand. By highlighting these distinctions and synergies, this paper underscores the need for nuanced approaches to the preservation and utilization of both intellectual capital and intangible cultural heritage.

Keywords: Intellectual capital, Intangible cultural heritage

1. Introduction

In academic discourse, the terms intellectual capital and intangible cultural heritage are not often discussed side by side. The significance of this paper lies in the fact that each year, an increasing number of intangible cultural heritage elements are added to national and international UNESCO lists. This trend indicates that we are continuously acquiring knowledge that can later be applied across various fields. As the topic of intangible cultural heritage is relatively new, there is still a limited amount of academic research available. However, existing studies suggest that this is a field that warrants further exploration. A major milestone in researching intangible cultural heritage from the perspective of intellectual property occurred in 2017, with the publication of the book Intellectual Property, Cultural Property and Intangible Cultural Heritage by Christoph Antons and William Logan. This work demonstrated that only more than a decade after the adoption of the UNESCO Convention for the Safeguarding of the Intangible Cultural Heritage did scholars begin to explore the interconnection between intellectual property, intellectual capital, and intangible heritage. Several important questions arise in these discussions: What regulations govern heritage and indigenous rights? How are these concepts perceived by governments, as well as by indigenous and local communities around the world? Therefore, this paper aims to examine both terms—intellectual capital and intangible cultural heritage—and explore their points of connection and divergence. It should be noted that in academic literature, intangible cultural heritage is often related to concepts such as intellectual property rights and human capital. However, since intellectual capital is an umbrella term that encompasses all these aspects, it will be used throughout this paper as the primary analytical framework. The object of this research is knowledge and culture, while the subject is the relationship between intellectual capital and intangible cultural heritage.

2. Theoretical Background

The topicality of intellectual capital has been embraced by most organizations worldwide. Intellectual capital plays a fundamental role within modern organizations and is part of the foundation of business in the 21st century (Hsu & Wang 2010). Spica et al. (2024) states that intellectual capital is an economic category, the spiritual value created by human potential, and it can be accumulated and converted into the value of other capitals. By investigating certain information about the management of education, we can increase the capacity and significance of a country's total economic capital movement. Other scholars assert that intellectual capital "is considered an intangible resource for an organization and must be included in determining organizational performance and sustained competitive advantage." (Rehman *et* al. 2021). At first glance, intellectual capital and intangible cultural heritage may appear to be unrelated concepts. However, this paper aims to explore their common characteristics and key differences, in order to understand how intangible cultural heritage might contribute to broader development and potentially gain economic value.

Intangible cultural heritage is often described as a "living heritage", namely, something that is still developing and is complicated to record because that would mean that this heritage is no longer alive. Intangible cultural heritage includes practices, representations, expressions, knowledge, skills, and various cultural elements that communities, groups, and individuals identify as part of their heritage. This heritage passed down from generation to generation, is constantly evolving and plays a crucial role in fostering cultural diversity, human creativity, and a sense of identity and continuity (Lenzerini 2011, Blake 2011).

It is essential to look back at the starting point from which the idea of safeguarding intangible cultural heritage emerged. As (Dewi *et* al. 2025) state it was mainly from the recognition that cultural heritage is not limited to material products of arts and architecture, but also involves, inter alia, knowledge, skills and practices that are passed down through generations. The reason why it is important to talk about intellectual capital and intangible cultural heritage is that similar to intellectual property protection intellectual capital refers to protecting intangible cultural heritage by incorporating it into intellectual property rights (Peng 2021). Intangible cultural heritage is also seen and understood as "a valuable cultural information resource of human society." (Hu *et* al. 2024) Safeguarding and promoting intangible cultural heritage is closely linked to the rights of the communities that hold it, as well as to their intellectual capital, which—through inscription on the national list—gains recognition not only as a philosophical value but also as one of economic importance.

One of the main factors that influenced its importance, according to Sullivan (2000), was "the spread of the Internet and information technologies. High-speed Internet use is associated with the dissemination speed of information. In the production era, the main source of value was given by the raw material resources, but in an information era intangible assets are more valuable than tangible assets." (Sullivan 2000) and it still plays a role today. Regarding intangible cultural heritage, once an element is accepted onto the national list, it also becomes available digitally—through videos, information, and photos—providing a more detailed view of why and how the intangible cultural heritage is maintained and practiced.

3. Methodology

In order to achieve the aim of this paper the following methodology was used:

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The following tasks were stated:

1. To conduct a theoretical exploration of intellectual capital and intangible cultural heritage in the context of knowledge and culture;
2. To examine the practical aspects of the interaction between intellectual capital and intangible cultural heritage in the context of knowledge and culture;
3. To carry out a case study on the interaction between intellectual capital and intangible cultural heritage.

The following theoretical research methods were used: referential analysis of scientific literature on knowledge, culture, intellectual capital, and intangible cultural heritage; and on the exploration of the interaction between intellectual capital and intangible cultural heritage in the context of knowledge and culture. It should be noted that this is a pilot study – small scale research in order to test and refine the approach for continuous research in the future. Empirical methods used in this pilot study were observation aimed at studying the mutual influence between intellectual capital and intangible cultural heritage; content analysis and interviews with an official from a non-governmental institution in Latvia; content analysis and interview with a representative of "Upīte Intangible Cultural Heritage Center" in Latvia; analysis of documents regulating intangible cultural heritage in Latvia; comparative analysis of intellectual capital and intangible cultural heritage from the perspective of knowledge and culture in Latvia; study of data from public and non-governmental institutions in Latvia. The research basis were the key features of intellectual capital and intangible cultural heritage in the context of knowledge and culture; exploration of the interaction between IC and ICH in the context of knowledge and culture in Latvia; an interview conducted by the author on the interaction between IC and ICH with a representative from "Upīte Intangible Cultural Heritage Center". Research Period – Theoretical exploration of the period from 2000 to 2025; observations during the period from October 2024 to March 2025; interview period March 2025.

4. Case study: Upīte's Cultural Space

This paper analyzes a case study of Latvia's National Intangible Cultural Heritage List. As of March 2025, the list includes 40 inscriptions, primarily showcasing the diversity of specific cultural spaces, such as the Piebalga Cultural Space, Bārta Cultural Space, and Vidzeme Livonian Cultural Space. This highlights that Latvia's national list covers a broad spectrum of cultural practices present in the region. On one hand, this demonstrates the uniqueness of these communities and their ability to preserve a rich variety of cultural artifacts and living traditions. On the other hand, it creates a situation where someone unfamiliar with the field may recognize that such a place exists, but it takes significantly more effort to fully grasp the meaning and depth of that cultural space. While it is beneficial for the cultural space to have the opportunity to present everything from the region as special and worthy of inclusion, the list does not always clearly communicate what the unique trait of each particular community is. To truly understand this, one must show genuine interest in the specific inscription.

One of the most active communities inscribed in the National Intangible Cultural Heritage List is the Upīte Cultural Space. Upīte is a small village located 249.7 km from Riga, the capital of Latvia, and only 3 km from the country's border with the Russian Federation. Due to its geographical location, limited job opportunities, and the fact that it can only be reached by car (public transportation is available but insufficient), the village faces significant challenges in being a competitive place for comfortable living. Nevertheless, thanks to its active community dedicated to preserving intangible cultural heritage, Upīte has gained visibility on social media and in national mass media. This renewed attention has revitalized the region, which now hosts several large concerts, local activities, heritage preservation projects, and even music festivals featuring well-known local artists and public officials. The community has also established the Upīte Intangible Cultural Heritage Center, which is responsible for coordinating intangible heritage activities in the region.

An expert interview with a representative of the Cultural Heritage Center was conducted in March 2025. The selected expert was Andris Slišāns, the main activist and leader of the Upīte Cultural Space and its community. Andris Slišāns has a long history of contributing to his community, as his father, Antons Slišāns, was a poet, folklorist, publicist, and cultural worker who was highly active in the region during the second half of the 20th century until his death in 2010. The interview was conducted in writing and the first interview question was "Does the inclusion of Upīte's cultural space in the list contribute not only to the promotion of your intellectual knowledge and skills but also to a financial contribution to the cultural space?". Andris Slišāns stated, "The inclusion of Upīte's cultural space in the list of intangible cultural heritage gave us the feeling that great work has been recognized and was not in vain." He added that "because of this inscription for the past 4 years, the Latvian Cultural Capital Fund has had a special program for the values from the intangible cultural heritage list, which can attract funding for community capacity building, research, and various activities that are important to us."

This case study highlights the importance of recognizing such communities on the National Intangible Cultural Heritage List. Inclusion provides them with access to a broader range of resources that can support the preservation of their heritage, culture, and, consequently, their intellectual capital. In this case, the community was able to monetize that capital to promote further development of both their heritage and the region. Recognition on the list not only helps preserve their traditions but also enables ongoing work with their intellectual capital. This interconnection offers a new perspective on how we perceive intangible cultural heritage. It shows that the intangible cultural heritage and intellectual capital are very likely linked concepts because "the fortunes and values of organizations, industry sectors, and regions can increase or decrease depending on how well they create, capture, and leverage their local knowledge" (Rusu-Tanasa 2015) and as "these economies evolve, there is a need to create and maintain networks of knowledge, to combine knowledge theory and business practice, to strengthen the cooperation between two different environments" (Romano et al. 2025). This also is important for the intangible cultural heritage, because it underlines the importance of how we can create an opportunity to cooperate with intangible cultural heritage and give it a chance to make some profit. Especially for such small regions, it is crucial that through such practices they are not only able to maintain their heritage but also able to make some profit. Even one concert or one event has an impact on society as such.

5. Discussion

To discuss intellectual capital and intangible cultural heritage, it is essential to begin with the fact that, like knowledge and skills in other sectors, intangible cultural heritage also needs to be protected from being restricted to the wider public due to the possible privatization of this knowledge. Deacon and Smeets mention

that "the relationship between IP rights protection and intangible cultural heritage safeguarding under this UNESCO Convention for the Safeguarding of Intangible Cultural Heritage (UNESCO 2003a), has not received much specific attention. (Deacon & Smeets 2018). Therefore, further research in this field is needed. As Yan and Li (2021) point out, the current intellectual property rights system has significant limitations in protecting traditional crafts, and its revision regarding these crafts needs to be more scientific and feasible (Yan & Li 2021). This is one of the main reasons why researchers acknowledge that greater precision is needed in defining the legal protection of intangible cultural heritage elements, as this would also make it possible to strengthen legal recognition in wider society (Hu *et* al. 2024). This is a problem that is similar to intellectual capital and its legal protection. When discussing intellectual property that intellectual capital is part of, it should be mentioned that "conventional intellectual property rights regimes, such as copyright, patents, and design protection, offer time-limited protection to the authors of original creations or new inventions. They cannot therefore easily be used to protect cultural expressions whose authors are unknown, and which have been passed down through generations, changing and adapting to new contexts." (Deacon & Smeets 2018). Resources that are valuable, rare, and impossible to copy or replace are the source of long-lasting competitive advantage (Kozak 2011). This is seen as intellectual capital, but we can also consider intangible cultural heritage as an advantage in international competition.

The interconnection and importance of both these terms are closely linked to the understanding of intellectual capital as a part of intangible cultural heritage and the other way around. Not only because nowadays we see the high demand for intangible resources, for instance, multi-skilled employees, well-handled customers, and societal relationships that are a driving force for organizations (Karol Jan Borowiecki 2016), but also because the communities of intangible cultural heritage build organizations based on their skills and knowledge and therefore work with intangible cultural heritage. It must be noted that according to Borowiecki, Forbes, and Fresa (2016), intellectual capital has "an influence on the organizations, regions and nations alike" (Borowiecki, Forbes & Fresa 2016). This means that also intangible cultural heritage is influenced by intellectual capital and should be recognized as an essential part of knowledge and skills that are usually connected to intellectual capital as something that brings profit, not only as intangible cultural heritage that needs financial support from the state to preserve it.

An important common characteristic of intangible cultural heritage and intellectual capital is that both concepts share the way knowledge is transmitted. "The importance of intangible cultural heritage refers to the wealth of knowledge and skills that is transmitted from one generation to the next ones" (Petronela 2016). Scholars note that intangible cultural heritage is a kind of "human-based cultural transmission, which is the shaping of people's morality, character, sentiment, will, ideals and beliefs, value orientation, humanistic cultivation, artistic taste, way of thinking, wisdom, and ability in the practice of production and life of various ethnic groups." (Zhao *et* al. 2022). Another aspect worth mentioning is that the term intellectual capital itself consists of an idea of capital. Therefore, it is seen as something that one is able to monetize and use to enhance an organization, a region, or a nation. The intangible cultural heritage, on the other hand, is not at first seen like this, because it consists of values that are learned by a certain community and therefore it is seen as something that needs resources, not as something that is able to create resources and profit. Nevertheless, the preservation of intangible cultural heritage should be seen as a long-term investment and the possibility to develop regions that hold intangible cultural heritage values recognized by the state or internationally.

The main difference that should be noted when discussing intellectual capital and intangible cultural heritage is that intellectual capital is seen as a more individual term, meaning something that refers to an individual, which is this organization or person's individual property and knowledge. This makes the comparison of such two terms complicated. The individualistic nature of this concept is however more applicable to Western societies that have been described as individualistic societies already since the 1980s, starting with Dutch social psychologist Geert Hofstede (Hofstede 2001) whose works about individualism versus collectivism have later been discussed in scientific discourse by many other scholars. The collective and individual nature of a nation is important when we discuss the concepts of intangible cultural heritage and intellectual capital. The collective and individual approach of society as such has a huge influence on the perception not only of the way intellectual capital works but also on the way it influences how the intangible cultural heritage is seen in the group. It is possible to also look at how the intangible cultural heritage is influenced by the collectivistic or individualistic nature of a nation. The main aspect that should be underlined is indicated in the core of how intangible cultural heritage is created. The intangible cultural heritage is seen as something heavily influenced by the collective idea because intangible cultural heritage needs a community for it to be maintained. Nevertheless, also intellectual capital needs at least two individuals for the transmission of the knowledge gained. Even if it is possible to underline the main

difference between intellectual capital and intangible cultural heritage, mainly the lack of a community, it still allows us to recognize the similarities which are mainly the transmission of knowledge. It is also important to involve the relationship between intellectual capital and the nation because that has a direct link to the intangible cultural heritage. After all, on the national list, also a nation's perception of intangible cultural heritage is represented and seen. Author Rusu-Tanasa's (2015) debate about the intellectual capital of a nation (or a region of nations) requires the articulation of a system of variables that helps uncover and manage the invisible wealth of a country. It is important to mention that "knowledge is considered a basic resource for value creation both at the corporate and regional level therefore the European Union's countries and regions try to promote/use regional and national innovation strategies to achieve the Lisbon aim to make the European economy the most competitive knowledge-based economy in the world." (Petronela 2016)

The intellectual capital of a nation (or a region of a nation) requires the articulation of a system of variables that helps to uncover and manage the invisible wealth of a country. Knowledge is considered a basic resource for value creation both at the corporate and regional levels. (Rusu-Tanasa 2015).

6. Conclusions

Intellectual capital and intangible cultural heritage are interconnected terms that share the same idea: 1. Intangible knowledge transmitted to the next generation or community, or in the case of intellectual capital to the further organization members; 2. Both concepts have assets that are seen as important and valuable, for instance, the specific knowledge and skills needed to contribute to the organization's wealth or for intangible cultural heritage the ability to learn the skills and knowledge in order to pass this knowledge to the community members. The main differences are: 1. The different perceptions of intellectual capital and intangible cultural heritage – intellectual capital is always seen as something that might contribute and should contribute to an organization's economic development, whereas intangible cultural heritage is seen as something that requires resources. Regarding the case study of Upīte's cultural district, it would be important not to forget that admitting intangible cultural heritage elements to the national list not only gives acknowledgment to the community but also an opportunity to gain significant financial support from the state. 2. The main difference is that because intangible cultural heritage is perceived as something that is owned by a community and recognized as something important by the state it entitles different perceptions of its legal protection, because intangible cultural heritage is not owned by an individual, but a community. This is not the case with intellectual capital, where we see that intellectual capital is seen as something that is owned by an individual or organization, but on the other hand, needs to be shared further. So, this is another important common issue that even though the intellectual capital is individual, it is still perceived as something that needs to be passed on to the next co-workers, team, or organization.

It must be concluded that both intellectual capital and intangible cultural heritage consist of such resources. Therefore, the role of intangible cultural heritage in the field of intellectual capital, and intellectual capital in the field of intangible cultural heritage, should not be undermined but taken seriously. Intangible cultural heritage should be seen as an asset that can bring economic profit to a community, region, or even a state, in the same way as intellectual capital does. Further research is needed to continue exploring the relationships between these two terms and to examine more case studies on how each intangible cultural heritage element has evolved since being inscribed on the list. Further research could also focus, for instance, on craft fair markets that certainly generate profits, but still rely on the knowledge gained from intangible cultural heritage.

Ethical Declaration: The author declares that there are no ethical issues related to the research presented in this paper.

AI Declaration: The author declares that no significant AI tools or technologies were used in the conduct of the research for this paper.

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Collective Knowledge Formation as a Dynamic Capability in Local Government

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Abstract: This article explores collective knowledge formation that supports socio-financial sustainability in local governments. The study aims to complement rationalistic and business-oriented knowledge management research by examining the social processes through which information is collected, interpreted, shared, and utilized. It addresses criticisms of knowledge management for its excessive internal focus, tackling tame organizational problems, and prioritizing data over meaning. In the context of local governance, characterized by complexity, hybridity, and a strong commitment to sustainability objectives, understanding factors that support collective knowledge formation is crucial for enhancing shared understanding of sustainability. The article applies the knowledge formation framework to analyze empirical data from three development workshops conducted in two Finnish cities. Preliminary findings suggest that leadership dialogue, which integrates political, strategic, and operational perspectives, can serve as an arena for collective knowledge formation. The findings also emphasize the importance of a shared knowledge base, recognition of core values, and a thorough understanding of organizational operations as enablers of effective knowledge formation processes. Additionally, these processes must occur at various organizational levels to effectively support the sustainability transition.

Keywords: Knowledge management, Knowledge formation, Public sector, Sustainability

1. Introduction

Local governments play a crucial role in promoting sustainability (Guarini, Mori and Zuffada, 2022). While sustainability has been increasingly explored in public management research, particularly in relation to the UN's sustainability goals and sustainability reporting, a gap remains in understanding how sustainability is institutionalized and how new goals impact managerial practices (Zeemering, 2018; Sinervo et al, 2024; Sinervo and Laihonen, 2024). This article argues that building a socially and financially sustainable local government requires reconciling diverse perspectives and goals. This process calls for dialogue and collective knowledge formation, where different viewpoints are negotiated and prioritized. The purpose of this article is to enhance the understanding of the factors that support the processes of knowledge formation involved in implementing socio-financial sustainability strategies in public management.

This article aims to complement the rationalistic and business-oriented KM research by examining the social process of knowledge formation, where information is collected, interpreted, shared, and utilized (Laihonen, Kork and Sinervo, 2023). In this way, the article aims to address the criticism faced by KM, particularly concerning its excessive internal focus (e.g., Kraaijenbrink, Spender and Groen, 2010), prioritizing data over meaning (Spender, 2014), and focusing on tame organizational problems (Dumay, 2020). Moreover, KM research in the public sector has been criticized for insufficient attention to the political-administrative nature of public organizations, the interaction in public policy implementation, and the complexities associated with defining and utilizing knowledge across administrative sectors and among public officials (Laihonen, Kork and Sinervo, 2023). There is thus a clear need to better exploit and understand KM within public administration (cf. Agrifoglio, Metallo and DiNauta, 2021).

We are particularly interested in identifying and understanding the intangible factors that enable collective knowledge formation in managing socio-financial sustainability. Specifically, we explore the antecedents, moderators, and consequences of knowledge formation. By analyzing how public managers discuss and interpret social and financial sustainability, we aim to contribute to the existing literature on knowledge management capabilities. This literature has primarily focused on an information science perspective, defining KM capability as an organization's technical proficiency in utilizing, generating, and safeguarding knowledge (e.g., Gold, Malhotra and Segars, 2001; Tseng and Lee, 2012). KM capabilities that build on intangible resources, such as individual experts' skills, internal and external networks, organizational practices, and cultural aspects, have received less attention (Laihonen and Mäntylä, 2018; Laihonen and Saranto, 2022), even though leveraging

these intangible resources may provide a more significant competitive advantage than relying on easily transferable tangible resources (cf. Hall, 1993).

The rest of the paper is organized as follows: The next section reviews the theoretical background of knowledge formation and capabilities. Section three outlines the study's empirical context and methods. Section four presents the empirical results, and finally, section five offers concluding remarks.

2. Theoretical Background

2.1 Knowledge Formation in Public Administration

Knowledge Management (KM) has diverse origins, including resource-based and knowledge-based perspectives. Despite their foundational role, these approaches have faced criticism for being overly focused internally and lacking clear definitions of resource value. This criticism also extends to KM, which has evolved from these theories. Spender (2014) highlighted that KM literature often prioritizes data over meaning. More recently, Dumay (2020) noted that KM tends to address straightforward organizational issues. Hujala and Laihonen (2021) added that the emphasis on organizational efficiency overlooks other essential aspects of performance, including quality, effectiveness, and sustainability.

Previous literature reviews on KM in the public sector have shown a strong focus on data production and analysis (Dumay et al, 2015; Massaro, Dumay and Garlatti, 2015). This body of research predominantly adopts models from the business sector, often neglecting the unique characteristics of public administration. Specifically, it has been noted that such research frequently overlooks the political-administrative nature of public organizations, the dynamics of public policy implementation, and the challenges in defining and utilizing knowledge across different administrative sectors and among public officials (Laihonen, Kork and Sinervo, 2023; Laihonen and Pusenius, 2025).

Instead of viewing KM through a rationalistic and business-focused lens, Laihonen et al. (2023) propose approaching KM in public administration as a social process in which information is gathered, interpreted, shared, and used. Their knowledge formation framework illustrates how knowledge is developed in public administration by integrating three perspectives: institutional complexity (Lounsbury et al, 2021; Thornton, Ocasio and Lounsbury, 2012), organizational responses (Greenwood et al, 2011), and individual sensemaking (Weick, 1995).

First, *the institutional complexity*, understood as the collective interpretation of public administration tasks and purposes in the face of various institutional powers (Lounsbury et al, 2021; Thornton, Ocasio and Lounsbury, 2012), has been largely overlooked in KM studies. This is despite the significant impact of regulatory, normative, and cultural factors on knowledge processes within public administration (Currie and Suhomlinova, 2006) and their influence on individual decision-makers. Second, the strategies, structures, and practices of public organizations are viewed as *organizational responses*, serving as methods to manage institutional complexity (Greenwood et al, 2011; Pache and Santos, 2013). These responses have a significant influence on how individuals perceive their environment and shape their perceptions and definitions of organizational success. Third, *individual sensemaking* of decision-makers in public administration plays a crucial role in knowledge formation. Public decision-makers hold legislative, administrative, or juridical positions and, as part of their sensemaking processes, they determine which information is relevant to their decisions (Weick, Sutcliffe and Obstfeld, 2005; Weick, 1995). By responding to institutional demands, they shape their environment and engage in collective knowledge formation, which helps envision future directions and anticipate actions, thereby reducing the complexity of their operating environment (Isabella, 1990).

The framework emphasizes the interaction of individuals' sensemaking processes in developing organizational responses and considering institutional complexity in public sector KM. This framework addresses key gaps in current public sector KM literature by highlighting the social process of knowledge formation, where individual and collective knowledge are continuously shaped through interaction. Knowledge formation is viewed as an iterative process, with policymakers playing a crucial role in interpreting societal issues and utilising information to address complex problems, thereby giving meaning to public policy. This approach helps to understand public policymaking as a social process that reflects institutional complexity and the intertwined nature of social problems and ambiguous solutions.

In the empirical part of the article, we examine how collective knowledge formation takes place in leadership dialogue (Figure 1). Leadership dialogue serves as an arena for knowledge formation on socio-financial sustainability, clarifying the shared situational picture and aligning service needs with resources. By following

the literature on dialogic management, we consider that dialogue fosters knowledge formation through critical self-reflection and collective learning, which involves listening to and understanding others' experiences (Isaacs, 1999; Spender and Strong, 2014). The dialogic perspective on public management combines approaches from strategic dialogue (Bourgoin, Marchessaux and Bencherki, 2018), dialogic accounting (Brown, 2009), and performance dialogue (Moynihan and Pandey, 2010; Laihonen and Mäntylä, 2017). It highlights the social processes where collective knowledge formation occurs and illustrates leadership dialogue as an arena where sustainability information is debated and prioritized.

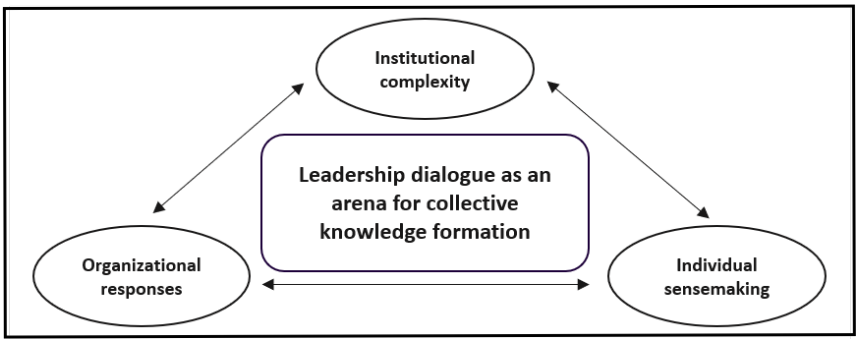


Figure 1: The empirical approach of the study: Leadership dialogue as an arena for collective knowledge formation in public administration (adapted from Laihonen, Kork and Sinervo, 2023)

2.2 Antecedents of Knowledge Formation

The knowledge formation framework lacks an empirical understanding of the antecedents of collective knowledge formation and the capabilities needed from the organization and individuals to support and participate in the process. We approach these prerequisites from a strategic management perspective, referring to capability as an organization's ability to leverage its existing resources through various path-dependent routines to achieve specific goals (e.g., Helfat and Peteraf, 2003). A resource is defined here as an asset that the organization owns or can access (Helfat and Peteraf, 2003). Conversely, a capability is the organization's ability to utilize these resources (Amit and Shoemaker, 1993). Capabilities are formed through the combination of individual and team skills, processes, organizational structures, decision-making rules, and disciplines (Teece, 2007). In addition to effective processes and routines, as well as essential resources, capabilities encompass an understanding of strategic direction. Previous literature on KM capabilities has predominantly focused on the information sciences perspective (e.g., Gold, Malhotra and Segars, 2001; Tseng and Lee, 2012) and lacks an understanding of the role of intangible resources in building organizational capability (Laihonen and Mäntylä, 2018).

Within the hierarchy of capabilities, ordinary capabilities are directed towards the organization's everyday activities, whereas dynamic capabilities modify and create ordinary capabilities, simultaneously transforming the organization (e.g., Helfat and Peteraf, 2003). Dynamic capabilities are defined as a learned and stable pattern of activity through which the organization systematically generates and modifies its routines to improve effectiveness (Zollo and Winter, 2002). The study of dynamic capabilities has evolved within the private sector; however, the definition of dynamic capabilities is also applicable to public sector organizations, as both sectors modify their routines to enhance effectiveness (Piening, 2013). It is also argued that public sector organizations are experiencing more environmental changes than private sector firms, due to frequent policy shifts and the enforcement of short-term perspectives aligned with electoral cycles (Boyne, 2002). Dynamic capabilities are thus recognized as essential for the success of public sector organizations (Piening, 2013).

In this article, we approach collective knowledge formation as a dynamic capability through Teece's (2007) framework, where microfoundations form the basis for an organization’s sensing, seizing, and transforming capacities. These microfoundations can be viewed as best practices, manifested through various skills, routines, structures and processes in different settings. According to Teece (2007), sensing involves an organization's continuous scanning of its environment to identify and collect strategically important information. Seizing refers to the organization's ability to assess the value of the gathered information, convert it into actionable steps, and make informed decisions. Transforming involves the organization's ongoing renewal efforts, which include assigning tasks, allocating resources, and ensuring the workforce possesses the necessary knowledge.

3. Context and Methods of the Empirical Study

To observe how public managers discuss and interpret social and financial sustainability, and to explore the factors that support collective knowledge formation, we adopted a qualitative case study approach (Eisenhardt, 1989; Gummesson, 2000; Yin, 2009). In practice, we conducted three development workshops in two Finnish cities, involving participants from early childhood education, basic education, and various management and expert roles in finance, catering, cleaning, and property services. This research design aimed to capture how public managers developed a shared understanding of socio-financial sustainability.

The workshops in both cities lasted three to four hours. During these sessions, researchers initiated discussions with research-based perspectives and then facilitated various group activities to generate empirical data, which were later supplemented with researchers' notes and observations. Four researchers participated in each workshop, except for the first one, which had only two researchers present. This enabled researcher triangulation, enhancing the reliability and validity of the findings (Patton, 1999). The data were analyzed using data-driven thematic analysis (cf. Braun and Clarke, 2006). However, it is essential to note that, since each workshop began with an introduction by the researchers, the process was not entirely inductive. The analysis involved carefully reading the data and summarizing the initial sub-themes from individual observations. These sub-themes were then further developed into central themes, which were subsequently compared with the existing literature on the topic, ultimately leading to the identification of factors supporting collective knowledge formation.

4. Results

4.1 Main Challenges and Solutions for Collective Knowledge Formation

To identify factors that contribute to successful dialogue and knowledge formation on socio-financial sustainability, we asked workshop participants to first list the challenges in integrating the operations and finances of early childhood and basic education. They then proposed solutions to these challenges. After documenting these problem-solution pairs, participants identified the factors that support effective dialogue on socio-financial sustainability.

During the analysis, we classified the identified problem-solution pairs into three categories. The first category included issues and solutions related to general management. The second category addressed specific, everyday management challenges. The third category focused on issues related to dialogue and knowledge formation. Identifying the factors that create a successful dialogue on socio-financial sustainability proved to be surprisingly challenging. While participants were able to compile a long list of problems and some practical solutions, they struggled to articulate the more general factors that contribute to a successful dialogue. Nevertheless, dialogue acts as a mediator between general management concerns and daily challenges. Figure 2 provides a summary of the main challenges and solutions discussed in the workshops.



Challenges of Knowledge Formation	Solutions to Challenges
Lack of staff interaction	Smaller scope, redefining dialogue responsibilities
Lack of time and forums	Developing operational models, shaking up structures, encouraging participation
Insufficient understanding of financial constraints, operations and finances viewed as opposites	Strengthening trustful dialogue to increase mutual understanding
Insufficient awareness of goals	Opening, documenting, and continuously monitoring goals
Impact of values on decision-making process	Open dialogue, recognizing the impact of values
Siloing	Identifying silos, building bridges
Key individuals not involved/recognized	Leader must ensure participation from various parties
Insufficient knowledge base regarding finance	Orientation, clarification of cost factors better
Discussion perceived as hindering decision-making	More responsible outcomes through discussion
Unclear roles and responsibilities	Knowledge and job descriptions must be known
Personal threats related to financial discussions	Open and early dialogue, experience of being heard
Failure to recognize the added value of dialogue	The benefits of the dialogue must be stated

Figure 2: Main challenges and solutions for collective knowledge formation

4.2 Capabilities for Knowledge Formation

In the next phase, we focused on individual capabilities needed for dialogue and knowledge formation on socio-financial sustainability. Building on insights from previous workshops, three key capabilities were identified in both cities. During the workshops, participants worked in small groups to consider concrete ways to harness these capabilities in their management tasks. The overall spirit of the workshops in both cities highlighted that dialogue is fundamental to modern public management, necessitating time, courage, and systematic effort. Recognizing and committing to developing these capabilities together were considered crucial steps towards a sustainable municipal organization.

In the first city, the identified capabilities were: *Understanding one's role in a larger organizational context*, *willingness and courage to engage in dialogue*, and *creating and maintaining models that support dialogue.* Participants agreed that successful dialogue on socio-financial sustainability requires personal engagement, curiosity, and a genuine desire to understand others' perspectives. Clear roles, active communication, guidelines, and peer support were identified as key factors in promoting dialogue and engaging in collective knowledge formation. It was emphasized that open and constructive dialogue necessitates trust, respect, and a sense of social security. Presence and attentive listening were considered essential, and it was stressed that haste should not lead to superficial participation. Participants highlighted that the work community should have clear and transparent frameworks for influence, making work feel meaningful. The third capability focused on organizational structures and models that support dialogue, enabling collective knowledge formation to take place. Prioritizing the ability to facilitate discussion was identified as a prerequisite for successful dialogue, particularly in meetings involving multiple actors. Participants also stressed that dialogue should be seen more as an ongoing operational model, rather than a one-time effort.

In the second city, the identified capabilities were: *Promoting actions aligned with shared values*, *fostering a willingness to find solutions* as a guiding principle for one's activities, and *utilizing a shared knowledge base*. Participants first focused on management practices. The role of supervisors was emphasized in encouraging and guiding dialogue towards a solution, fostering a positive atmosphere, and the acceptance of mistakes. In addition, setting and communicating clear goals, as well as making achievements visible, support progress towards these goals. Collaboration, along with the equitable treatment and clear articulation of shared values, as well as making these shared values visible in practical work, were considered important. The availability and effective use of relevant, timely information, along with the promotion of shared understanding of this information, were considered critical components of decision-making and knowledge formation. Participants also regarded organizational structures and practices that support dialogue and knowledge formation on socio-financial sustainability. Key elements included creating safe spaces where psychological safety fosters genuine presence and effective dialogue. Trust, interaction, and clear rules for dialogue and participation were deemed essential for building these spaces. Additionally, recognizing and selecting appropriate participants for relevant forums was found to be crucial in ascertaining fruitful dialogue. Furthermore, clarity and systematic implementation of organizational strategies should be prioritized to ensure they are achievable in daily work.

4.3 Knowledge Formation in key Phases of Public Management

Finally, we aimed to concretize and operationalize the concept of knowledge formation in public administration by linking it to the key phases of public management—*planning, implementation, and evaluation*—and exploring how dialogue supports and enhances collective knowledge formation in these phases. The workshop discussions revealed that dialogue practices are path-dependent and closely tied to organizational culture.

The importance of dialogue and knowledge formation was highlighted, particularly in synthesizing diverse information, in creating a shared understanding of the situation, and in defining future actions. A comprehensive information base, integrating multiple types of information, such as financial and personnel data, legislation, regulations, norms, staff experiences, and information about children and families, was considered critical for collective knowledge formation. This information should guide both operational plans and budgeting. A continuously updated common operational picture, including tacit knowledge to understand the context behind the numbers, was regarded as invaluable, enabling the systematic advancement of socio-financial sustainability. Participants in both cities emphasised that it is not only about the quantity of information, but also about enhancing the flow of information to ensure that the right information reaches the right people. Here, the crucial role of KM involves producing relevant information and combining data from various sources to support informed decision-making. Participants also emphasized the need to develop improved evaluation and measurement methods, particularly for qualitative indicators, to monitor well-being and the effectiveness of services.

The importance of built-in management structures in all phases of the public management cycle was emphasized. Participants mostly referred to regular meetings where information is discussed and interpreted in collaboration with various experts. However, they also recognized the need for informal gatherings and discussions. It was noted that, especially in multidisciplinary and multiprofessional meetings, patience is often required when building a shared understanding, as each function and individual interprets sustainability goals differently. Indeed, managing socio-financial sustainability necessitates that dialogue takes place at various levels of public management. In the public sector, it is also necessary to acknowledge that political and operational dialogue often overlap. Additionally, it was also discussed how social media has lowered the threshold for participation, bringing politics and citizens closer to everyday service production and public management. This is an essential aspect of dialogic public management and collective knowledge formation, both of which strongly rely on engaging various actors and stakeholders and incorporating their needs and expectations into the discussion. This also relates to another recurring theme discussed in workshops: the role values that always guide dialogue and knowledge formation, whether consciously or unconsciously. Participants strongly emphasized that education services must always strive for the best outcomes for children, and maintaining this core mission should provide a clear guideline for making difficult decisions. Finally, strategies and planning documents were deemed essential for establishing a baseline for dialogue. However, it was noted that strategies often lag behind rapidly changing service needs, highlighting the capability to engage in operational dialogue when strategies do not provide answers to complex questions at hand.

5. Discussion and Concluding Remarks

In this study, we examined how public managers discuss and interpret social and financial sustainability and identified factors that facilitate collective knowledge formation during leadership dialogues in local government. The study enriches the existing KM literature by highlighting its social dimensions and uncovering the factors that support collective knowledge formation in the implementation of sustainability transitions. Our results underscore the importance of dialogue and collective knowledge formation as crucial elements of good governance. These elements foster the creation of public value through open communication and inclusive participation, which are critical for socially responsible and economically viable activities. Trade-offs between social and economic sustainability pose significant challenges for public managers (Zeemering, 2018; Sinervo et al, 2024; Sinervo and Laihonen, 2024). Therefore, it is essential for KM research to explore how it can contribute and assist public managers in navigating resource constraints and increasing service demands.

In this article, we focused on the factors that facilitate collective knowledge formation in public management, a perspective that has not been empirically examined before. Our study examined the process of knowledge formation during leadership dialogues in local government and identified the intangible resources and capabilities required from both organizations and individuals to support and engage in this process. Theoretically, we build on the concepts of knowledge formation (Laihonen, Kork and Sinervo, 2023) and capabilities (Helfat and Peteraf, 2003; Teece, 2007). Table 1 summarizes the identified resources and capabilities for leadership dialogue and collective knowledge formation, highlighting the central role of intangible resources. These resources encompass both organizational and individual aspects. Knowledge formation involves not only individuals and their competences and capabilities, but also requires organizations, specifically leaders and managers, to create enabling conditions for encounters and dialogue between different perspectives. Organizational structures, practices, and culture play crucial roles in facilitating dialogue and collective knowledge formation. On the capabilities side, our data highlights individual capabilities that are perceived as critical for collective knowledge formation.

Table 1: Resources and capabilities for collective knowledge formation

Resources for collective knowledge formation	**Capabilities for collective knowledge formation**
Organizational resources:	*City 1*:
Shared knowledge base	Understanding one's role in a larger organizational context.
Appropriate organizational structures	Willingness and courage to engage in dialogue.
Ongoing operational models for dialogue	Creating and maintaining models that support dialogue.
Open organizational culture	
Clear objectives	*City 2*:
Trust, psychological safety	Promoting actions aligned with shared values.

Resources for collective knowledge formation	Capabilities for collective knowledge formation
Shared values Sufficient time Communication between the siloes Communication across the levels Relevant participants in dialogue *Individual resources* Personal skills and competences Strong leadership skills Motivation for dialogue Communication skills	Fostering a willingness to find solutions. Utilizing a shared knowledge base.

The empirical data support the theoretical argument that dialogue and collective knowledge formation are integral components of modern public management (Laihonen and Mäntylä, 2018; Laihonen, Kork and Sinervo, 2023). Public managers recognized, at least implicitly, that in leadership dialogue, the viewpoints of institutional complexity, organizational responses, and individual sensemaking are present, conveyed, and integrated into the planning, implementation, and evaluation processes of local governments. This empirical finding supports the knowledge formation framework and reinforces our view that leadership dialogue indeed serves as an arena for collective knowledge formation. Leadership dialogue was considered necessary in all key phases of public management to sense the operational environment, seize relevant managerial issues, and transform actions into effective implementation (Teece, 2007). Notably, the emphasis on specific microfoundations supporting these dynamic capabilities varied between phases. Thus, collective knowledge formation can support the adaptation and renewal of public organizations, potentially serving as a dynamic capability of local governments. This opens intriguing research opportunities regarding the role of knowledge management as part of an organization's dynamic capabilities.

Ethics declaration: The ethical clearance was not required for this research. Research permission was obtained, and the study was conducted in accordance with established good scientific practices.

AI declaration: Microsoft 365 Copilot was utilized to improve text quality and clarity by checking grammar and spelling, and rephrasing content.

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AI-Driven Antifragile Knowledge Management System: Transforming ERP Simulated Disruptions into Learning Opportunities

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Abstract: *Purpose*: Enterprise Resource Planning (ERP) systems, such as SAP (Systems, Applications, and Products in Data Processing), are critical to modern enterprises, enabling the integration of core business functions and the management of essential data. Ensuring their availability, reliability, and adaptability is paramount, as disruptions can result in significant operational and financial consequences. Traditional Knowledge Management (KM) approaches emphasize the preservation of ERP-related knowledge but often lack responsiveness to emergent risks. This study introduces a novel framework grounded in the concept of antifragility—where systems grow stronger under stress—by simulating disruptions to enable continuous knowledge evolution and system adaptation. *Methodology:* A mixed-methods research design combines simulation-based inquiry with Design Science Research (DSR) to investigate antifragile KM within ERP environments. Artificial Intelligence (AI) tools are integrated into the KM system to analyse ERP failures, generate runbooks, and proactively manage recovery knowledge. Controlled simulations of kernel upgrades and failure scenarios—modelled on ITIL 4 incident typologies—serve as structured stressors to expose vulnerabilities. Lightweight LLMs, Retrieval-Augmented Generation (RAG) pipelines, and semantic search tools are employed to codify procedural knowledge and enhance the responsiveness of ERP operations. *Findings:* The results demonstrate that embedding antifragile principles into ERP KM improves organizational learning, responsiveness, and recovery capabilities. Transitioning from static knowledge repositories to dynamic, AI-enabled systems allows for autonomous decision-making, decentralized knowledge flow, and adaptive documentation. Each disruption becomes a learning event, reinforcing the resilience and self-improvement of the ERP knowledge ecosystem. *Implications:* Empirical insights suggest that AI-driven antifragile KM transforms ERP disruptions into opportunities for growth, rather than threats to stability. The proposed framework supports the development of systems that not only recover from failure but also become progressively more robust and adaptive through structured experimentation and continuous learning.

Keywords: Antifragility, Knowledge management, ERP, SAP, Artificial intelligence

1. Introduction

In today's rapidly evolving business landscape, organizations are under constant pressure to ensure the continuous availability, reliability, and adaptability of their Enterprise Resource Planning (ERP) systems. ERP systems streamline internal processes, promote data consistency, and enable informed decision-making across departments (Yılmaz Börekçi et al., 2020). However, their complexity and tight integrations across functions make them particularly vulnerable to disruptions and incidents. The advent of Artificial Intelligence (AI) technologies and advances in Knowledge Management (KM) frameworks offer new opportunities to enhance the resilience and intelligence of ERP systems (Jarrahi et al., 2023). More recently, the concept of antifragility, introduced by Nassim Nicholas Taleb, has emerged as a powerful paradigm that goes beyond resilience (Taleb, 2012). Unlike resilient systems that resist shocks and maintain function, antifragile systems improve and learn from disruptions (Taleb and Douady, 2013). This article positions antifragility as a central conceptual lens and explores how the strategic integration of ERP, AI, and KM systems can create the organizational conditions necessary for antifragile behaviours and capabilities to emerge in dynamic and uncertain environments.

2. Literature review

2.1 ERP Systems and Organizational Dependency

ERP systems integrate various business processes into a single unified system, offering a centralized data platform that spans finance, HR, procurement, manufacturing, inventory, and more (Moon, 2007). The main objectives include improving process efficiency, enhancing data accuracy, and reducing operational costs (Jacobs and Whybark, 2000). However, ERP systems are often criticized for their vulnerability during downtime

periods (Prihandono et al., 2024). When such systems become inaccessible due to server issues, version conflicts, or system upgrades, the entire organization may face operational paralysis. Prolonged ERP downtimes can lead to data inconsistencies, decision-making delays, financial loss, and reputational damage.

2.2 ERP Systems as Complex and Wicked Systems

Modern ERP platforms, especially those based on SAP (Systems, Applications, and Products in Data Processing), have become increasingly complex and tightly coupled (Bansal and Negi, 2008). These systems resemble what Rittel and Webber (1973) termed "wicked problems": complex, dynamic issues that defy simple solutions (Crowley and Head, 2017). Misconfigurations in kernel upgrades, mismatches between portal systems and operating environments, and a lack of domain knowledge among system engineers exacerbate the risks. As such, organizations require more than routine resilience measures.

2.3 The Concept of Antifragility

Taleb's (2012) concept of antifragility refers to systems that benefit from disorder. Rather than merely resisting shocks, antifragile systems adapt and grow stronger when exposed to volatility. In organizational contexts, antifragility can be cultivated through proactive exposure to stressors, learning from incidents, and decentralizing knowledge flows (Adobor and Kudonoo, 2025). The progression from fragility to antifragility can be further clarified through visual representations that capture how systems respond to stress over time or under varying degrees of change. As shown in Figures 1, antifragile systems not only withstand shocks but improve and innovate as a direct result of them. While fragile systems tend to break under pressure and robust systems merely resist change, resilient systems recover, but it is the antifragile systems that learn, evolve, and thrive amid volatility.

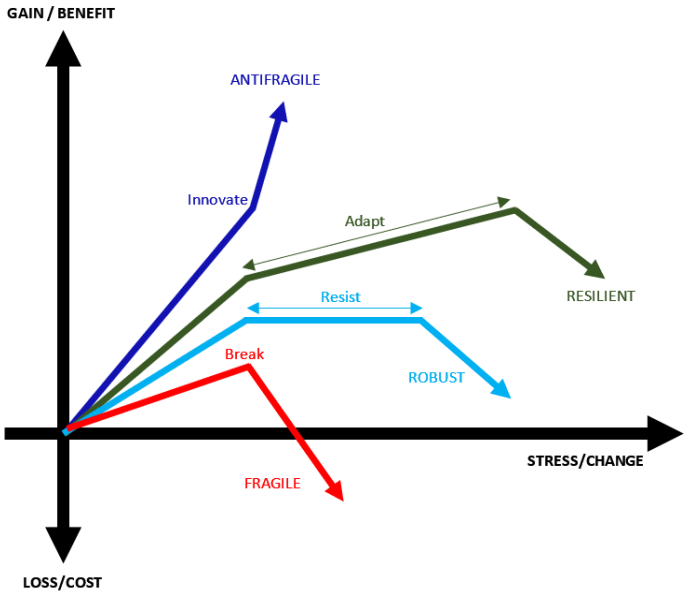


Figure 1: Behaviour of antifragile, resilient, robust and fragile systems. Source: (Tiwari and Bhatt, 2023)

2.3.1 Fragility, robustness, resilience, and antifragility in KM

To understand antifragile KM, it is necessary to contrast it with other modes of organizational behaviour:

- *Fragile KM systems* break under pressure. These systems rely heavily on specific individuals, are overly reliant on rigid procedures, or are not frequently updated. When disruption occurs, knowledge is lost, and processes come to halt (Hillson, 2023).
- *Robust KM systems* endure shocks without adapting. They may include redundancies or fail-safes, but they do not learn from disruption (Dufour and Steane, 2007).
- *Resilient KM systems* recover from setbacks. They absorb the damage and eventually return to their original state. This is often the goal of disaster recovery and continuity planning (Zieba, 2024).
- *Antifragile KM systems*, by contrast, improve through volatility. They learn from failures, adapt processes, update knowledge repositories, and modify organizational behaviours in response to challenges (Taherdoost and Madanchian, 2023).

Table 1 summarizes how different types of KM systems respond to disruption, highlighting the unique characteristics of antifragile KM.

Table 1: KM systems respond to disruption. Source: Authors

System specification	Fragile	Robust	Resilient	Antifragile
Behaviour at disruption	Breaks under stress; loses functionality	Withstands shocks without change	Absorbs impact and restores original state	Gains from stress; adapts and improves performance
Response Mechanism	Collapse or failure; high dependency on stability	Passive resistance; static buffers or redundancies	Active recovery; pre-planned response mechanisms	Dynamic adaptation; real-time learning and self-improvement
Knowledge flow	Disrupted or lost	Preserved but static	Temporarily stalled, then resumed	Enhanced through learning loops and feedback
Organizational learning	None; knowledge loss or erosion	Minimal; learning is not integrated	Moderate; learning after the fact	Continuous; learning is integral to the system's evolution
Adaptability	Rigid; unable to respond to change	Inflexible; designed to resist change	Flexible within predefined limits	Highly adaptive; thrives on variability and experimentation
Examples of KM practices	Unshared expertise; undocumented procedures	Backup systems; static knowledge repositories	Post-incident reviews; business continuity planning	Simulation-based testing; AI-driven scenario generation
Outcome over Time	Degrades	Stagnates	Returns to baseline	Evolves and strengthens

As shown, antifragile KM not only survives disruption but actively benefits from it, turning volatility into a catalyst for learning and continuous improvement.

2.3.2 Core principles of antifragile KM

Antifragile KM is not a product but a mindset, shaped by several interconnected principles:

- Learning from failure: Mistakes, near misses, and failures are rich sources of insight. Antifragile KM systems are built to document, analyse, and learn from these events systematically (Coelho and McClure, 2005).
- Distributed knowledge ownership: Knowledge should not reside in silos or be dependent on single individuals (Miller and Smith, 2012).
- Dynamic documentation: Instead of static knowledge bases, antifragile systems rely on living documents—constantly updated based on emerging insights and new data (Mehta et al., 2023).
- Scenario-based testing: Stress tests and "what-if" scenarios are central to antifragile learning (Cem Kaner, 2013). These simulations force organizations to confront blind spots and discover hidden weaknesses.
- AI and augmentation: AI enhances antifragile KM by identifying patterns, predicting risks, and generating new insights from historical and real-time data.
- Runbooks and institutional memory: Capturing experiential knowledge in clear, structured formats (e.g., runbooks) ensures that learning survives turnover and becomes institutional (Ferrara, 2024).
- Culture of curiosity and adaptation: Ultimately, antifragility is cultural. Organizations must embrace discomfort, value dissent, and reward iterative improvement (Adobor and Kudonoo, 2025).

2.4 KM System and Antifragility

KM plays a vital role in capturing, organizing, and reusing organizational knowledge. Traditional KM systems focus heavily on protecting existing knowledge and ensuring knowledge retention (Adobor and Kudonoo, 2025). However, in volatile environments, static KM approaches are insufficient. By aligning KM with the antifragility concept, organizations can create dynamic learning environments that evolve continuously in response to new experiences and data.

2.5 Integrating AI into KM and ERP Systems

Traditional ERP systems often lack the flexibility to meet rapidly evolving business needs, as they depend on static rules and fixed decision-making structures. With increasing demands for agility and customization, transforming conventional ERP architectures has become essential. AI-powered ERP systems address this need by automating tasks, offering intelligent recommendations, enhancing forecasting, and improving operational efficiency (Goundar et al., 2021). AI also significantly boosts the effectiveness of KM systems by streamlining processes and improving key performance indicators (Taherdoost and Madanchian, 2023). Integrating AI into KM enhances the capture, sharing, and application of knowledge, resulting in greater efficiency, higher-quality content, and increased user engagement.

2.6 Towards a Triadic Model: ERP + AI + KM with Antifragility

While recent studies have explored the integration of AI and KM into ERP systems, most focus narrowly on automation, efficiency, or decision support—often in isolation. Few address how these technologies can be combined to build systems that not only recover from disruption but improve because of it—what Taleb (2012) calls *antifragility*. ERP research typically centres on resilience within fixed recovery frameworks, lacking empirical insight into how systems can evolve under real stress.

This study addresses that gap by experimentally testing an AI-enabled ERP-KM framework based on principles of antifragility. Controlled stressors—simulated disruptions—serve as structured "disaster drills" to expose vulnerabilities, trigger adaptation, and reinforce learning. To ensure realism, disruption scenarios are based on common enterprise IT incidents, classified using the ITIL 4 framework (Agutter, 2020), which categorizes incidents by impact, urgency, and source. This alignment ensures that the antifragile model is not only conceptually sound but operationally relevant. A key exercise involved simulating kernel upgrades under complex configurations. In enterprise systems like SAP, kernel upgrades update the OS core to apply patches or improve performance. However, due to interdependencies across databases, OS, and applications, such upgrades can destabilize systems if not carefully managed (Kaplan and Oehler, 2011).

Focusing on kernel upgrade failures—classified under ITIL 4 as software-related incidents—allowed the study to simulate a high-risk, high-priority scenario. These include OS incompatibilities, application bugs, and misconfigurations. When a crash leads to a major service disruption, it qualifies as a critical event according to ITIL 4, justifying its use for antifragility testing. This classification grounds the experiment in real-world ERP risks and service management standards, enhancing the model's practical relevance.

2.7 Metrics for Evaluating Antifragile Behaviour

Two fundamental characteristics for measuring antifragility in organizational systems are self-organization and adaptation.

- *Self-Organization* (SO) refers to the spontaneous emergence of new structures, behaviors, or patterns within a system through the interaction of internal agents, without centralized control (Adobor and Kudonoo, 2025). This behavior is nonlinear and often unpredictable, yet it enables systems to reorganize and evolve in response to environmental changes.
- *Adaptation* (AD), on the other hand, involves the system's ability to learn from disruptions, experiment, and reconfigure itself to remain functional under new conditions (Adobor and Kudonoo, 2025). It reflects the organization's capacity to evolve through feedback, innovation, and participatory decision-making, particularly in volatile or uncertain environments.

Both characteristics are essential indicators of a system's potential not just to recover from stress but to improve because of it. Taleb (2012) suggests that antifragility can be identified by examining how an organization asymmetrically responds to disorder or crisis. If the impact of stressors leads to disproportionately greater benefits than harms—producing more gains than losses—the system can be considered antifragile. Conversely, if the negative consequences of disruption outweigh the positive outcomes, the organization exhibits fragility.

2.8 Metrics for Evaluating Operational Functionality

To assess the system's ability to recover from disruptions, two widely recognized continuity metrics are employed: Recovery Time Objective (RTO) and Recovery Point Objective (RPO) based on ISO 22301:2019. These measures provide a baseline for evaluating operational resilience in terms of downtime tolerance and acceptable data loss. These two metrics are defined as follows:

- *RTO*: The maximum acceptable time to restore a product, service, or activity after a disruption (Wong and Shi, 2014).
- *RPO*: The point in time to which data must be restored to resume operations (Wong and Shi, 2014).

2.9 Research Question and Research Objectives

To align theory with practice, this study is guided by a central research question integrating ERP systems, AI-driven KM, and antifragility. Based on this, specific research objectives were established to structure the design, simulation, and evaluation processes.

Research Question:

How can AI-driven approaches be used to develop antifragile KM systems that enhance ERP environments by not only coping with uncertainty but also benefiting from operational disruptions?

Research Objectives:

- To develop a conceptual framework that integrates ERP, KM, AI, and antifragility for improving organizational learning and system resilience.
- To simulate critical ERP failure scenarios (e.g., kernel upgrades) and assess the system's response using standardized IT continuity metrics (RTO and RPO).
- To evaluate the role of AI in automating knowledge codification and generating novel failure scenarios that enhance the system's adaptive capacity.
- To measure antifragility in ERP-based KM systems (SO and AD).
- To validate the antifragile KM model through iterative simulations and analyse how ERP systems evolve from fragile or resilient toward antifragile behaviour.

3. Method

This study follows a mixed-methods research design, combining Design Science Research (DSR) and simulation-based inquiry to develop, apply, and validate an antifragile KM framework integrated into an ERP environment. The methodological aim is to bridge theoretical innovation with practical application by iteratively designing and testing a model that enhances organizational learning and system resilience through AI-enhanced KM mechanisms. A kernel upgrade scenario was selected due to its known risk of disrupting ERP operations. Kernel updates were deliberately introduced in a test environment under real-world complexity.

3.1 Conceptual Model Construction

The research began with the development of a conceptual model that integrates four core domains: ERP, KM, AI, and antifragility. This phase reflects the DSR paradigm, which emphasizes the creation and refinement of artifacts (such as models or methods) intended to solve complex, real-world problems. Figure 2 illustrates the conceptual framework developed for this study.

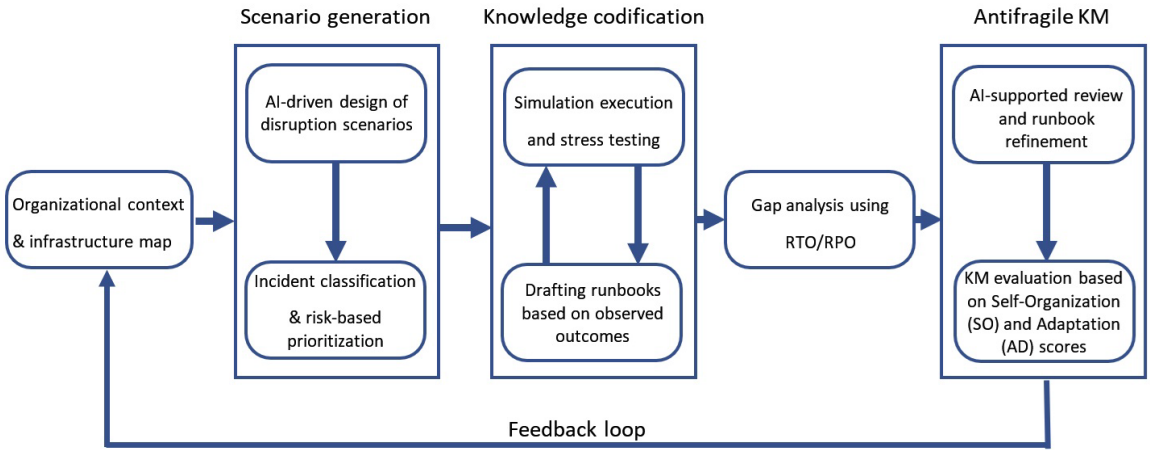


Figure 2: Conceptual model

This model demonstrates how AI-supported knowledge mechanisms, scenario planning, and simulation testing are combined to create an adaptive, learning-focused ERP ecosystem. Key features include:

- Use of AI to suggest new risk scenarios,
- ERP stress testing in a laboratory environment,
- AI-supported knowledge codification (e.g., runbooks),
- Outputs include reduced system downtime, improved knowledge retention, and structured incident prediction.

3.2 Simulation-Based Experimental Validation

The second phase of the research applied a simulation-based inquiry to test and validate the conceptual model in a controlled environment. Simulations were conducted within an SAP ERP system to replicate real-world operational disruptions, with a particular focus on kernel upgrade scenarios, chosen due to their high risk of failure and complexity of system dependency.

3.3 AI-Augmented Scenario Planning and Knowledge Codification

AI played a central role in enhancing documentation by generating structured, accurate runbooks and analysing prior incidents to propose new, ERP-specific stress scenarios. This shifted the approach from reactive incident handling to proactive resilience building. To operationalize this, an AI-based assistant was developed to automate recovery documentation from ERP logs and expert simulations. At its core, the system utilized a local large language model (Mistral, via the Ollama framework) to extract structured, YAML-formatted steps from unstructured log data.

To enhance contextual relevance, a Retrieval-Augmented Generation (RAG) pipeline was implemented utilizing FAISS for rapid similarity search and Sentence Transformers (MiniLM-L6-v2) for document embedding. Argos Translate enabled bilingual documentation for multilingual usability.

The assistant featured a Streamlit interface for uploading logs, generating or editing runbooks, and exporting them in YAML and DOCX formats. It also offered semantic search to retrieve relevant content using natural language queries or metadata tags.

The simulation process produced the following key outputs:

- A comprehensive runbook for technical staff
- A library of probable incident patterns
- A noticeable reduction in average recovery time
- Evidence of improved ERP system understanding among the technical team

These AI-generated runbooks were continuously refined through simulations, aligning with the antifragility model by transforming disruptions into drivers of learning and system evolution.

3.4 Measurement Framework

To assess how the ERP-based KM system responds to disruption and improves over time, this study employs a quantitative antifragility framework across four dimensions: two operational (RTO and RPO) and two behavioral (SO and AD). RTO and RPO measure recovery speed and data retention, while SO-Score and AD-Score capture structural and cognitive evolution post-disruption. Deliberate kernel modifications—such as version mismatches and compatibility issues with the portal kernel—were used to simulate real-world complexity and expose vulnerabilities stemming from tight couplings among kernel, OS, and database versions. Multiple failure modes were introduced to test recovery limits and build a repeatable runbook. Repeating these exercises enabled improvements in response time and reliability, with each iteration enriching a structured knowledge base used during real incidents. Antifragile behavior was quantitatively evaluated using expert assessments and simulation data across the four key dimensions: SO, AD, and Recovery (RTO/RPO).

3.4.1 Measurement of SO

To quantitatively evaluate SO as a dimension of antifragile behaviour, the underlying qualitative characteristics—such as centralization, autonomy, knowledge flow, emergence, and responsiveness—were translated into measurable indicators. Based on theoretical foundations and prior empirical observations, SO was categorized into three levels: *Low SO, Moderate SO*, and *High SO.*

These categories were operationalized through five dimensions, as summarized in Table 2.

Table 2: Dimensions of SO

Dimension	Low (Centralized)	Moderate	High (Self-Organized)
Decision Autonomy	Decisions made centrally; minimal local flexibility	Some local input, but key decisions require upper approval	Local teams make decisions independently within defined boundaries
Knowledge Flow Direction	Top-down; knowledge is siloed or hoarded	Mostly hierarchical; limited two-way communication	Lateral and bottom-up flows; open sharing across units
Emergence	No spontaneous process change; only top-down mandates	Occasional local adjustments with limited impact	Processes evolve from local interaction and systemic feedback
Responsiveness	Reactive; changes occur only after disruptions	Somewhat adaptive; slower response to signals	Proactive and adaptive; continuous sensing and adjustment
Dependence on key individuals	High dependence on a few experts or managers	Partial role overlap; some redundancy	Low; distributed roles and peer-based operational resilience

Each dimension was assessed using a Likert-type scale, with experts rating system behaviour based on a structured questionnaire. Ratings were collected from multiple IT domain experts who supervised or directly participated in the ERP simulation and disruption response exercises. These responses were then aggregated to calculate the SO Score using the following formula:

$$\text{SO-Score} = \frac{1}{m} \sum_{j=1}^{m} \left(\sum_{i=1}^{n} w_i \cdot \text{Item}_{ij} \right)$$

Where: m = number of expert respondents, n= number of measurement dimensions, w_i = weight assigned to the i^{th} dimension and $Item_{ij}$= score assigned by expert j to item i

The final SO-Score is calculated as:

$$\text{SO-Score} = w_1 * \text{Autonomy} + w_2 * \text{Knowledge Flow} + w_3 * \text{Emergence} + w_4 \cdot \text{Responsiveness} + w_5 * \text{Key individual dependence}$$

This structured measurement approach provides a replicable method for evaluating how autonomously and adaptively the ERP system behaves in the face of disruption.

3.4.2 Measurement of AD

To evaluate the adaptive capacity of the system—defined in this study as its ability to adjust, learn, and structurally evolve in response to disruptions—an operational framework was developed based on three levels of organizational adaptation: *Static AD, Responsive AD*, and *Transformative AD.*

These levels were decomposed into five measurable dimensions, each representing a distinct aspect of organizational adaptation according to Table 3:

Table 3: Dimensions of AD

Dimension	Static	Responsive	Transformative
Process updates	Rarely updated	Updated after issues	Proactively and frequently updated
Learning mechanism	Absent	After-action reviews only	Embedded, proactive feedback-driven learning loops
Innovation trigger	Only when forced	After failures	Initiated before failures, driven by foresight
Structural change	Never	Minimal	Radical or systemic changes in structure and processes
Knowledge integration	Poor	Local or isolated	Organization-wide and cross-functional knowledge sharing

The measurement of AD-Score was conducted in the same way as the SO-Score, using the following formula:

$$\text{Adaptation Score} = \frac{1}{m}\sum_{j=1}^{m}\left(\sum_{i=1}^{n} w_i \cdot \text{Item}_{ij}\right)$$

Where m, n, w_i and $Item_{ij}$ are the same as in the So-Score. The weighted AD score can be simplified as:

Adaption score=

w_1*Learning mechanism+w_2*Process updates+
w_3*Innovation trigger+w_4*Structural change+w_5*Knowledge integration

4. Results

ERP systems play a foundational role in operational continuity. However, the kernel upgrade scenario revealed that even minor version mismatches can cause portal system crashes and inter-module failures. Without a pre-defined recovery plan, organizations risk exceeding RTO/RPO thresholds. Downtimes of more than a few hours led to significant productivity losses, missed Service, and compromised decision-making (Prihandono et al., 2024). These risks underscore the need for ERP systems that are not only resilient but also capable of adapting and improving through adversity. The measurement approach provides a replicable framework for evaluating how dynamically an ERP-based knowledge system can learn and evolve in response to disruptions. Based on structured simulations and expert evaluations, the following results were observed:

- *SO-Score* increased from 2.2 out of 5 (Moderate) in Round 1 to 4.1 out of 5 (High) in Round 2.
- *AD-Score* rose from 2.3 out of 5 (Responsive) to 4.0 out of 5 (Transformative).
- *RTO* decreased significantly from 13 days to 90 minutes.
- *RPO* remained constant at 0, indicating complete data retention.

In the first round, despite having all relevant documentation and upgrade procedures in place, the technical team encountered unforeseen complications. As a result, the complete kernel upgrade, along with post-upgrade data validation, took approximately 13 days to complete. While no data was lost (RPO = 0), the system downtime significantly exceeded the defined RTO target. During this extended period, all observed bugs, failures, and corresponding resolutions were systematically documented in the runbook.

In the second round, the lessons learned from the initial attempt were fully incorporated. The team reviewed all server parameters and configurations using a checklist derived from the first round. The upgrade was then performed again, this time utilizing the updated runbook and AI-generated recommendations. The team's responsiveness to unexpected issues significantly improved. Without requiring direct managerial intervention, the technical team completed the kernel upgrade and validation process in 90 minutes, entirely within the RTO target, and again with zero data loss. This progression reflects not only improved recovery but also the operationalization of antifragility, as the ERP system transformed disruption into embedded learning, enabling faster, autonomous responses through iterative learning, AI-supported knowledge codification, and scenario planning.

5. Discussion

5.1 Antifragility and Organizational Resilience: Learning From Stress in Practice

The study highlights the value of adopting an antifragile approach to ERP-related KM. Unlike traditional resilience models that aim to avoid failure, antifragility embraces controlled disruptions as opportunities for learning and improvement (Rane et al., 2024). Capturing insights from these events strengthens organizational capabilities and reduces future vulnerabilities. Integrating AI with KM transforms static knowledge repositories into adaptive systems that evolve through experience (Jarrahi et al., 2023). AI analyzes past incidents, suggests new testing scenarios, and turns failures into structured learning moments. AI-powered analytics also enhance the feedback loop between ERP systems and technical teams by automating runbook generation and improving incident response. This leads to more efficient decision-making, faster recovery, and reduced RTO, ultimately minimizing the operational impact of disruptions.

The key takeaway from the stress testing simulations was that the ERP system not only withstood the changes but also improved as a result. By introducing controlled disruptions, the system was able to identify weak points and, over time, refine its processes and responses. Each iteration of the test increased the system's ability to handle future incidents, which is the core concept of antifragility—systems becoming stronger under stress. This iterative learning process, facilitated by AI, enabled the documentation of new, previously

undetected failure modes, thereby enriching the runbook with actionable insights. This approach proved more effective than merely adhering to static recovery protocols, as it integrated knowledge from each event into the overall system architecture, thereby contributing to the organization's antifragility. Through this antifragile KM approach, ERP disruptions were transformed into opportunities for systematic learning, process optimization, and continuous preparedness, converting potential weaknesses into organizational strengths.

5.2 Challenges and Limitations

Despite its potential, implementing AI and antifragility in ERP systems presents several challenges. First, integrating AI into existing ERP infrastructures can be resource-intensive, requiring adequate technical and human capacity. Second, effective AI depends on robust data governance—poor data quality can compromise predictions and hinder antifragile outcomes. Lastly, while AI enhances recovery and learning, over-reliance on automation poses risks. Human oversight remains essential, especially when AI outputs conflict with strategic or operational goals.

5.3 Future Directions

The future of KM lies in evolving into an adaptive system powered by AI and principles of antifragility. Research should examine how KM can autonomously detect weak signals, adapt to disruptions, and scale experiential learning. Beyond ERP, antifragile KM should be explored in areas like supply chains, cybersecurity, and organizational change. Advancing AI tools to contextualize knowledge across languages, platforms, and timelines will support strategic intelligence. Additionally, addressing ethical, governance, and explainability concerns is essential for building trust and ensuring sustainable learning. Future studies should also include diverse testing scenarios to explore the potential of antifragility fully.

6. Conclusion

This study presents a novel approach to KM by embedding it within an antifragile framework powered by AI and tested through ERP disruption simulations. Rather than treating knowledge as a static asset to be preserved, the proposed methodology reframes KM as a dynamic system that grows stronger when exposed to stress. By simulating disruptions and learning from them, organizations enhance the adaptability, responsiveness, and decentralization of their knowledge processes. AI technologies play a critical role by automating knowledge capture, generating procedural content such as runbooks, and suggesting new failure scenarios based on historical data. These capabilities significantly enhance the evolution of organizational knowledge, enabling faster decision-making, improved preparedness, and an institutional memory that improves with each iteration. As businesses continue to navigate increasingly volatile and complex environments, fostering antifragile KM systems will be essential. This research demonstrates that by integrating AI with KM, organizations can establish self-reinforcing learning ecosystems that not only recover from disruptions but also learn and evolve through them, ensuring long-term resilience and innovation readiness.

Ethical and AI declaration: Ethical clearance was not required for the research conducted in this study, as it did not involve personal data or sensitive content necessitating formal ethical approval. AI was employed as part of the research, as the topic of the paper is directly related to AI. However, AI tools were not used for drafting, writing, or generating the text of this paper.

Acknowledgment

The authors gratefully acknowledge PARTO Company and its management for their valuable support and for providing the necessary infrastructure that enabled the successful execution of this study.

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Overcoming Knowledge Silos in Multimodal Transport Systems: A Knowledge Management Perspective

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Abstract: Multimodal transport systems are crucial for the efficient movement of freight, but organisational and sectoral knowledge silos hinder effective coordination and decision-making. This paper applies knowledge management (KM) principles to explore how transport and logistics companies can overcome these barriers, focusing on insights from the KEYSTONE project. The project surveyed transport and logistics operators, freight terminals, and enforcement authorities across the EU and the UK. A major challenge is the lack of a unified regulatory framework for multimodal transport. Variations in the implementation of international transport conventions across Member States cause regulatory fragmentation. Additionally, differing cross-border documentation requirements—such as customs declarations, vehicle registration, and driver permits—complicate knowledge sharing and real-time coordination. Technological challenges, particularly fragmented IT environments, hinder collaboration. Non-interoperable B2A (Business-to-Authority) and B2B (Business-to-Business) systems limit seamless data sharing, creating cross-border inefficiencies. Trust concerns, such as electronic signatures and document verification, further restrict digital tool adoption. To address this, KEYSTONE proposes an Application Programming Interface (API) Reference Model and Standard using Plug & Play principles to enhance interoperability across digital systems. This model streamlines data transfer, reducing inefficiencies and enabling real-time B2A and B2B information sharing. Cross-Border Governance provides a strategic framework for managing regulatory and procedural complexities. By fostering cooperation and developing common rules for cross-border operations, this approach ensures smoother integration between national systems and addresses challenges related to differing documentation and compliance requirements. KEYSTONE's findings highlight the need for a common digital and regulatory framework to support multimodal transport operations. This paper presents the frameworks developed by the KEYSTONE consortium and discusses how it addresses both technical and regulatory barriers to knowledge sharing, helping overcome knowledge silos in multimodal transport.

Keywords: Knowledge management, DataiIntegration, Interoperability, Multimodal transport, Logistics, Digital ecosystem

1. Introduction

As of recent statistical data, road transport accounts for approximately 24.9% of the overall freight transport in the European Union, while maritime transport dominates with 67.8%. The remaining percentages are divided between rail (5.5%) and inland waterways (1.6%) (European Commission, 2024c). Multimodal transportation in logistics is a vital component of the global economy, serving as the backbone of trade and commerce. However, the movement of goods via road, rail or sea presents unique challenges, including delays at border crossings, customs clearance issues, inventory mismanagement, and communication breakdowns between international logistics operators in Multimodal Freight Transportation (Karam et al, 2023**)**. An integrated multimodal transport network is essential for companies to efficiently manage their supply chain operations at both domestic and international levels. However, the complexity of multimodal integration—particularly the involvement of diverse operators—often creates significant challenges that hinder its seamless implementation (Grancharova et al, 2021). One of the primary constraints is the lack of effective and efficient information connectivity between various transport modes, leading to operational inefficiencies. This includes fragmentation of information and the lack of standardized protocols across various logistics operators and transport modes (Sarraj et al, 2013). These disparities hinder seamless knowledge sharing, leading to inefficiencies, delays, and increased operational costs. A crucial step in addressing this issue is the development of a standardized knowledge management framework (KM) (Alavi, 2001) that integrates

disparate systems, ensuring seamless information exchange and collaboration. Such a framework would facilitate secure and efficient coordination among stakeholders while ensuring compliance with regulatory and security requirements. By reducing information gaps and improving interoperability, this approach would enhance decision-making, foster trust among transport operators, and streamline multimodal logistics operations. In the long term, these advancements promise improved efficiency, reduced administrative burdens, and greater resilience in multimodal transport networks.

Knowledge management plays a critical role in tackling these challenges by enabling the systematic collection, organization, and dissemination of information among stakeholders in the transport and logistics sector. Traditionally, KM systems in transportation agencies have been either manual or semi-automated, often lacking the scalability and flexibility required to adapt to the evolving demands of the industry (Paddeu et al., 2019). The absence of fully integrated KM frameworks limits organizations' ability to effectively manage logistics processes, optimize decision-making, and enhance coordination within multimodal transport networks. Addressing these gaps through advanced KM strategies and digital transformation is essential for improving operational efficiency and fostering innovation in the transport sector (Nakash and Bolisani, 2025).

This paper proposes a novel model to standardize and integrate existing fragmented protocols through secure API (Application Programming Interface) architectures (Kumar et al., 2023). An API Reference Model is a standardized framework that outlines how software components should interact, enabling different systems to communicate effectively through defined endpoints, data formats, and protocols. Unlike current isolated systems, our approach enables seamless authentication and verification of identity holders across borders. A distinguishing aspect of our model is its alignment with, and integration of existing European digital platforms used by enforcement authorities for regulatory information exchange in the logistics and road transport sector. By linking these systems through a unified digital architecture, we aim to reduce administrative burdens, enhance trust and operational transparency, and improve the overall efficiency and security of cross-border logistics in the EU.

This research paper explores the complex landscape of logistics interoperability by drawing on extensive qualitative data gathered from stakeholder surveys, focus groups, round table discussions and semi-structured interviews within the KEYSTONE project (KEYSTONE EU Project, 2024). Knowledge Management plays a central role in this research, as the project utilizes KM frameworks to systematically collect, organize, and disseminate critical data across stakeholders, thereby improving decision-making and collaboration in multimodal transport systems. Through the application of KM, the KEYSTONE project seeks to address the challenges of interoperability and foster a more cohesive, efficient transport network. Identifying gaps in Knowledge management for Multimodal transport

The current transport infrastructure has been designed primarily to support national economies rather than a broader European framework. The absence of unified standards in infrastructure design, traffic management, and data exchange leads to cross-border bottlenecks that hinder the efficient movement of goods (Golinska, 2013). The key gaps identified in the knowledge management infrastructure of multimodal transport include technological barriers, obstacles to digital adoption, and regulatory challenges that impede cross-border transport.

2. Technological Barriers

Multimodal transport faces significant technological barriers that hinder its efficiency and integration. One of the primary challenges is the lack of a universal technological standard for data exchange between different transport modes. The absence of standardized protocols results in non-interoperable systems, making it difficult for stakeholders—such as logistics operators, enforcement authorities, and transport providers—to seamlessly share and process information across borders. Additionally, the fragmented IT infrastructure, where various digital platforms operate in isolation, lead to inefficiencies in real time data exchange. Many of digital platforms are designed for specific transport modes or national regulations, preventing smooth intermodal coordination. The lack of integration between transport management systems, tracking technologies, and digital documentation platforms leads to inefficiencies, increased administrative burdens, and delays in operations. Cybersecurity risks also pose a significant challenge. The increasing reliance on digital platforms for real-time tracking, data sharing, and electronic documentation raises concerns about data security, privacy breaches, and cyberattacks. For instance, the Transportation Security Administration (TSA) has proposed new cybersecurity regulations for pipelines and railroads to enhance the protection of critical infrastructure, highlighting the growing sophistication of cyber threats targeting industrial machinery (WSJ,

2024). Many transport operators are hesitant to fully embrace digitalization due to the risks associated with unauthorized access, data manipulation, and potential financial losses from security breaches.

2.1 Barriers to Digital Adoption in Multimodal Transport

Even with advancements in digital tools accessibility issues continue to hinder the widespread adoption of digital solutions in multimodal transport. A key challenge is the non-acceptance of digital documents by many stakeholders. Despite legislative advancements, paper-based documentation remains dominant, as not all authorities or operators are ready to fully embrace digital alternatives. Additionally, high competition among stakeholders—not only between different transport modes but also within the same mode—discourages information sharing. Operators may be reluctant to share data if they believe it could put them at a competitive disadvantage. The cost of implementation for digital platforms also poses a barrier, particularly for smaller logistics companies that may lack the financial resources to invest in such technologies. Language barriers further complicate communication in international transport, as different Member States use platforms with varying linguistic requirements, limiting data accessibility across borders. The absence of standardized electronic documents also prevents smooth information exchange, as different stakeholders use varied formats and systems. Finally, the unreadiness of drivers—especially in an aging workforce—further delays the adoption of digital technologies, as older drivers may not be comfortable using smart devices or digital tools in their daily operations (KEYSTONE EU Project, 2024).

2.2 Regulatory Challenges

Regulatory inconsistencies across jurisdictions add another layer of complexity to the knowledge management of multimodal transport. One significant issue is the lack of obligation to use digital platforms, as not all Member States mandate the adoption of electronic documents. While some countries have embraced digital solutions, the absence of uniform legal requirements results in inconsistent enforcement practices, creating inefficiencies in data exchange and compliance (Wittenberg et al., 2024). Another major challenge is the fragmented legal framework, which imposes varying obligations on enforcement authorities regarding the acceptance of electronic documents. This inconsistency enables different implementation practices across regions, making it difficult for transport operators to adhere to a standardized approach. Furthermore, the fragmented IT environment is shaped by a variety of non-interoperable systems used for the transfer of electronic transport information and document exchange in both B2A (Business-to-Authority) and B2B (Business-to-Business) contexts. The lack of system compatibility between stakeholders prevents seamless data flow, leading to inefficiencies and delays in multimodal transport operations. Additionally, the lack of harmonization of laws across Member States creates barriers to effective cross-border cooperation. Each country follows its own regulatory framework, leading to operational inefficiencies, added administrative burdens, and delays in transport processes. Another critical issue is the absence of clear definitions of responsibilities regarding data access and management. Without standardized guidelines on who can access, share, and protect data, disputes may arise, resulting in unauthorized access, confidentiality breaches, and limited trust among stakeholders.

3. Knowledge Management in Multimodal Transport

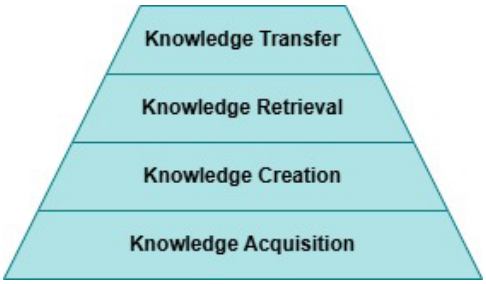


Figure 1: Knowledge management Framework

The knowledge management framework is represented as a pyramidal structure, with knowledge acquisition forming the base. Above it, knowledge creation, knowledge retrieval, and knowledge transfer are layered as shown in Figure 1 (Dalkir., 2017). Each of these pillars plays a crucial role in the effective management of knowledge within a framework, contributing to the creation, sharing, and utilization of valuable information for improved decision-making and organisational performance.

In the context of transport information, Knowledge Acquisition involves collecting data from both internal and external sources. This process includes gathering real-time data from transport networks, government bodies, or other sources, and making it available for further use within the framework. The knowledge framework must ensure this data is captured efficiently for future processing and sharing with stakeholders. This data is then processed in the Knowledge Creation phase, where raw data is transformed into actionable insights through analysis, trend identification, and collaboration with experts to develop strategies and solutions. Knowledge Retrieval ensures that this valuable information is organized, categorized, and easily accessible, enabling quick responses to changing conditions. Finally, Knowledge Transfer involves sharing the processed data and insights with relevant stakeholders, ensuring secure distribution for further analysis, policymaking, and decision-making in the transportation sector.

4. Implementing a Unified Digital and Regulatory Framework

To address the challenges discussed in Section 2, a unified digital and regulatory framework that enhances interoperability, streamlines compliance, and fosters collaboration is needed. The integration of API -based digital solutions and the establishment of common regulatory frameworks play a pivotal role in overcoming these obstacles.

4.1 Best Practices for Integrating Digital Solutions in Multimodal Transport

The integration of digital solutions in multimodal transport requires a structured approach that ensures system interoperability, data security and real-time collaboration. These best practices can be categorized into several aspects. For example, the adoption of API-based interoperability standards, including API reference models and standards, facilitates real-time data exchange between B2B and B2A platforms. This enables seamless integration across different transport management systems, reducing inefficiencies caused by incompatible IT environments. Among the best practices are:

- The adoption of an API-based interoperability standard enables seamless communication between digital platforms users, ensuring consistency in data structure, authentication, and access protocols across different transport management systems.
- Enhancing digital documentation and verification, especially regarding the electronic consignment note (eCMR) (Tomicová, Poliak and Zhuravleva, 2021), which can significantly increase data security boost efficiency, and contribute to a more streamlined, safe, and secure transport system.
- Digital integration on multiple levels (regional, national and European) is essential for ensuring efficient multimodal transport. At the European level, initiatives such as the Digital Transport and Logistics Forum (European Commission, 2025e), the DeployEMDS project for transforming European mobility data sharing (European Commission, 2025i), and the Electronic Freight Transport Information and Regulation (EU) 2020/1056 (European Union, 2025j) aim to enhance digital documentation, standardize data-sharing, and mandate electronic freight transport information systems by 2025. At the National level, adopting EU directives and developing National Digital Freight Corridors can interconnect transport data among key stakeholders. Meanwhile, regional efforts focus on cross-border cooperation to harmonise customs digitisation, enable real-time freight tracking, and streamline exchange of electronic documentation.
- Enhancing cybersecurity and data protection in logistics by promoting awareness, training, and secure IoT protocols, to safeguard operations. This aligns with the EU regulations, such as the Cyber Resilience Act (European Commission, 2025d), which aims to strengthen data security in transport and logistics networks.
- A Plug & play digital ecosystem (European Commission, 2024b) for logistics and transport promotes the development of interoperable digital platforms that seamlessly connect stakeholder data, by adopting standardized APIs and data-sharing protocols. ‘Plug and Play’ refers to a design principle that allows systems and components to connect and function together with minimal configuration, enabling stakeholders to integrate their platforms without requiring complex technical setups. This enhances operational efficiency, reduces administrative burdens, and fosters real-time collaboration across the supply chain.

4.2 Developing Common Regulatory Frameworks for Improved Compliance

Harmonizing regulatory frameworks is essential for ensuring seamless operations across transport sectors. The variations in national regulation can create inefficiencies, increase compliance costs, and create barriers for digital integration. Establishing common standards for data exchange, documentation, and enforcement, as

previously mentioned, can significantly enhance real-time information sharing, reduces cross-border delays and streamline administrative procedures. By aligning policies at the EU level and promoting stronger cooperation among member states, regulatory frameworks can support greater interoperability, improve compliance efficiency and enhance the overall resilience of the logistics sector. Furthermore, common regulations will encourage innovation and investment in digital solutions, help logistics operators meet global standards, and provide clarity that can support small and medium-sized enterprises (SMEs) in participating in global trade.

4.3 EU-Level Platforms for Unified Digital Integration

A critical component of the proposed unified digital and regulatory framework is the integration of existing EU-level platforms currently used by enforcement authorities for road transport regulation and compliance. These platforms are foundational to enabling secure, real-time data exchange and digital identity verification across borders. The following are key EU-level platforms for knowledge sharing and are integral to the proposed unified digital and regulatory framework. RESPER (Register of Road Transport Undertakings) (European Commission, 2005f) – Provides a register of professional drivers' license and qualification information, essential for verifying driver eligibility and compliance across EU member states. TACHONET (European Commission, 2024h)– Facilitates the secure exchange of digital tachograph card data between national authorities. It enables verification of driver activity, rest periods, and compliance with EU driving time regulations. ERRU (European Register of Road Transport Undertakings) (European Commission, 2024g)– Allows national authorities to share and access information on transport operators' compliance with EU rules, including infringements and penalties, supporting better enforcement coordination. By incorporating these systems through a standardized API-driven architecture, authorities and logistics operators can achieve real-time access to verified data. This will significantly reduce redundant paperwork, streamline cross-border inspections, and support compliance with social, safety, and market regulations. Their integration into the proposed plug-and-play digital ecosystem ensures that the framework is not only innovative but also grounded in existing infrastructure, enhancing feasibility and adoption potential across the EU.

5. Digital Solutions for Overcoming Knowledge Silos: The KEYSTONE Approach

To overcome these persistent challenges, the KEYSTONE project is developing digital solutions that facilitate seamless knowledge exchange, ensuring that all stakeholders have access to consistent and standardized transport data. By integrating an API Reference Model and a common regulatory framework, KEYSTONE aims to eliminate knowledge silos and enable a more efficient multimodal transport ecosystem. A major impediment identified during consultations, surveys and interviews with stakeholders in logistics and law enforcement is the lack of a unified regulatory framework for multimodal transport, with variations in the implementation of international transport conventions causing regulatory fragmentation. Additionally, differing cross-border documentation requirements further complicate knowledge sharing and real-time coordination.

To address these issues, KEYSTONE is developing frameworks that tackle both technical and regulatory barriers to knowledge sharing. These frameworks are designed to breakdown existing knowledge silos. Figure 2 illustrates the overall knowledge management framework in line with the Keystone approach.

5.1 API Reference Model and Standard: Enhancing Interoperability Through Plug and Play Principles

The KEYSTONE project actively develops solutions that significantly contribute to the KM aspect of the logistics sector and the regulatory compliance, particularly overcoming knowledge silos within multimodal systems. At the core of its developments is the creation of an API Reference Model and the subsequent API standard designed with the Digital Transport and Logistics Forum (DTLF's) Plug and Play principles at its heart as outlined in the EU Transport Policy framework (European Commission, 2024e). This approach enables seamless interoperability across diverse platforms and systems. Furthermore, KEYSTONE addresses critical aspects of cross-border governance and standardized data sharing, ensuring real-time, efficient and sustainable coordination among stakeholders. The first pivotal component of KEYSTONE's approach is the development of a comprehensive API Reference Model (Keystone EU Project, 2025), which serves as a blueprint for facilitating seamless, interoperable digital exchange within the transport and logistics sector. In essence it serves as a foundational framework to build upon the API standard. By establishing a structured approach to API standardisation, the API Reference Model strives to bridge existing gaps in data-driven operations and enable 'Plug and Play' solutions that can overcome the limitations of current legacy systems. It - streamlines connectivity, enhance scalability and ensure secure, regulatory-compliant business transactions.

This model (Refer figure 2) connects information from various regulatory platforms example, RESPER, TACHONET and ERRU based on knowledge acquisition, knowledge creation (Integrating Platforms using API standard), and knowledge retrieval (KEYSTONE's standardized Plug and Play solutions) in a seamless and efficient flow. DTLF's Plug and Play is a set of concepts and procedures designed to let individual stakeholders—from public authorities to private enterprises—seamlessly connect and share data through a common digital platform. It removes barriers associated with intricate knowledge and technical expertise needed for setting up, configuring software components and integrating, by providing standardized, predefined settings and agreements, which simplify the process of linking disparate legacy systems and ensures interoperability across the transport and logistics ecosystem. Therefore, with these principles incorporated, the API reference model and the derived API standard are structures that provide single, predefined connection endpoints for each data-sharing need a stakeholder may have. This simplifies the definitions of the proper data-providing/consuming APIs, streamlines the integration process, and reduces the need for manual setups. Through this system, the Knowledge Hub and the Authority can efficiently exchange data in a standardized and secure manner for cross-border transport. In the context of logistics data sharing, the KEYSTONE project adopts Plug and Play design principles to meet the diverse needs of individual end-users, fostering a user-centric, inclusive, and easily accessible environment, as specified in the DTLF Interim Report (European Commission, 2024a). That is why it is the first pivotal step towards eliminating data silos and ensuring that data is shared in a consistent, interoperable format, contributing to the knowledge management aspect in the logistics field and data-driven decision-making.

Regarding the components, the API reference model includes robust technical specifications that define data formats -using JSON (JavaScript Object Notation), a lightweight data-interchange format that is easy for humans to read and write, and easy for machines to parse and generate, commonly used in communication protocols that follow REST (Representational State Transfer) principles, which use standard HTTP methods (GET, POST, PUT, DELETE) for interaction and allow web-based systems to communicate in a scalable, stateless manner (Neumann et al., 2021). Security is also a core element, ensuring that all data exchanged remains confidential and intact through measures such as HTTPS (Hypertext Transfer Protocol Secure) encryption. In this way the model is designed to standardize not only technical aspects but also to serve as a cornerstone for effective knowledge management in multimodal transport ensuring safety and security. Additionally, the model provides a scalable, simple architectural blueprint that defines API components—endpoints, requests, and responses—based on stakeholder needs and current digital standards.

The overarching goals of the API Reference Model are multifaceted. It established standardized data exchange protocols that enhance safety within the transport ecosystem while fostering collaboration and interoperability among diverse systems used by organisations and authorities. It aims to reduce compliance costs for involved stakeholders of all sizes and legacy capacities, optimise resource utilisation, boost digitalisation, transparency and automation to a greater extent of certain operations and processes, and promote consistency, reusability, and modular integration for improved efficiency and scalability. Ultimately, this framework encourages the broad adoption of digital solutions across the transport and logistics industry.

The goal is that once the API Standard is developed based on this model, different stakeholders can connect their systems and exchange data with minimal complexity in configuration, embodying the essence of Plug and Play. Data can remain at its source and be accessible to competent authorities for cross-border checks along various transport routes, as per the KEYSTONE's scope. However, a standardized API is vital for knowledge management not only for the project's purposes but also well beyond that. By providing a consistent, secure method for querying and retrieving data across disparate systems, the API standard enables authorities and stakeholders to integrate and analyse information without needing to centralise it. This uniformity allows for real-time monitoring, comparative analysis, and the extraction of actionable insights while preserving data ownership and privacy. Ultimately, it enhances decision-making, promotes regulatory oversight, and builds a comprehensive, interoperable knowledge base that drives efficiency and sustainability in the transport sector

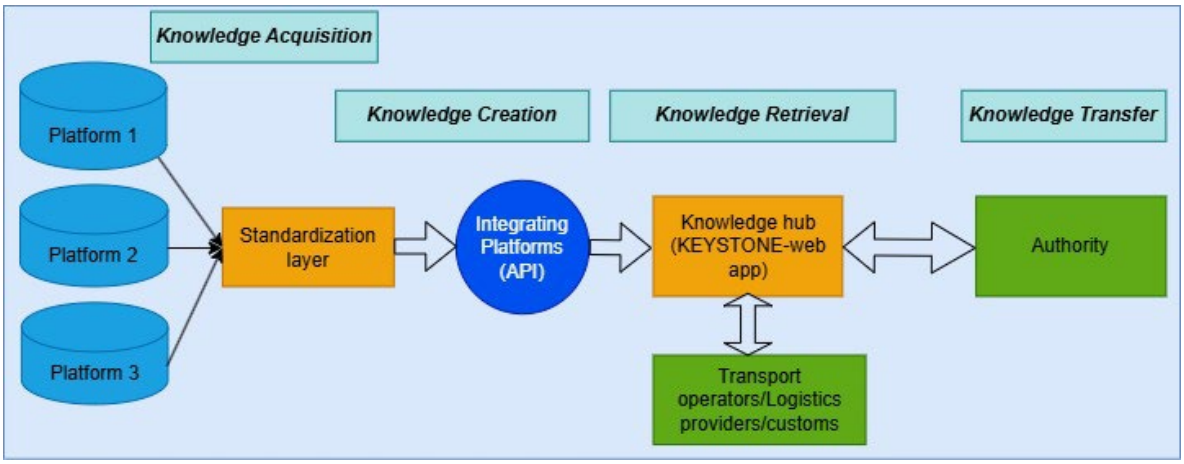


Figure 2: Knowledge Management framework explaining KEYSTONE concept (KEYSTONE EU Project, 2025)

5.2 Cross-Border Governance Framework: Addressing Regulatory and Procedural Complexities

The KEYSTONE project acknowledges that a major challenge in multimodal transport is the lack of a unified regulatory framework across the EU and the UK. To address these regulatory and procedural complexities, KEYSTONE aims to contribute to a cross-border governance framework with the development of its solutions. This framework aims to foster cooperation and develop common rules for cross-border operations, ensuring smoother integration between national systems and addressing challenges related to differing documentation and compliance requirements. The API model and the respective deriving API standard are designed to support such a framework by providing a technical mean for the exchange of regulatory information and compliance-related data. The model and consequently the standard will facilitate the definition of API endpoints and thus the creation of such standardized APIs that can handle the diverse data elements required for cross-border transport, such as those related to vehicle status, driver qualifications, and cargo details among others. The intention is that a standardized API will facilitate the verification of compliance with existing legislation by enforcement authorities and their competent agencies across the EU in a quick and secure way and without language/paper barriers.

Furthermore, to evaluate and validate these developed solutions and thus showcase in a measurable manner the value they aim to deliver, KEYSTONE develops a data exchange web-based application based on the API standard. This web application will serve as a concrete example of the effectiveness and viability of the API standard and reference model, demonstrating real-time data exchange. The backend of this system will manage requests and process data, integrating with third-party systems through standardized APIs and connectors. The emphasis on REST services for the APIs will provide a standardized external interface for data consumption by the web app and other systems, facilitating real-time information access.

The web app and the demonstrations of it are in essence a validation tool for the entire KEYSTONE endeavour. By demonstrably using the API standard and reference model to achieve real-time data exchange with integrated systems through its backend and RESTful APIs, it directly addresses regulatory complexities withing the cross-border governance framework by showcasing how standardized data exchange can streamline compliance checks and information sharing across different regulatory domains.

5.3 Standardized Data-Sharing Models for Real-Time B2A and B2B Coordination

Fragmentation in data exchange within the transport and logistics sector often arises from the use of disparate systems, leading to inefficiencies and communication barriers, issues which standardisation also aims to tackle, by ensuring flow smoothly between systems without the need for extensive custom integrations, effectively reducing said fragmentation. For Business-to-Business (B2B) exchanges, the implementation of standardized APIs facilitates real-time data sharing between logistics operators, suppliers, and customers. This immediacy enhances supply chain visibility, allowing businesses to respond swiftly to market demands and operational challenges. Additionally, it reduces manual data entry errors and streamlines processes, leading to cost savings and improved partner relationships by allowing them to coordinate in an optimised manner.

In the context of Business-to-Authority (B2A) interactions, standardized APIs enable efficient and secure data transmission between businesses and competent enforcement authorities. This capability is crucial for compliance with legal requirements, as it allows for automated reporting and real-time monitoring.

Consequently, authorities can perform their oversight functions more effectively, and businesses can ensure adherence to regulations with minimal administrative burden.

Furthermore, for both cases (B2B and B2A), automation of data exchanges is becoming feasible and easy to implement with the adoption of the API standard. As a result, manual data entry, and the use of paper documents, which are still prevalent in many cases and prone to mistakes, may become obsolete. For instance, integrating systems through standardized APIs allows for real-time updates of transport statuses, shipment tracking and more, creating a seamless flow of information. This automation not only streamlines operations but also enhances data accuracy allowing interventions and checks to be focused on targeted cases. Moreover, all parties can access up-to-date information for informed decision-making. This immediacy reduces delays associated with traditional data exchange methods and enables prompt responses to any emerging issues, significantly reducing the administrative workloads, which are a prominent issue in many cases.

By implementing a unified API Reference Model, a common regulatory framework, and a cross-border governance approach, KEYSTONE addresses long-standing challenges in multimodal transport. These solutions enable real-time data exchange, enhance regulatory compliance, and improve coordination between businesses and authorities. The standardisation of data-sharing models not only reduces inefficiencies but also fosters digital innovation, creating a resilient, transparent, and efficient logistics ecosystem. As these technologies and frameworks gain traction, they lay the foundation for a more harmonised and future-ready multimodal transport network.

6. Conclusion and Future Directions

Multimodal transport systems are essential for efficient freight movement, yet persistent knowledge silos, regulatory fragmentation, and technological barriers hinder seamless coordination. This paper has explored how knowledge management principles can address these challenges, focusing on insights from the KEYSTONE project.

A major finding is that the lack of a unified regulatory framework creates inefficiencies in cross-border operations. Variation in transport conventions, documentation requirements, and compliance standards across member states complicates coordination. Additionally, fragmented IT systems and interoperability issues in B2A and B2B interactions limit knowledge sharing. Based on knowledge management principal KEYSTONE project propose an API reference model and standard, facilitating seamless digital interoperability through plug and play principles. This approach enhances data exchange between existing platforms like RESPER, ERRU and TACHONET, reducing inefficiencies between stakeholders. To demonstrate the feasibility of this approach, KEYSTONE has also developed a web-based application as a proof-of-concept. This tool serves as a validation mechanism for the API standard and reference model, showcasing real-time data exchange and seamless integration with third-party systems using RESTful APIs. It exemplifies how such frameworks can translate into tangible solutions that improve operational workflows.

Future research should focus on advancing digital transformation strategies to address persistent interoperability and regulatory challenges in multimodal transport. While technical solutions, such as those proposed by KEYSTONE, contribute to bridging knowledge gaps and enhancing digital connectivity, further exploration is needed to refine digital ecosystems and improve real-time data exchange. One key area is the development of artificial Intelligence- driven systems that can automate logistics process and support decision making for transport operators.

Another important aspect is the development of digital governance frameworks and standardization efforts at various level to promote alignment across member states. Collaboration among policymakers, industry stakeholders, and technology providers will be crucial in achieving a fully integrated multimodal transport network.

By implementing the recommendations outlined in this paper, the transport and logistics sector can move towards a more connected, efficient, and knowledge-driven ecosystem, ultimately enhancing global trade and supply chain resilience.

Acknowledgement

This research was conducted as part of the KEYSTONE project, which has received funding from the European Commission’s Horizon Europe programme under grant agreement number 101103740 (EU HORIZON-CL5-2022-D6-02).

Ethics declaration: This research did not require ethical clearance as it does not involve human participants, animal studies, or sensitive data. All information used in the paper is publicly available or based on secondary data sources.

AI declaration: No AI tools were used in the development of this paper. The manuscript solely reflects the authors' intellectual contributions, interpretations, and domain expertise.

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Artificial Intelligence in Knowledge-Intensive Task Automation: Insights from the Social Learning Cycle

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Abstract: These days, we are witnessing with amazement the exponential increase in the possibilities of AI in tasks that only a few months ago we thought were reserved for humans. This work aims to study how AI is impacting the way we perform knowledge-intensive tasks by addressing the following research questions: How does AI impact the learning process? Are new kinds of learning cycles fueled by AI? Or even, is AI capable of using and creating knowledge without learning? To explore this, we rely on Boisot's I-Space theoretical knowledge management framework, which proposes a model of how learning happens within a three-dimensional space via the so-called Social Learning Cycles (SLC). The SLC explains how information flows in a social system and, consequently, how knowledge is generated, transmitted, and applied. Our work examines the evolution of automation as a basis for scalability, now applied to knowledge tasks. Specifically, we analyze how AI impacts the SLC. Scalability was the foundation of the Industrial Revolution, as it enabled the mass production of goods and the emergence of economies of scale. It began with craftwork, assisted production, the systematization of tasks, and their automation. Now, for the first time in human history, AI allows the automation of complex knowledge tasks, even creative ones such as image generation. Moreover, other types of tasks based on analysis, review of information, and decision-making can be completely automated, leveraging the massive power of AI processes (i.e., vast datasets and computational capacity). As a second objective, our work studies how the evolution of knowledge-intensive automation is driving greater scalability. Drawing on a multiple-case study of organizations implementing AI in knowledge-intensive activities, the paper presents two main contributions. First, the findings suggest that the adoption of AI may decouple the learning process from human agency, proposing that the fifth stage of the SLC model, Absorption, may undergo a significant reconfiguration. This suggests that organizational learning built on shared individual experiences could be fundamentally altered. Second, the authors introduce a curve that synthesizes the exponential relationship between cognitive automation and efficiency gains, demonstrating a new form of scalability analogous in its potential impact to the manufacturing transformations of the Industrial Revolution.

Keywords: Artifical intelligence, Social learning cycle, Organizational learning, Automation, Knowledge-intensive, Scalability

1. Introduction

These days, we are witnessing with amazement the exponential increase in the possibilities of AI in tasks that only a few months ago we thought were reserved for humans.

This work aims to study how AI is impacting the way we perform knowledge-intensive tasks by addressing the following research questions: How does AI impact the learning process? Are new kinds of learning cycles fueled by AI? Or even, is AI capable of using and creating knowledge without learning? To explore this, we rely on Boisot's I-Space theoretical knowledge management framework, which proposes a model of how learning happens within a three-dimensional space via the so-called Social Learning Cycles (SLC). The SLC explains how information flows in a social system and, consequently, how knowledge is generated, transmitted, and applied. Our work examines the evolution of automation as a basis for scalability, now applied to knowledge tasks. Specifically, we analyze how AI impacts the SLC.

Scalability was the foundation of the Industrial Revolution, as it enabled the mass production of goods and the emergence of economies of scale. It began with craftwork, assisted production, the systematization of tasks, and their automation. Now, for the first time in human history, AI allows the automation of complex knowledge tasks, even creative ones such as image generation. Moreover, other types of tasks based on analysis, review of information, and decision-making can be completely automated, leveraging the massive power of AI processes (i.e., vast datasets and computational capacity). As a second objective, our work studies how the evolution of knowledge-intensive automation is driving greater scalability.

The qualitative empirical work is based on the study of real cases through the perception of their protagonists, who are implementing AI in knowledge-intensive activities.

2. Theoretical Context

In any domain, new activities begin as manual, exploratory processes that rely heavily on individual expertise. To achieve scalability, organizations systematize these activities by clarifying steps and documenting procedures, an initial investment that builds efficiency (Parasuraman et al., 2000). Once structured, tools such as checklists and decision-support systems are introduced to assist human performers, transitioning to human-in-the-loop

guidance (Miller & Parasuraman, 2007). The final stage is automation, in which tasks are fully or partially delegated to software and machines, executing explicit processes with minimal human intervention (Bernabei & Costantino, 2024). This evolution informs the understanding of automation maturity.

2.1 General Process Automation

Business Process Maturity Model (BPMM)

Understanding the evolution of business processes through progressive levels of maturity is essential to studying the foundations of automation in productive activities. The Business Process Maturity Model (BPMM) provides a structured framework for assessing the capability of an organization's processes to deliver predictable, efficient, and continuously improving outcomes. BPMM builds on earlier maturity models such as the Capability Maturity Model (CMM) developed by the Software Engineering Institute (Lee et al., 2007). The model is composed of five maturity levels (Weber et al., 2008): initial, managed, standardized, predictable, optimizing.

A Maturity Model for the Autonomy of Manufacturing Systems.

This model, introduced by Fan Mo (Mo et al., 2023), is especially relevant in manufacturing and industrial automation. It emphasizes the progression from tool-based support to fully self-regulating systems. The model includes five levels: no autonomy, assistance, partial autonomy, conditional autonomy and full autonomy

Business Process Reengineering (BPR)

Hammer and Champy introduced BPR as the radical redesign of business processes to achieve dramatic performance improvements (Hammer & Champy, 1993). While BPMM and CMMI advocate for gradual maturity, BPR promotes disruptive reconfiguration, providing an important alternative logic for initiating automation.

2.2 Robotic Process Automation

Robotic Process Automation (RPA) is an emerging form of business process automation technology based on software robots that mimic human interactions with digital systems. It is particularly relevant in domains where routine, rule-based tasks dominate, such as administrative, financial, and back-office operations (Lacity & Willcocks, 2016). RPA is grounded in several theoretical streams:

- Task-Technology Fit Theory (Goodhue & Thompson, 1995)
- Socio-technical Systems Theory
- Capability Maturity Models

Additionally, RPA is often linked to business process reengineering (BPR (Chakraborti et al., 2020).

2.3 Knowledge and Intelligent Process Automation (IPA)

A more technological approach was published in 2019 by the IEEE Standards Association: the Software Based Intelligent Process Automation (SBIPA), IEEE 2755.1 (Hood, 2019). It has become very popular in the 'industry 4.0' literature.

RPA relies on explicit algorithms, requiring encoded functionality, that cannot evolve or adapt to new situations or events. It is therefore most effective for automating very repetitive tasks.

Another variant is Cognitive Process Automation (CPA), which uses probabilities to drive automation decisions. In this case, AI can adapt and learn from new data.

The Process for Knowledge Automation: APeM

This model, developed by Yotung Wang (Wang et al., 2023) integrates autonomous modes (AM), parallel modes (PM), and expert/emergency modes (EM), collectively referred to as APeM. It automates workflows on knowledge factories, accounting for over 80% of operations in the autonomous mode.

2.4 Knowledge-Intensive Processes and AI

Knowledge Creation and Transformation (SECI Model)

The SECI model developed by Nonaka and Takeuchi (1995) offers a dynamic theory of knowledge creation through four modes: Socialization, Externalization, Combination, and Internalization. These phases capture the transformation of tacit knowledge into explicit, shareable forms, which is essential for systematizing tasks and eventually embedding them in technological systems. The model's emphasis on abstraction and codification

provides a bridge between human-centered craft and machine-executable procedures, essential in automation design.

I-Space and the Social Learning Cycle

Boisot's I-Space framework conceptualizes the flow of knowledge through three dimensions: codification, abstraction, and diffusion (Boisot, 2013). The Social Learning Cycle (SLC) within the I-Space model describes six phases:

- Scanning: Identifying weak signals from unstructured data.
- Codification: Structuring and clarifying insights.
- Abstraction: Generalizing insights into broader principles.
- Diffusion: Disseminating structured knowledge.
- Absorption: Applying knowledge through practice.
- Impacting: Embedding knowledge into systems and routines.

The I-Space highlights the tension between the utility of knowledge (through codification and abstraction) and its scarcity (through limited diffusion). It provides a theoretical foundation for understanding how knowledge becomes machine-processable and thus automatable.

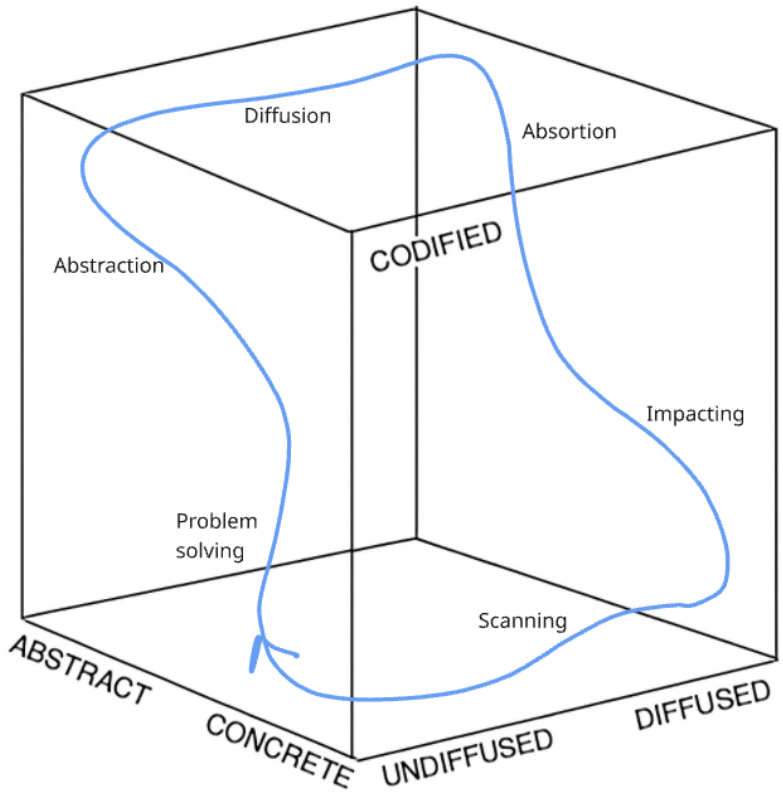


Figure 1: The Social Learning Cycle. Source: Boisot, 1998

Stages of Automation in Digital Work

The model conceptualizes automation as a continuum, particularly within knowledge work, rather than a binary state. It frames automation not as replacement, but as augmentation and transformation of knowledge work. The relevant stages of automation are: assisted, augmented and autonomous intelligences (Davenport, 2018).

3. Research Questions

The rise of AI, particularly large language models, machine learning systems, and expert systems, is reshaping how cognitive work progresses through the I-Space. These shifts suggest that AI accelerates movement through the Social Learning Cycle but may also bypass key human phases such as absorption or institutional validation

Our research questions are:

- AI enables transition from craft to automation in cognitive work
- Adopting AI in cognitive processes modifies some steps of the I-Space SLC.
- AI reduces the need for human-led abstraction by externalizing pattern recognition to statistical systems.
- AI automated knowledge tasks make knowledge less likely to be culturally embedded than socially-produced knowledge.

4. Research Design and Methodology

The qualitative research adopts a multiple-case study design (Yin, 2018) to explore how AI is enhancing and automating cognitive tasks in knowledge-intensive environments. This approach allows for an in-depth, contextualized investigation of complex socio-technical processes that cannot be easily isolated or quantified. Multiple cases enable analytical generalization by comparing patterns across settings rather than aiming for statistical representativeness.

The study includes purposefully selected cases that represent diverse organizational contexts, sizes, and industries. The analyzed activities in several companies are knowledge-intensive, and they differ in the type of knowledge involved (visual, strategic, engineering), offering variation in cognitive task structure and the role of AI technologies.

Table 1: List of cases analyzed in the research. Source: Authors' elaboration

Case	Industry	Organization
A	Health	A public sector institution that promotes and develops biomedical research
B	Manufacturing	A graphic design and manufacturing company
C	Marketing services	A digital marketing agency
D	Supplies	A group specialized in water and environmental management
E	Manufacturing	A group specializing in the manufacturing of plastic piping systems
F	Science	A laboratory with the world's largest and most complex scientific instruments
G	Pharma	A pharma company

Data were collected through semi-structured interviews, internal documents, and AI-generated artifacts, ensuring triangulation and richness of insight. A guiding questionnaire was prepared covering all stages of the SLC, asking participants to compare their perceived effort before and after AI adoption.

5. Findings and Discussion

From our empirical work we have found some significant elements.

5.1 Scaling Knowledge-Intensive Activities

The evolution of automation is closely related to efficiency improvement, which we interpret as scalability in knowledge-intensive activities, much like the industrial revolution enabled scalability in goods manufacturing.

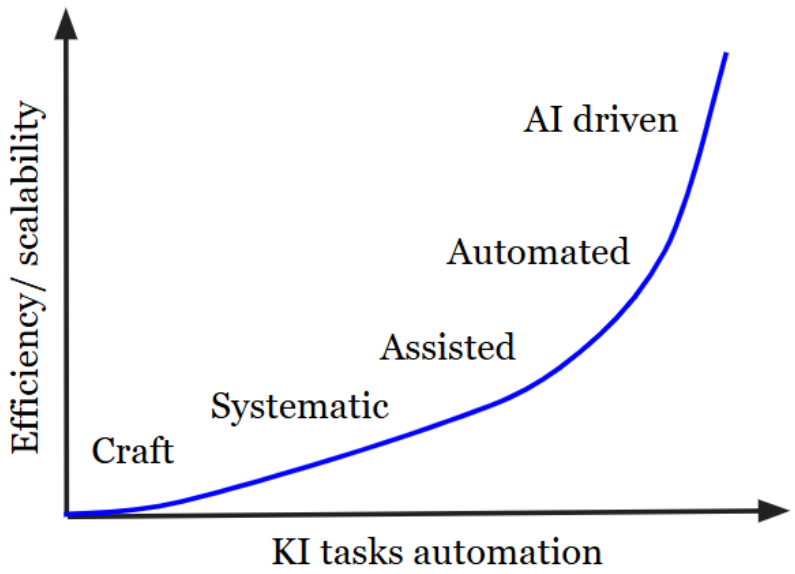


Figure 2: Automation of KI tasks and scalability. Source: own elaboration

The curve presents a clear progression through five distinct stages of automation, exhibiting an exponential rise in the "AI driven" stage. This signifies that leveraging Artificial Intelligence for KI tasks unlocks unprecedented levels of efficiency and scalability.

5.2 Impact of AI on the effort required to perform SLC steps: Basis for scalability

We analyze the perceived effort required to perform each step of the SLC compared with the initial "craft" stage, considered a strong effort.. The following table shows the effort required to perform each SLC activity.

Table 2: Required effort at each SLC step at different automation levels (very high, high, moderate, low, very low). Source: own elaboration

Stage #	Automation SLC Stage \	Craft	Systematic	Assisted	Automated	AI driven
1	Scanning	High	High	High	High	Moderate
2	Codification/ Problem solving	High	Very High	Very High	Very High	Very High
3	Abstraction	High	Very High	Very High	Very High	Low
4	Diffusion	High	Very High	High	Low	Very low
5	Absorption/ (Adoption)	High	High	Low	Low	Very low
6	Impacting	High	High	Low	Low	Very low

*It requires a high effort to contextualize, setup and train first and select provided outputs after. But its ability to manage big data and apply brute force to solve problems compensates it.

6. Conclusions and Implications

The automation curve highlights that while all forms of automation contribute to efficiency and scalability, AI-driven solutions represent the peak of this progression, offering disproportionately higher returns. They enable intelligent, autonomous operations capable of scaling rapidly and performing complex tasks with increasing effectiveness, maximizing operational capabilities in a domain that remained unscalable until now.

It should be noted that while later stages of the SLC become much less demanding, the initial stages, particularly contextualizing and training AI systems, remain effort-intensive. Nevertheless, the exponential increase in the amount of data that can be processed and the variety of tasks that can be automated clearly enhances efficiency.

The persistent “very high” effort in codification/problem solving implies that creating novel learning content or complex solutions remains a challenge. Human expertise is still needed in tasks such as providing valid and meaningful data, setting objectives, and critically reviewing outputs.

This reinforces the need for human expertise in the core design and development of social learning interventions such as:

- Previously: contextualizing, providing valid and meaningful data, providing clear objectives while keeping an open window to alternative and out of the box thinking.
- After: reviewing outputs, conducting critical evaluations, iterating, and training the AI.

"Abstraction" turns into a low-effort stage, AI's ability to reduce it from It suggests the potential of AI to assist in identifying patterns and generating generalized insights from complex data, more effectively than rule-based systems.

Required efforts for the last stages of the SLC are very low, meaning that thanks to AI, there is no need to make it very diffused at all.

The most critical implication is that adoption does not necessarily imply human learning. Stage 5 of the SLC model (Absorption) may disappear, suggesting that organizational learning built on shared individual learning could be lost.

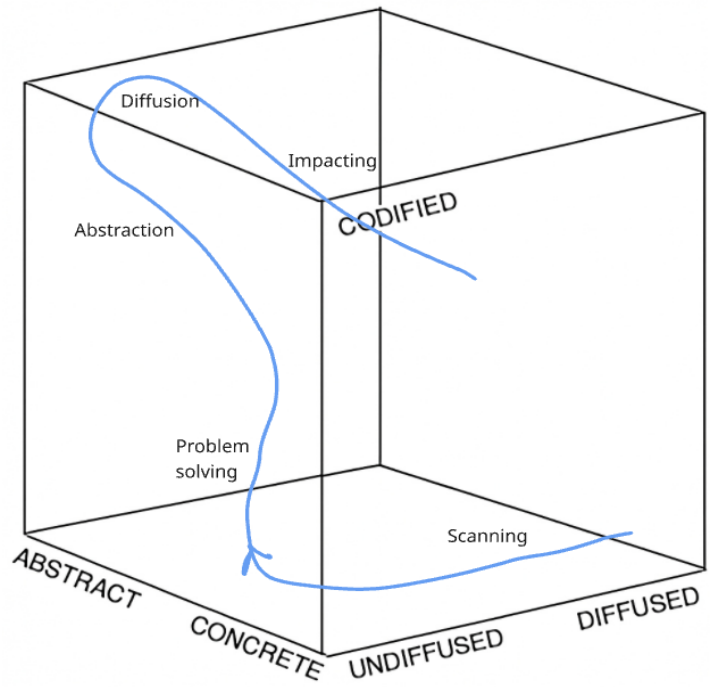


Figure 3: AI impact on the SLC. A revisited model. Source: Own elaboration

Ethics declaration: Ethical procedures for the work were meticulously followed, ensuring the protection and rights of all participants. The cornerstone of our ethical approach was the implementation of a comprehensive Informed Consent Statement. This document was presented to every potential participant to provide them with sufficient and clear information, enabling them to make a fully informed decision about their participation in the project. The informed consent process guaranteed the following ethical standards: Informed Participation: All participants were informed about the project's objective, the specific nature of their involvement, and the type of data that would be collected for analysis. Voluntary Consent: Participation in the study was explicitly stated as voluntary. Participants were clearly informed of their right to withdraw their consent and discontinue their involvement at any point without consequence. Data Protection and Confidentiality: The collection and processing of personal data strictly adhere to the General Data Protection Regulation (EU) 2016/679 and Organic Law 3/2018. Key protections included: Purpose Limitation: Personal data was collected solely for non-profit teaching and research purposes within the scope of this project. Confidentiality and Anonymization: All personal information is kept secret and will be anonymized to ensure that individuals are not identifiable in the project's results. Data Controller: The name and contact information of the Data Controller responsible for processing the

data were clearly provided. Data Minimization: The data collected was limited to the minimum necessary to achieve the project's objectives, and all personal information will be permanently destroyed once the research purpose is fulfilled. Authorization for Image and Voice: Separate and explicit authorization was sought for the capture and use of participants' image and voice through audiovisual recordings, to be used exclusively for the research purposes outlined in the project. Participant Rights: Participants were made aware of their rights, including the right to access, rectify, erase, and object to the processing of their personal data. The procedure for exercising these rights was clearly explained.

AI declaration: During the preparation of this manuscript, the authors utilized artificial intelligence (AI) tools to assist with specific tasks. These tools were employed for: Text Enhancement: Reviewing and refining the manuscript for grammar, spelling, and clarity. Information Retrieval: Assisting in literature searches to identify relevant sources and background information. Source Interpretation: Summarizing and aiding in the interpretation of existing research papers. All AI-generated outputs were critically reviewed, edited, and verified by the authors. The authors take full responsibility for the intellectual content, accuracy, and final conclusions of this publication.

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A Comparative Analysis of Generative AI Systems for Document Summarisation

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Abstract: Generative AI (GenAI) systems can support knowledge workers in managing their knowledge, for example, by effectively processing explicit knowledge, such as document location, classification, integration, and summarisation. Document summarisation is especially useful in many cases since it allows users to quickly identify and understand the key information in a written document (a technical report, an academic paper, a user manual, etc.). In other words, effective summation facilitates distilling the essential meaning, ideas, or information from documents. At present, the main used GenAI tools allow document summarisation. However, they provide different performances since they are based on different Large Language models. In this paper, we compare the summarising performance of a sample of the most popular GenAI tools, i.e., ChatGPT, Copilot, Gemini, and Claude. Our analysis compares the summaries of six documents (academic and nonacademic, in English and Italian) provided by the four tools. These summaries were obtained through a prompt engineering process in which we specified the requirements for the summaries. These summaries were then analysed using quantitative metrics, such as ROUGE and BERTScore, and qualitative criteria. By integrating both types of analysis, we achieved a comprehensive evaluation, reducing subjectivity and analysing the summaries across multiple aspects. Our analysis results do not allow us to conclude that there is a "best-in-class" tool regarding the summarisation function. However, we find that the different summaries have specific characteristics, such as the length of the sentences or the number of synonyms used connected with the GenAI model on which each is based. Therefore, our results confirm that a correct understanding of how GenAI tools work is needed to use them consciously, exploit their potential, and reduce their limitations. The study has some limitations. In particular, we compared only a limited number of tools based on a likewise limited number of documents. Moreover, as these tools are constantly evolving, their performance continues to improve over time.

Keywords: Generative artificial intelligence, Document summarisation, Knowledge management, Comparative analysis

1. Introduction

Generative Artificial Intelligence (GenAI) systems are valuable tools for enhancing the efficiency and effectiveness of various knowledge management (KM) processes (Alavi et al., 2024; Jarrahi et al., 2023). These systems rapidly process explicit knowledge, facilitating tasks such as document location, classification, integration, and summarisation. Document summarisation is especially beneficial in numerous scenarios, enabling users to quickly identify, comprehend, and use key information in written documents (e.g., technical reports, academic papers, and user manuals). Effective summarisation distils the core meaning, ideas, and information from documents, streamlining knowledge acquisition and utilisation.

Currently, all widely used GenAI systems offer document summarisation capabilities. However, as these systems are built on different Large Language Models (LLMs), they exhibit varying performance regarding the relevance and significance of the summaries they produce and, consequently, the knowledge that can be extracted from them. In light of this, our paper compares the summarisation performance of various popular GenAI systems, namely ChatGPT, Copilot, Gemini, and Claude. In particular, we evaluated summaries of six documents (both academic and non-academic, in English and Italian) generated by these four systems. These summaries were obtained through a prompt engineering process in which the specific requirements of the summaries were outlined. The summaries were then analysed using quantitative metrics, such as ROUGE and BERTScore, and qualitative criteria. By integrating these two types of analysis, we achieved a comprehensive evaluation that minimised subjectivity and examined summaries in multiple dimensions.

The results of the analysis do not allow us to conclude that there is a "best-in-class" system regarding the summarisation function. However, we observed that summaries produced by different tools exhibit specific characteristics, such as variations in sentence length or frequency of synonym usage, which are linked to the underlying LLM used by each system. Consequently, our findings underscore the importance of fully understanding how GenAI tools work. Furthermore, since many of these systems are offered as a component of

a specific technological ecosystem, we also reflected on the ecosystems to which the investigated tools belong. This knowledge is crucial for users to employ these tools consciously, maximise their potential, and mitigate their limitations.

The paper is structured as follows: Section 2 provides the background of the study, while Section 3 outlines the research objectives and methodology. Section 4 presents the results of the comparative analysis, which are then discussed in Section 5. The final section also includes conclusions and addresses the limitations of the study.

2. Background

Generative AI is a branch of AI that can create new content (text, images, audio, video) and has the potential to transform domains that rely on creativity, innovation, and knowledge processing (Feuerriegel et al., 2024; Brynjolfsson and Raymond, 2025). In terms of knowledge creation, GenAI can especially support the combination and internationalisation of explicit knowledge (Alavi et al., 2024). Based on massive amounts of data, GenAI can merge, categorise, aggregate, and summarise knowledge from different data sources and, in this way, generate new content and identify patterns. Compared to traditional IT systems, GenAI is not a passive provider of information but an active co-creator.

GenAI systems are evolving rapidly, particularly in natural language processing. Although early summarisation systems were mostly extractive, selecting and copying essential sentences from the source, GenAI models create novel sentences to capture the essence of the original source, which is challenging since it often struggles to match human-level quality (El-Kassas et al., 2021).

The recent developments in deep learning, particularly the introduction of transformer architecture such as BERT, have significantly enhanced models' ability to understand language context. More recently, the evolution of large language models has demonstrated the rapid progress of GenAI tools in summarisation (Balagopal, 2024).

The rapid development of GenAI has raised questions about the reliability, performance, and overall performance of different tools, directly affecting how practitioners select among them. Every generative model has strengths and weaknesses. Therefore, performance can vary across data sets and evaluation criteria (Betzalel et al., 2024; Tewari et al., 2024). Several authors have already compared different GenAI tools along with several criteria and the background of the application. For instance, a comparative analysis of BART, T5, and PEGASUS revealed that each performance differs depending on the quantitative metric used, highlighting that no single model consistently outperforms others in all aspects (Dharrao et al., 2024). Rane et al. (2024) compared Gemini and ChatGPT with respect to their effectiveness and performance in finance and accounting. Their literature and tool documentation analysis showed that performance differences exist, while both GenAI models contribute to higher efficiency in finance and accounting tasks. Shukla et al. (2024) compared ChatGPT, Gemini and Perplexity regarding their performance in text generation, information retrieval, transparency, and context understanding. They found different strengths and weaknesses, and no overall winning tool could be identified. Sobo et al. (2025) conducted an experimental study, evaluating the generated software code for robots with experiments on whether the intended robot task was completed successfully based on the generated code. The authors found that Claude was the most successful GenAI tool compared to Gemini and ChatGPT.

In our study, we focus specifically on document summarization as an organisational KM activity. Our study differs from existing research in that it considers four different GenAI tools, has a specific focus on document summarisation, and compares the various tools with both quantitative and qualitative measures to achieve a thorough evaluation.

3. Study Goals and Methodology

Our study aimed to evaluate the performance of some GenAI tools in summarising documents. To accomplish this goal, we implemented a four-step methodology. First, we selected the GenAI tools considering each tool's degree of diffusion, its underlying mathematical model, and especially the ability to process documents. Then, we selected the documents to be summarised. Afterward, the interaction methods with the tools were established: appropriate prompts were defined to generate the summaries. Lastly, we established the method for evaluating the produced summaries. In this regard, BERTScore and ROUGE as quantitative metrics were used, together with a qualitative evaluation. In the following, we will give only a brief description of each step of the methodology. Readers interested in more details about the individual steps of the methodology can contact the authors. The comparison was made between September and November 2024.

3.1 Selection of GenAI Tools

We selected four of the most known and diffused GenAI tools. The first was ChatGPT, which is the most widely used tool. It can accept images, documents, and texts as input and provide texts and images as output. At the time of the study, three versions of GPT-4 were available: GPT-4 Turbo, GPT-4o and GPT-4o mini, which had rather comparable performance (OpenAI, 2024). We used GPT-4o, as it was available, with limited access, in the free version: after reaching the allowed usage limit, access to this model was temporarily unavailable. However, we could still use the tool with the GPT-4o mini model.

The second selected tool was Google Gemini. It was available in a free version, but this version did not allow document processing. There were four versions of Gemini: Ultra, Pro, Google, and Nano (Google DeepMind, 2024). We used Gemini Pro 1.5, available with the paid version of the tool, because it was the most advanced model with superior performance (Gemini Team, 2024).

The third choice fell on Microsoft Copilot, which is based on Prometheus, a proprietary technology from Microsoft that uses Bing and GPT (at that time ChatGPT-4 Turbo) to generate responses based on real-time data. We had access to the free version through the University account. A key feature of Copilot is to be integrated into all Microsoft applications (Microsoft, 2024).

Lastly, we chose Claude by Anthropic, specifically the paid version 3.5, which was much more powerful than the free one. This version was based on the Sonnet model (Anthropic PBC, 2024). Table 1 provides a summary of the compared tools.

Table 1: Characteristics of the compared tools

	ChatGPT	**Gemini**	**Copilot**	**Claude**
Documents uploading	Yes	Yes	Yes	Yes
Access	Free	Paid	Free	Paid
Model	GPT-4o	Gemini Pro 1.5	GTP.4 Turbo	Sonnet 3.5
Open source	No	No	No	No
Integration	OpenAI platform	Google services	Microsoft Office	Anthropic platform
Languages	Multilingual	Multilingual	Multilingual	Multilingual

It is worth recalling that the type of access (free or paid) did not affect the quality of the content produced since all the tools used the most advanced model provided by each company. For Copilot and ChatGPT, the difference compared to the paid versions was only in the limitations of the use of the model.

3.2 Document Selection

Given that we wanted to use a mix of quantitative and qualitative metrics, which required significant time to examine each summary, the number of selected documents could not be particularly high. Consequently, we decided to choose six documents for twenty-four summaries to examine. Furthermore, we selected academic and non-academic documents to avoid bias induced by a specific topic. Furthermore, to identify possible due to the language, we used documents in English and Italian. Table 2 gives a brief description of the selected documents.

Table 2: List of selected documents

Document Type	**Topic**	**Language**
Academic	Marketing	Italian
	Innovation management	English
Non-academic	Supply chain management	English
	Circular economy	
	Economy	Italian
	Business information management	

3.3 Structuring Prompts

As is widely known, the quality of responses generated by a GenAI tool does not depend solely on the characteristics of the neural network (depth, parameters) or the data used for training, but also on the formulation of the prompt. Therefore, a properly structured prompt is needed to obtain effective and informative responses (Lo, 2023). In this regard, we referred to the new prompt engineering discipline, which concerns "the process of constructing a prompt for LLMs to obtain precise, coherent, and relevant responses" (Lo, 2023). In particular, we used the CLEAR (Concise, Logical, Explicit, Adaptive Reflective) framework and the Prompt Pattern Catalogue to create effective prompts. The catalogue provides a set of prompt patterns applied to solve common problems and enhances both the tool's responses and the prompts themselves (White et al., 2023). In the study, only some of these patterns have been selected and adapted to the specific context, specifically: Persona, Template, Question Refinement, Cognitive Verifier, and Context Manager.

3.4 Setting the Evaluation Criteria

As mentioned above, we employed a mix of qualitative and quantitative evaluation criteria.

For quantitative analysis, we used the two most common metrics, ROUGE and BERTScore, which complement each other in assessing summary quality. BERTScore is ideal for measuring semantic similarity, whereas ROUGE is better suited for assessing surface-level, word-based overlap (Özbolat, 2023; Dharrao et al., 2024).

In principle, the two metrics can be used to compare the summary generated by AI with the original document or the AI-generated summary with a quality summary produced by a human. Since the second option presents several criticalities, for example, the strict dependence on the quality of the human-generated summary, in this study, we chose the first option, thus compering the AI-generated summary with the original document. It is important to specify, therefore, that the values of ROUGE and BERTScore do not represent a measure of the summary quality, but only whether it manages to capture information from the original text. For the mathematical formulas of the two metrics, please refer to Lin (2004) and Zhang et al. (2019), respectively.

The ROUGE factor is an automatic evaluation metric that allows for similarity between two texts by calculating precision and recall (Lin, 2004). Precision identifies whether information not present in the original text has been added to the summary, while recall identifies parts of the AI-generated summary that are also present in the original text. In our study, the two factors are combined to obtain the F-score.

The BERTScore is a language metric that identifies the similarity between two texts and is based on using Bidirectional Encoder Representations from Transformers (BERT). This model uses a Transformer architecture to process the language (Zhang et al., 2019).

Qualitative analysis was based on subjective evaluation of the authors on five criteria, each representing a specific aspect of the summary. We used a scoring system in which each criterion was assigned a score of one to five (Likert scale). The closer the score assigned to a criterion was to five, the better the summary was considered. The criteria considered were:

- **Alignment** (between the request and the response): indicates the tool's ability to understand the prompt and generate a summary that is consistent with the request. It considers the time needed to define the prompt and how well the response aligns with the user's requests.
- **Comprehension**: indicates the AI tool's ability to understand the content of the original document and identify logical connections. It considers the ability to identify key points of the document (Zipitria et al., 2008).
- **Coherence**: evaluates the structure and logical connections between sentences in the summary. It identifies whether the logical progression of sentences allows the reader to understand the summary and evaluates the presence of redundant or unnecessary sentences for comprehension (Zipitria et al., 2008).
- **Cohesion**: evaluates the fluency of the summary and the use of cohesive devices such as connectives, ellipsis, lexical substitution, etc. The more fluid the summary and the more correctly it connects sentences, the higher the score assigned to cohesion (Zipitria et al., 2008).
- **Lexical competence**: evaluates grammar, lexical accuracy, the ability to rephrase the text, and the style used. A good summary should not copy sentences from the original document but rephrase them to make them appropriate to the context.

This analysis took a long time since each original document had to be read and compared with the summaries produced by the four tools.

4. Findings of the Comparative Analysis

4.1 Prompt Definition

The methodology used to define the prompts employed in the study consists of three macro-phases. The first phase defines a basic architecture using specific frameworks and rules. In the second phase, the AI tool's capabilities are leveraged to improve the architecture defined in the previous macro-phase. The improved prompt is tested in the third phase, verifying that the tool provides an adequate response. The prompt is approved if the verification yields a positive result; otherwise, the process is repeated. Fig. 1 shows the flow chart of the process.

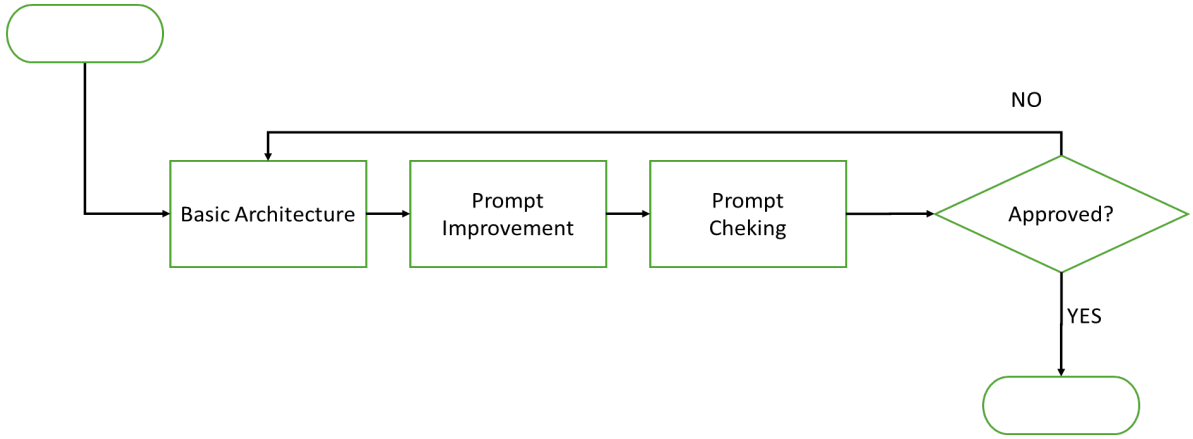


Figure 1: Prompt Engineering process

An example of a final prompt that was created in several iterations for a marketing document with ChatGPT-4 is:

Act as if you were a marketing expert. Use the following structure to generate an academic summary [Introduction, Literature Review, Methodology, Results, and Discussion]. Focus on the logical steps necessary to reach the conclusion and the results obtained, ignoring the bibliography. Maintain an academic tone suitable for a management engineer seeking an informative overview. The keywords to incorporate are: new technologies, fashion, luxuryfication, omnichannel, and retailing. The text must be approximately 15% of the original length, which corresponds to about 1500 words. Strictly adhere to this requirement.

4.2 Validation of Summaries

Two criteria were used to select the summaries to be submitted for comparisons: structure and length. The structure was included in the final prompts and had a binding function during summary generation. When a tool did not meet this requirement, the summary was regenerated until the desired structure was obtained. Using the same structure for all summaries (of the same document) facilitated the comparison of the tools. We met no particular difficulties with this criterion, except for a single case with Google Gemini. As concerns the length of the summaries, first of all, we had to establish. a) how to measure length; b) how to define the length of summaries.

We used the number of words to measure length as it is the most precise method. In particular, we decided that the length of the summaries should be about 15% (only for a document full of graphs and tables, such a value was increased to 20%) of that of the original text. This percentage ensured a balance between summary length and content. Furthermore, a longer length could have flattened the differences between the tools, making evaluation more difficult.

It is worth noting that the length is relevant for calculating quantitative metrics. To make a fair comparison, summaries relating to a specific document had to have the same length. This criterion can also influence qualitative evaluation; a longer summary can more easily include the key points of the original document and insert more details.

4.3 Results

The analysis consisted of calculating individual quantitative and qualitative scores for each summary provided by each tool. Consequently, a total of 6 * 4 * (5 + 5) = 240 individual scores were assigned. After that, scores

were aggregated in various ways to have an overall evaluation of the different tools. For instance, as concerns the qualitative evaluation of the ChatGPT-generated summaries, we assigned the scores shown in Table 3, where the average score is the weighted sum of the individual scores. Additionally, as not all of the five criteria have the same importance, each criteria got a weight (the sum of all weights was 30). The highest weights of 9 were assigned to comprehension and coherence, as a document summary that does not include the content of the original document or reports incorrect information or is logically disconnected, is considered incorrect. The other criteria got a lower weight of 4. Such weights reflect a subjective evaluation of the relative importance of the five qualitative criteria.

Table 3: Scores obtained by the summaries provided by ChatGPT

Summaries	Alignment	Comprehension	Coherence	Cohesion	Lexical competence	Average
Scientific (IT)	5	4	4	3	5	4.13
Scientific (EN)	3	3	4	5	4	3.70
Not scientific (EN)	3	2	3	4	4	2.97
Not scientific (EN)	4	3	4	3	5	3.70
Not scientific (IT)	3	3	4	4	4	3.57
Not scientific (IT)	4	4	4	4	5	4.13

Finally, the scores relating to the four tools were calculated for each criterion. Figure 2 shows the scores obtained in relation to coherence.

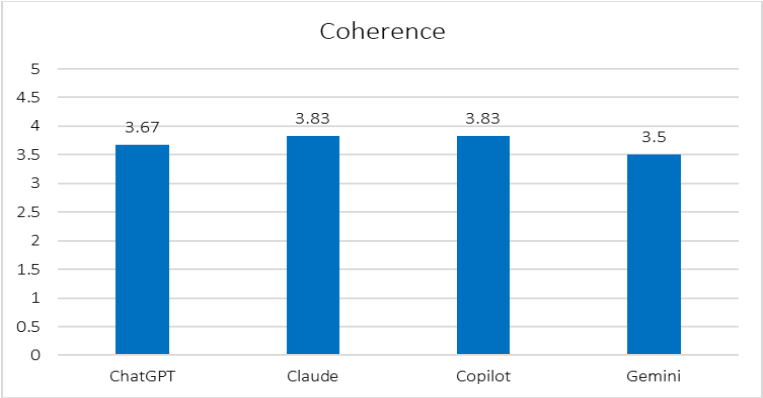


Figure 2: Coherence score

Having calculated the score obtained by each system in each criterion, we calculated the total score of the qualitative analysis as the weighted average score on the five criteria (Fig. 3).

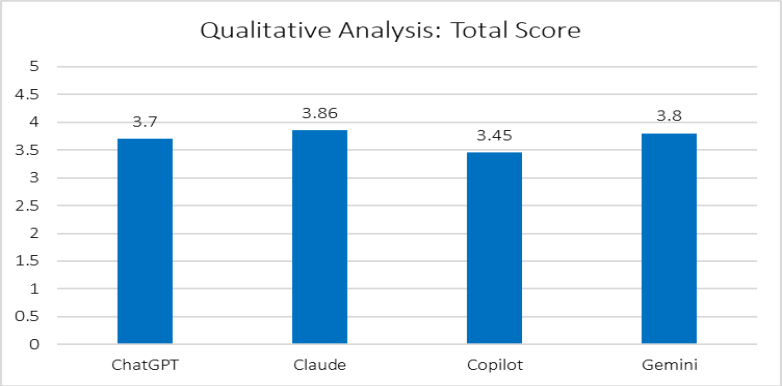


Figure 3: Total scores of the qualitative analysis

Regarding the quantitative analysis, four different ROIUGE indexes were calculated and then aggregated into an overall score, together with the BERTscore. The resulting scores are shown in Table 4.

Table 4: Quantitative scores

	ROUGE (overall) score	BERTscore
ChatGPT	0.157	0.699
Gemini	0.148	0.689
Copilot	0.168	0,709
Claude	0.171	0.702

Lastly, we compared the summaries in relation to the used language. We did not find major differences between the Italian and English summaries, especially concerning the quantitative analysis.

5. Discussion and Conclusion

The present study has thoroughly examined the topic of GenAI. Specifically, the objective was to evaluate the performance of the main GenAI systems currently used for summarising documents. First, we conducted a general overview of how these systems function. Then, the study's methodology was defined, which involved analysing six articles of different types (scientific and non-scientific), topics, and languages (English and Italian). Finally, the summaries produced by the various systems were analysed using both qualitative and quantitative criteria.

The most relevant results of the analysis are summarised as follows:

- **ChatGPT**: In the qualitative analysis, its summaries achieved the highest scores in linguistic competence. The quantitative analysis revealed that the tool rephrases summaries more than Claude and Copilot.
- **Gemini**: The quantitative analysis indicated that this tool rephrases summaries the most. For this reason, the qualitative analysis's summaries received the best scores for coherence and cohesion.
- **Claude**: The qualitative analysis identified this tool as the best in understanding the original document and capturing its key points. It also achieved the highest scores regarding alignment between the request and the response. The quantitative analysis highlighted that the tool retains the original document's style more closely. Indeed, its summaries contained more details compared to those of other tools.
- **Copilot**: In the qualitative analysis, together with Claude, it achieved the highest scores for alignment between the request and the response. The quantitative analysis results show that the tool tends to maintain the same style and use the words of the original document. However, the composition of the summaries is similar to that of ChatGPT.

Overall, no definitive conclusions can be drawn regarding which tool is the best; however, the results indicate that Copilot's performance is slightly inferior to the others.

Finally, we compared the performance of the tools in producing summaries in Italian and English. The analysis highlighted that linguistic competence is better for summaries in English, whereas logical and reasoning abilities are better for summaries in Italian. However, when analysing the summaries as a whole, no significant differences were found between the two languages.

Compared to already existing literature that mostly compares two different GenAI tools for different tasks, our paper focussed on a typical knowledge management task - document summarization, considering even four main GenAI tools for the evaluation. Furthermore, while most studies use quantitative measures for their comparison, our study combined qualitative and quantitative measures to gain a more in-depth understanding of the GenAI tool performances.

5.1 Managerial Implications

This study focused on analysing the performance of GenAI tools in summarising documents. However, it is important to remember that the overall value of a technology is determined by the sum of technological utility, the availability of complementary goods, and the customer base (Schilling, 2022).

Applying this concept to our case, we have that:

- "Technological utility" refers to the performance of generative AI tools in summarising documents, which was the subject of the analyses conducted in this study.
- "Availability of complementary goods" considers the presence of additional components and the possible integration of the tool within an ecosystem.
- "Customer base" refers to the users of GenAI tools or those using an ecosystem in which a GenAI tool can be integrated.

If an organisation wishes to integrate a GenAI tool within its corporate environment, it should consider all three aspects mentioned above. Therefore, choosing one tool over another should also depend on the business context, not just the intrinsic performance. Below are some illustrative examples.

5.1.1 Microsoft ecosystem

If an organisation decides to fully adopt the Microsoft ecosystem for document storage and management (e.g., using Microsoft Teams to share documents within a workgroup), Copilot would be the preferred choice despite its slightly inferior performance. By purchasing Copilot for Microsoft 365 (the enterprise version), the tool can be integrated into all Microsoft applications such as Word, Outlook, Teams, PowerPoint, etc.

Examples of possible activities include summarising texts directly in Word, generating summary reports from PowerPoint presentations, or summarising conversations in Outlook. Furthermore, access to the Microsoft 365 portal, where all organisational documents are stored, allows AI to perform various operations. The integration of this tool facilitates smoother workflows by reducing the time spent switching between applications compared to using other tools.

Thus, both the ecosystem and the large customer base (many companies use Microsoft applications) play a significant role in the selection.

5.1.2 Google ecosystem

Google Gemini would be the logical choice if an organisation opts to utilise the Google ecosystem for document storage and management fully. The reasons and advantages are similar to those mentioned earlier, as Google Gemini can also be integrated within the Google ecosystem, providing easy and quick access to all Google Workspace applications for summarising documents, presentations, and emails.

5.1.3 Hybrid ecosystems

If an organisation chooses to use a proprietary system (not Google or Microsoft) or a mix of multiple ecosystems for document management, the advantages of a unified and integrated ecosystem would be lost. In this case, ChatGPT or Claude would be the choice. Since OpenAI and Anthropic do not have their own ecosystems for integrating these tools, both are valid options for generating summaries, achieving similar performance.

However, it is interesting that ChatGPT has introduced a feature allowing document uploads directly from Google Drive or OneDrive. The strategies of AI tool developers differ: Microsoft and Google aim to induce users to adopt their ecosystems by integrating AI tools, whereas OpenAI seeks to expand its user base by opening up to the most widely used ecosystems.

Finally, during the study, several topics emerged that were not explored in depth as they were not essential for evaluating the tools' performance. For example, the impact of these tools on organisational processes was not analysed. The research methods themselves offer opportunities for reflection, such as conducting further quantitative analysis using a set of high-quality reference summaries instead of comparing with the original document. Another possibility is to conduct a sample study for qualitative analysis to make the study results statistically significant.

5.2 Future Research Directions

The findings provide valuable insights for future developments. Potential areas for further research include:

- Conducting the study using documents that are not STEM-related.
- Increasing the number of documents analysed to evaluate Claude's performance in understanding scientific journal articles, given that its results differed from those of other documents.
- Conducting a focused analysis of ChatGPT's linguistic competence in Italian, as it achieved unexpectedly high scores compared to other tools.

5.3 Limitations

The study presents some limitations. In particular, as a pilot study only a limited number of tools were compared based on a likewise limited number of documents, given the length of the comparison process, mainly due to the use of qualitative criteria. Another limitation relates to the subjectivity of the qualitative evaluation. Lastly, tools are continuously evolving, and hence, their performance is improving.

Ethics declaration: We did not need ethical clearance for the research referred to in this paper.

AI declaration: We used ChatGPT, Copilot, Claude and Gemini to produce the summaries that were analysed.

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Rethinking Smart Green Cities for Knowledge-Led Urban Innovation

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Abstract: Cities of tomorrow are rethinking on the urban planning, adopting a smart city view to drive green urban innovation and growth. The study aims to elucidate that cities are planning a smart city view to make the city a smart green and knowledge-led urban community, an engine of collaborative spaces for innovation. The study relies on the analysis of one single case study related to the smart city framework as urban planning that aims at designing the future pathway to drive urban innovation. Florence is redesigning the urban planning, adopting a smart city view that supports collaborative approaches in order to make green and wealthy urban spaces and communities. The findings elucidate that cities may identify the smart city framework to make a smart green urban community, leading to the city an engine of social innovation, and developing collaborative pathways that contribute to social innovation and value. The smart city urban planning enables the city to make a smart green community in order to develop knowledge-led urban development and innovation.

Keywords: Smart green cities, Smart communities, Green urban innovation

1. Introduction

The future smart society relies on cities that are able to rethink on green urban innovation and communities (Hu and Han, 2023; Yan, Sun, Shi and Zhao, 2023) by combining knowledge sources, capabilities and technologies (Angelidou, 1997; Knight, 1995), and promoting knowledge-led urban spaces of innovation (Yigitcanlar and Bulu, 2016). The smart city helps the city to develop collaborative pathways (Capdevila and Zarlenga, 2015) and knowledge management practices that contribute to driving community-led and people-driven smart green urban innovation (Israilidis, Odusanya and Mazhar, 2021; Nam and Pardo, 2011).

Cities adopt a smart city vision to make smart urban communities (Eger, 2005), that support collaborative knowledge making and sharing (Israilidis, Odusanya and Mazhar, 2019), leading to urban collaborative ecosystems for innovation (Mora *et al.*, 2023; Dolmans *et al.*, 2023).

Knowledge-based urban development relies on smart cities that enable the city to achieve urban sustainability (Chang *et al.*, 2018), and support the maintenance of urban ecosystems (Yigitcanlar and Teriman, 2015). Smart cities help support green technological innovation and development (Yan, Sun, Shi and Zhao, 2023).

Cities of the future aim at becoming smart green communities, by adopting a smart city planning view to develop knowledge assets for urban innovation (Angelidou, 2015), and understanding the potential of information technology in order to make the city an innovation-driven and knowledge-oriented urban community. Smart urban development relies on cities that are rethinking on smart green urban future (Hu and Han, 2023).

Cities are going smart in order to build a smart green city. The greenness of a city is positively related to the smartness of the city (Bonab, Bellini and Rudko, 2023) as the city's capability to develop collaborative pathways that contribute to social value and innovation within urban communities (Meijer and Bolívar, 2016).

Few studies investigate the role of smart city urban planning as a driver of green urban innovation and issues.

The aim of the smart city plan is to enable the city to make a smart green innovative urban community.

The research question refers to how cities are rethinking the urban future, following a knowledge-led view, shaping the city a socially green innovative urban community that relies on urban knowledge.

The case study concerns the choices drawn by the *Firenze Smart City Plan*. The aim of the smart city framework is to track the itinerary in order to make the city a smart green innovative urban community. The study analyses and elucidates the main issues of the document. Cities are re-planning the urban setting, following a smart city view to drive wealthy and green urban communities that develop knowledge sources to drive innovation.

The aim of this study is to elucidate how smart city urban planning enables cities to rethink on the green urban future, by strengthening multi-actor and knowledge-led collaboration that contribute to urban innovation. The paper is articulated in five sections. After introduction and theoretical background, in the third section, the methodological section follows. Findings, discussion and conclusions are set out.

1.1 Towards Smart Green Innovative Cities. A Knowledge-Led and Collaboration-Driven View

As organisational spaces (Knox, 2010), and arenas of innovation (Zhang and Wu, 2019), cities are pursuing knowledge-led urban spaces of innovation (Yigitcanlar and Bulu, 2016), following a smart city view to ensure better quality of life by strengthening the collaboration for knowledge management and sharing issues (Israilidis, Odusanya and Mazhar, 2019), and leading to open social innovation in long-term horizon (Paskaleva, 2011; Costales, 2022).

Cities of tomorrow will be smart green and collaboration-driven urban communities (Bonab, Bellini and Rudko, 2023; Capdevila and Zarlenga, 2015; Gil-Garcia *et al.*, 2016), by fostering multi-actor collaborative innovation (European Commission, 2012; Sørensen and Torfing, 2018). Smart city policies and approaches help cities to drive collaborative innovation (Capdevila and Zarlenga, 2015).

As smart communities (Eger, 2005), cities develop knowledge sources and capabilities, and support the urban stakeholders to engage in collaborative pathways in order to drive intentional urban development and ensure better quality of life (Knight, 1995; Angelidou, 2017; Meijer and Bolívar, 2016), leading to social innovation issues (Costales, 2022).

Smart city construction does improve green living, production and growth. Thereby, urban planners aim at identifying policies that contribute to smart green urban places (Jiang and Sun, 2025). Smart city strategies and planning help the city to develop knowledge networks and drive urban innovation (Angelidou, 2015). Technologies empower cities to provide a meeting space for knowledge creation and sharing, by encouraging and nourishing the collective knowledge (Edvinsson, 2006), and supporting a culture of openness, collaboration, by promoting knowledge sharing skills (Capdevila, 2019).

The smart city framework is emerging as an innovation-driven strategy to achieve green development and support social green urban spaces (Jiang and Sun, 2025; Hu and Han, 2023).

Planning smart urban development relies on promoting bottom-up initiatives, and enables the cities to become intelligent, innovation-driven and knowledge-led urban communities (Komninos *et al.*, 2019; Dameri, Ricciardi and D'Auria, 2014; Israilidis, Odunsanya and Mazhar, 2021).

Smart city design may contribute to qualitative urban change, leading to collaborative processes that make healthy urban future, and improve the quality of life (Meijer and Thaens, 2018; Mora, Deakin, Reid and Angelidou, 2019).

Smart city planning helps the city to design smart green policies for urban innovation and community development (Israilidis, Odusanya and Mazhar, 2021; Macke *et al.*, 2018).

Cities are following a smart city approach to redesign the urban planning in order to support knowledge management practices that contribute to driving green urban development and innovation (Chang *et al.* 2018; Yan, Sun, Shi and Zhao, 2023). Smart city relies on knowledge generation, dissemination and absorption as enablers of innovation (Han, 2025). The smart green city helps to drive the city a smart innovative and knowledge-led urban community (Bonab, Bellini and Rudko, 2023). Implementing the smart city helps the city to make smart open and accessible urban spaces for everyone willing to contribute to urban social value (Obringer and Nateghi, 2021).

2. Methodological Section

The study has employed a qualitative, descriptive and exploratory methodology to analyse how cities are adopting a smart city framework to drive green urban innovation. The study focuses on one exploratory and illustrative case study concerning the city of Florence which is re-planning on the urban design, and following the smart city framework to drive green urban innovation and growth. The smart city framework aims to provide an exploratory and illustrative case study with regards to a city which is combining the potential of smart city applications and policies with the opportunity to drive green urban innovation and communities. The case study helps to explore and provide a comprehensive understanding of a phenomenon still in progress and emerging in contemporary times, whereas the boundaries between the phenomenon and the context are not clearly evident. The case study methodology follows an empirical inquiry without the rigidity of a predefined structure for observations and analysis (Yin, 2009). The study relies on the analysis of the official document related to the municipal urban planning framework. The research method has involved case selection and data collection from the policy document related to the smart city strategy framework *Firenze Smart City Plan* as the main data and information source to be collected and analysed. The future urban development relies on urban planning as a

platform that helps combine smart city approaches and green views as drivers of the city, an urban community and engine of urban innovation and social growth. Investigating the role of the smart city framework helps to understand the pathway of innovation that cities are following, by adopting a smart city vision and planning to drive knowledge-led green urban growth and innovation (Angelidou, 2017; Angelidou, 2015; Mora and Bolici, 2017; Sancino and Hudson, 2020; Dameri, Ricciardi and D'Auria, 2014).

3. Findings

Smart city planning may help cities to rethink on green urban innovation and growth by employing knowledge management practices. Cities are rethinking on the urban development, following a green view by designing a smart city framework in order to develop the city a social platform to drive community-led and green innovation.

Cities are planning the future urban development by selecting a smart vision to green urban growth and innovation.

In particular, Florence aims at constructing a smart city-led and green urban community which is able to drive urban innovation, by following both a community-led and social innovation view that relies on collaborative as well as knowledge management practices that contribute to urban value creation and innovation.

A smart green urban community relies on encouraging all the urban stakeholders to work together and collaboratively, by enhancing knowledge sharing practices, and rethinking the city a system of interconnected processes that refer to technological, social and human capabilities.

The green urban future and innovation relies on the city which is able to employ the potential of smart city design to make a smart community an engine of innovation and collaborative meeting places among the urban stakeholders.

Florence aims at planning a smart city view to enable the urban community to proactively develop green and eco-friendly policies and services. The urban community aims at becoming an agent of social change and green urban development.

Florence is recognizing the importance of designing effective urban planning as a hub for innovation that aims to support green urban growth, by developing collaborative and knowledge-led practices that involve all the urban stakeholders of the community.

Florence is approaching a smart city view to make urban meeting cooperative spaces that contribute to social innovation, and support the design and the implementation of green and eco-friendly policies that help the city to shape a socially innovative and cohesive urban community.

The role of smart city urban planning is to provide guidelines that contribute to enhancing urban energies, competences and intelligence in order to enable urban spaces for social innovation and change, empowering citizens and the urban community, and supporting private, public and no profit actors to identify innovative solutions for policy and services co-production that help to improve the urban life and the sustainability of a city that is making a smart socially innovative green community.

Firenze is following a smart and green approach to urban planning and future in order to support social innovation within urban communities. In the *Firenze Smart City Plan*, the smartness is emerging as the way by which the city aims at becoming a sustainable, collaborative-led and green urban community. The smart city plan aims at becoming not only a descriptive document concerning subjects, ideas, proposals and guidelines on urban development but also a space for debate, confrontation and social exchange in order to support the urban actors to work together to improve green solutions and policies that contribute to ensuring better quality of urban life.

In the *Firenze Smart City Plan*, the concept of smart green city refers to a city that is continuously changing by constructing new social, urban, and economic responses to environmental and historical pressures, by developing the smartness as a collaborative approach to urban innovation, and leading to green solutions and policies in order to improve the quality of urban life of citizens and communities.

The smart city plan is an open space for debate, confrontation, exchange of information and knowledge that supports all the urban stakeholders to work together. A smart city master plan helps support a green urban vision, relying on knowledge resources, capabilities and competences that several stakeholders provide, by engaging in relational and cooperative exchanges that shape social meeting urban places.

Urban policies help the city to develop smart green urban innovation and growth by promoting collaboration among all the stakeholders that get involved along the urban value chain.

Smart city frameworks rely on promoting open innovation by involving the urban stakeholders (public administration, research centres, cultural institutions, businesses, associations, groups, citizens) to engage in collaboration in order to develop: the *integration* with regards to the competences they get; the *innovation* in terms of development of innovative services and solutions through digital and interactive information technology; the *involvement* as a means to enable stakeholders to work together, identify and implement strategic goals; and the *information* as a way to consolidate the relationships within the urban community.

This findings of the analysis elucidate that the city of Florence is rethinking on a green and smart vision to drive urban future, relying on collaboration as a pillar to enable urban energies and competences of stakeholders that support and construct urban innovation. The smart city framework helps the city to develop a community-led view to green urban innovation, by redesigning the urban planning, and support the city to rethink about the future perspectives of urban growth within urban communities. As a sustainable and innovative community, the city is adopting a smart vision, strengthening the collaborative frameworks, and designing urban collaborative spaces that enable several stakeholders to drive innovation processes in order to improve the quality of urban communities.

4. Discussion and Conclusions

Planning smart city frameworks for designing the urban future helps the city to develop green policies and solutions that improve the quality of urban life, and contribute to urban innovation and growth. The urban planning is becoming a social platform that helps the city to support community-led and collaborative innovation, investing in knowledge sources to make the city a smart green and knowledge-led urban community which is able to drive open collaborative innovation. Cities of tomorrow are planning the urban future to make smart green innovative urban communities, by adopting a knowledge management view to engage urban communities and shape collaborative open urban spaces.

In the city of Florence, the smart city planning focuses on bringing together integration, innovation, involvement, and information as driver of green and social innovation. The smart city framework enables several urban stakeholders to work together in order to make the urban community an engine of social innovation.

The main issue of the smart city planning in Florence refers to the development of collaborative approaches and frameworks that contribute to green urban innovation for sustainable growth, and support community and citizen engagement, and knowledge management practices.

The future development of cities relies on building smart green urban communities, and sharing urban knowledge-led practices. Smart green cities enable the city to develop organisational competences that support collaborative frameworks.

As engines of smart green urban innovation, cities contribute to building smart community-oriented and human-centred open urban spaces, putting the people first, and focusing on human and social capital in order to drive multi-actor collaborative innovation.

There are social, managerial and organisational implications. The smart city planning supports green policies and enables the pathways to drive social innovation. The smart city plan makes the urban community the pillar of smart green policies and fosters the development of urban managerial capabilities. Planning a smart city view enables the city to support green urban growth, leading to social and collaborative innovation, and promoting community development.

Smart city planning helps the city to enhance urban energies and capabilities that enable the urban communities to achieve green issues and mind set within the community. Smart city frameworks help support green, collaborative and knowledge-led urban innovation.

Further research perspectives imply to investigate how Italian cities are planning the future of urban communities, following a smart green city vision and framework to urban innovation and growth, by employing knowledge sources and capabilities in order to enhance collaborative itineraries that contribute to enriching the urban potential for value creation and innovation.

Ethics statement: I declare that any ethical clearance was required for the research.

AI statement: I declare that AI tool were not used to create this paper.

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Multicultural Workplaces and Intellectual Capital: A Case Study in SMEs

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Abstract: In today's globalised business environment, understanding the impact of multiculturalism on intellectual capital management is crucial, particularly for Small and Medium-sized Enterprises (SMEs). This study examines how a diverse workforce influences the effective management of intellectual capital in SMEs, addressing the key challenges these organisations face. The research explores both the benefits and difficulties of such diversity by analysing the effects of a multicultural setting on intellectual capital management and SME performance. Additionally, it examines the dynamics of cultural differences within small and medium-sized enterprises (SMEs) in Tunisia and Portugal. A case study methodology approach is used to thoroughly explore how intellectual capital is managed in a multicultural workplace, providing rich insights into decision-makers' perspectives and practices through a qualitative lens. The findings emphasise the importance of recognising and utilising diverse perspectives and experiences in a multicultural workplace. The study concludes that multicultural workplaces can positively influence intellectual capital when supported by inclusive practices. It highlights that strong cultural intelligence and inclusive leadership are key enablers of knowledge sharing, innovation, and improved organizational performance.This research provides actionable recommendations for small and medium-sized enterprises (SMEs) to enhance intellectual capital management in diverse environments. Moreover, it explores whether a multicultural workforce boosts innovation and organisational performance. By filling a notable gap in empirical research, this study offers valuable insights for academic researchers and practitioners seeking to navigate the complexities of managing intellectual capital in SMEs.

Keywords: Multicultural workplace, Intellectual capital management, Small and medium-sized enterprises (SMEs), Innovation performance, Organizational performance

1. Introduction

The multicultural workplace is rapidly becoming a norm due to globalisation and cross-border labour mobility (European Commission, 2015). As businesses expand internationally, especially small and medium-sized enterprises (SMEs), they increasingly rely on diverse teams that bring together individuals from different cultural backgrounds. This diversity introduces not only creativity and innovation (Herring, 2009; Hofstede, 1984) but also challenges in communication, knowledge-sharing, and the integration of diverse perspectives (Gudykunst & Kim, 2003; Anantatmula, 2010).

In this evolving context, managing intellectual capital (IC), defined as the collective knowledge, skills, relationships, and processes within an organisation (Bontis et al., 2000; Edvinsson et al., 2019), has emerged as a strategic priority. IC comprises three pillars: human capital, structural capital, and relational capital, all of which are influenced by cultural dynamics.

Although the literature has emphasised the importance of IC in driving SME innovation and performance (Tidd & Bessant, 2009; OECD, 2005), there is limited empirical research that links multiculturalism directly to IC management, particularly in non-Western contexts. This paper addresses that gap by exploring how cultural diversity in SMEs affects the management of intellectual capital through an analysis of SMEs in Tunisia and Portugal.

Using Hofstede's cultural dimensions as a comparative lens (Hofstede, 1984), this study examines the intersection between national culture and IC practices in multicultural SME settings. The goal is to highlight how diverse environments can either support or hinder innovation, learning, and organisational performance depending on how cultural knowledge is managed and leveraged (Lauring & Selmer, 2012; Earley & Ang, 2003)

This paper aims to investigate how multiculturalism in the workplace affects the management of intellectual capital in small and medium-sized enterprises (SMEs). It focuses specifically on SMEs in Portugal and Tunisia to provide comparative insights.

To guide this investigation, the following research questions are proposed:

RQ1. How does multiculturalism influence the management of intellectual capital (IC) in SMEs?

RQ2. What challenges do multicultural SMEs face in knowledge sharing and communication ?

RQ3. How does cultural intelligence (CQ) help manage diversity and enhance IC in multicultural teams ?

RQ4. What are the effects of multiculturalism on innovation and organizational performance in SMEs?

2. Theoretical Considerations

Intellectual Capital (IC) has become a central concept in organisational research, especially in the context of knowledge-driven economies. Defined as the collective intangible resources of an organisation, IC is generally divided into three interrelated components: human capital, structural capital, and relational capital (Bontis, 1998; Edvinsson et al., 2019). Human capital refers to the skills, expertise, and competencies of employees; structural capital includes organisational routines, databases, and intellectual property (Sveiby, 1997); and relational capital relates to external relationships with customers, suppliers, and partners (Nahapiet & Ghoshal, 2009).

While large corporations often have established systems for managing intellectual capital (IC), small and medium-sized enterprises (SMEs) frequently face resource constraints that limit their ability to develop and leverage these assets effectively (Durst & Edvardsson, 2012; Anand et al., 2020). Nonetheless, literature shows that IC plays a critical role in supporting SME innovation and performance when managed strategically (Muda et al., 2020; Stewart, 1991).

In parallel, the growing multiculturalism of today's workforce has introduced both opportunities and challenges to IC management. Diverse cultural backgrounds within teams can enrich the organisation with varied perspectives, problem-solving approaches, and creative ideas (Ozgen et al., 2011; Adler & Gundersen, 2008). However, without inclusive systems in place, this diversity may also lead to misunderstandings, reduced cohesion, and communication barriers (European Commission, 2020; Okoro, 2012). Communication challenges, especially in multicultural teams, are well documented and can include language barriers, differing norms of interaction, and contrasting expectations (Gudykunst & Kim, 2003; Sue & Sue, 2016; Muir, 2007). These barriers can ultimately sharing and collaboration, core mechanisms for leveraging intellectual capital.

To better understand these dynamics, Hofstede's (1984) cultural dimensions framework provides a useful comparative lens. By examining differences in power distance, individualism versus collectivism, uncertainty avoidance, and other cultural traits, researchers and managers can identify how national cultures shape workplace behaviour and IC practices (Taras et al., 2010). Additionally, the concept of Cultural Intelligence (CQ), defined as one's ability to function effectively in culturally diverse situations, has been proposed as a crucial capability for leaders and employees in multicultural organisations (Earley & Ang, 2003; Ang & Van Dyne, 2015).

From a strategic management perspective, diversity management theory emphasises the value of recognising, respecting, and leveraging individual differences to enhance organisational effectiveness (Lauring & Selmer, 2012; Madhani, 2010). This aligns with the resource-based and knowledge-based views of the firm, which posit that intangible assets, such as intellectual capital (IC) and cultural diversity, can drive competitive advantage when effectively integrated into organisational processes.

Finally, innovation performance theory highlights the importance of IC and multicultural collaboration in fostering innovation. Research has shown that culturally diverse teams can outperform homogeneous ones in generating novel ideas, provided that appropriate knowledge management practices are in place (Tidd & Bessant, 2009; OECD, 2005; Herring, 2009). Effective knowledge management, therefore, becomes essential for SMEs seeking to transform diversity into innovation through structured knowledge-sharing and inclusive leadership (Davenport & Prusak, 1998; Jordão & Novas, 2022; Anantatmula, 2010).

3. Methodology and Data Sources

To explore the influence of a multicultural workplace on intellectual capital (IC) management in SMEs, a qualitative research design was adopted, specifically using a multiple case study approach as recommended by Yin (2014). The study focused on SMEs operating in Portugal and Tunisia, leveraging their distinct but comparable multicultural dynamics. Eight participants were selected through purposive sampling to ensure a diverse range of national and professional backgrounds relevant to the research topic. The sample included individuals from Portugal, Tunisia, Ukraine, Morocco, and France, with roles in senior and middle management as well as operations. Data collection involved remote semi-structured interviews conducted between July and August 2023, using a carefully tested interview guide that ensured relevance and clarity. The interviews explored themes such as knowledge sharing, cultural challenges, and IC practices. Ethical considerations were rigorously

followed, including informed consent and data confidentiality. Thematic analysis was applied to the interview transcripts to identify common patterns and draw insights into how cultural diversity affects the management of IC. This methodology allowed for a nuanced understanding of the real-life dynamics within SMEs in multicultural environments and supported the study's aim to contribute both theoretically and practically to knowledge management and organisational behaviour research.

4. Data Analysis

This section presents the main findings of the study based on semi-structured interviews with professionals working in multicultural SMEs in Portugal and Tunisia. Through thematic analysis, several recurring patterns emerged around perceptions of multiculturalism, communication challenges, cultural intelligence, and the impact of diversity on the management of intellectual capital. The analysis offers both cross-country insights and shared experiences that reveal how cultural diversity can influence organisational practices and outcomes.

4.1 Sample Characterisation

The study examined a total of eight participants working in SMEs, split evenly between Tunisia and Portugal. Participants represented diverse nationalities—Portuguese, Tunisian, Ukrainian, Moroccan, and French—and occupied roles in senior and middle management as well as operations. The average participant age was approximately 28.5 years, with experience in current roles ranging from 1 to 5 years. The work arrangements also varied: five participants worked in a hybrid setting, two on-site and one remotely. This diversity ensured a rich, multifaceted perspective on how multicultural dynamics affect the management of intellectual capital.

4.2 Perceptions of Multiculturalism

Interviewees unanimously acknowledged the multicultural nature of their countries and work environments. In Portugal, the presence of immigrants from Eastern Europe, Africa, Asia, and South America was widely cited, while in Tunisia, the interplay between Arab-Berber heritage and other cultural influences like Jewish and European traditions was emphasised. The varying degrees of workplace diversity reflect broader societal multicultural dynamics and confirm that both countries are ideal for studying multicultural effects on IC management.

4.3 Communication and Collaboration Challenges

One of the core challenges identified was communication. Language barriers were mentioned but not deemed significant, as most workplaces had adopted a common working language. However, deeper communication issues stem from cultural differences in communication styles—such as directness versus indirectness and differing feedback norms—which can impact the sharing and development of intellectual capital (W. B. Gudykunst & Ting-Toomey, 1988; Hall, 1976; Hofstede, 1984). Despite these hurdles, respondents expressed an overall positive outlook, highlighting their companies' inclusive practices and open communication strategies, including regular meetings, team-building activities, and informal knowledge exchanges.

4.4 Cultural Intelligence and Learning

Participants across both regions emphasised the importance of cultural intelligence (CQ) in managing a diverse workforce. Effective leadership in multicultural environments was attributed to cultural awareness, openness to learning, and intentional exposure to different working styles (Earley & Ang, 2003). Strategies to foster CQ included educational programs, mentorship, cross-functional team projects, and multilingual collaboration. These approaches not only improved day-to-day communication but also enhanced overall team cohesion and innovation capacity.

4.5 Cross-Cultural Dynamics and Inclusion

Thematic analysis revealed strong efforts by organisations to create inclusive environments, with a specific focus on knowledge sharing and mutual respect. Respondents noted that cross-cultural understanding enriched decision-making and enabled more innovative solutions. While Tunisia showed a tendency toward more structured, hierarchical practices, Portugal displayed more openness to decentralised approaches. These differences affected how intellectual capital was managed, particularly concerning decision-making and innovation strategies.

4.6 Organisational Performance and Intellectual Capital

Overall, the participants agreed that a multicultural workplace positively contributes to the development and utilisation of intellectual capital. The integration of diverse viewpoints fosters greater creativity, stronger problem-solving skills, and a broader skill base (Herring, 2009; Cox et al., 2019). Respondents reported enhanced adaptability and innovation, which led to improved organisational performance. This aligns with studies emphasising the role of cultural diversity in fostering a more dynamic and high-performing work environment (Martins & Terblanche, 2003; Alvesson & Sveningsson, 2015)

4.7 Summary of Key Themes

To enhance the clarity and accessibility of the findings, the table below summarises the key themes that emerged from the interview analysis, along with brief descriptions and participant quotes that illustrate these insights.

Table 1: Summary of Key Themes from Interview Data

Theme	Description	Illustrative Quotes
Knowledge Sharing	Participants emphasised the importance of trust and communication in multicultural teams.	"Trust is the foundation—without it, knowledge is hoarded."
Cultural Challenges	Differences in communication styles and cultural misunderstandings created friction.	"Sometimes what's polite in one culture is rude in another."
Inclusive Leadership	Effective management of IC waslinked to leaders who promote inclusion and open dialogue.	"Our manager values every voice, no matter the background."
Innovation through Diversity	Cultural diversity was viewed as a source of creativity and innovation.	"We come up with better ideas because we all think differently."
Human Capital Development	Diverse teams encouraged mutual learning and professional growth.	"I learned so much from my colleagues from different countries."
Structural Capital Practices	Documentation and internal systems supported knowledge retention and sharing.	"We use shared platforms to make sure everyone stays informed."

5. Conclusion and Limitations

This paper examined how multiculturalism affects the management of intellectual capital (IC) in SMEs, using qualitative interviews conducted in Portugal and Tunisia. The study explored how multicultural teams influence knowledge sharing, communication, innovation, and organizational performance within SMEs.

The findings show that multiculturalism positively contributes to the development of human, structural, and relational capital when managed effectively. Participants noted that diverse cultural perspectives can lead to stronger collaboration, more creativity, and improved adaptability in dynamic environments. However, communication challenges and differences in feedback and working styles were highlighted, especially in settings lacking inclusive practices.

Cultural intelligence emerged as a key factor in managing diversity. Organizations that actively promote cultural learning, inclusive leadership, and mentorship practices are better equipped to harness the benefits of multiculturalism.

Regarding innovation and performance, the results indicate that multicultural workplaces foster broader ideation, faster learning, and increased problem-solving capabilities, particularly when supported by intentional diversity strategies.

Overall, this study confirms that multiculturalism, when strategically embraced, can be a powerful asset for SMEs seeking to strengthen their intellectual capital and improve long-term performance.

Despite its contributions, the study has several limitations. First, the small sample size limits the generalizability of findings across broader SME contexts. Second, the study focuses on only two countries, which, although culturally distinct, may not capture the full spectrum of multicultural workplace dynamics. Lastly, due to the qualitative design, the study is exploratory in nature and would benefit from future research using quantitative methods to validate and expand on the findings.

Data Availability Statement: The interview script can be made available by the paper's authors upon request.

Ethics Declaration: This study did not require ethical clearance, as it ensured the anonymity of all participants and obtained their informed consent prior to conducting the interviews.

Declaration of AI Tools: In this article, the authors utilised an AI tool to assist with language refinement and grammar checks. The authors reviewed and verified all AI-generated content to ensure its accuracy and integrity and take full responsibility for the final manuscript.

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Decentralizing Knowledge Management: Affordances and Impacts - Revisited

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Abstract: This paper updates a 2019 EJKM article (Electronic Journal of Knowledge Management). Rather than divergently analysing and differentiating knowledge management (KM) perspectives of real-world observations, the two publications aim for a convergent synthesis of corroborated models and terminologies to provide a holistic systemic base for comprehension and system design. Based on conceptual analysis and design science research, the original paper amalgamated twelve renowned models of dynamic knowledge creation in a three-dimensional 'public-transport-like' map. This update integrates four further models; it also demonstrates the map's application for benchmarking the affordances of a more knowledge-worker-centric KM System approach (KMS) currently developed as a digital knowledge co-creation platform in a start-up environment. To attest to the platform's mission for serving community members typified by diverse individual abilities, contexts, means, and ends (ACME), its envisaged functionalities were aligned to the map's pathways to identify unserved areas as well as verify compliance with requirements of KM standards and practices. Accordingly, this paper contributes to the intersection of KM, KMS design, and digital transformation (including educational technologies). As part of a longitudinal stream of research and publications, it also provides feedback on lessons learnt experiences often lacking in the KM and KMS fields corpora and may inspire or warn other scholars and entrepreneurs attempting to switch from path dependencies to path creation.

Keywords: Knowledge management, Dynamic knowledge management models, Digital platform ecosystems, Personal knowledge management system (PKMS), Knowledge co-creation, Memetics, Boundary objects (BO)

1. Dynamic Knowledge Management Model Mapping

Traditional theoretical lenses at the heart of current organizational knowledge management approaches have been explored in a EJKM-article (Schmitt, 2019a) covering twelve renowned dynamic models of knowledge creation. Rather than focussing on their particular differences, the conceptual analysis and design science research (Schmitt, 2016) focused on their complementing features and visualized them in a three-dimensional dynamic 'public-transport-like' map as an expanded version of Boisot's three-dimensional information or I-space (Boisot, 2004). Table 1 and Figures 1 and 2 modify the original representations as follows:

- Four more models have been added (m-p) to all three exhibits.
- The Figures' colour scheme has been modified together with some minor spatial adjustments to better accommodate the extended visualizations of the added systemic features.
- The amended original 3D-Map has been flipped horizontally to better fit flows and logistics.

Table 1: Integration of 16 Knowledge Creation Frameworks; based on (Schmitt, 2019, table 2) with m-p added

Legend (copied also in Figure 1):		Table & Figure	
Knowledge Creation Theories/Models:	**Sources:**	**T:1**	**F:234**
Information-Space, SLC, Knowledge Assets	(Boisot, 2004)	a	a
SECI-Spiral, Ba, Knowledge Assets	(Nonaka and Takeuchi, 1995; Nonaka, Toyama and Konno, 2000)	b	b, d6
Three Worlds	(Popper, 1978; Gaines, 1989)	c	c
'Seven Waterfalls', ARME, and OEAM Spirals	(Wierzbicki and Nakamori, 2007b, 2007a; Nakamori, 2011)	d	d, d0-d9
Foraging and Sensemaking Process	(Pirolli and Card, 2005)	e	e
Experiential Learning Model	(Kolb, 2014)	f	f
Holistic KM Framework	(Yang, Zheng and Viere, 2009)	g	g
Tacit and Explicit Knowledge	(Collins, 2010)	h	h

Self-Transcending Knowledge	(Uotila and Melkas, 2008)	i	i
Inferencing: Abduction Induction Deduction	(Shank and Cunningham, 1996; Chow, Jonas and Schaeffer, 2009)	j	j
Cumulative Synthesis	(Usher, 1954, 2013)	k	k
Memetic Evolution	(Dawkins, 1976, 2006)	l	l
Extended C-K-Design Theory	(Carvajal-Pérez *et al.*, 2018)	m	m
Orders of Ignorance	(Armour, 2000) aligned to (Kerwin, 1993; Schamanek, 2012)	n	n
Minimal Viable Product (MVP)	(Dennehy *et al.*, 2019)	o	o
Exaptive Bootstrapping	(Lane, 2011, 2016)	p	p
# Letters correspond to notions (table 1, fig. 2, 3, 4) and cycle phases (Figure 1) which may be followed by a lower capital letter to indicate sequence or sub-notions depicted.			

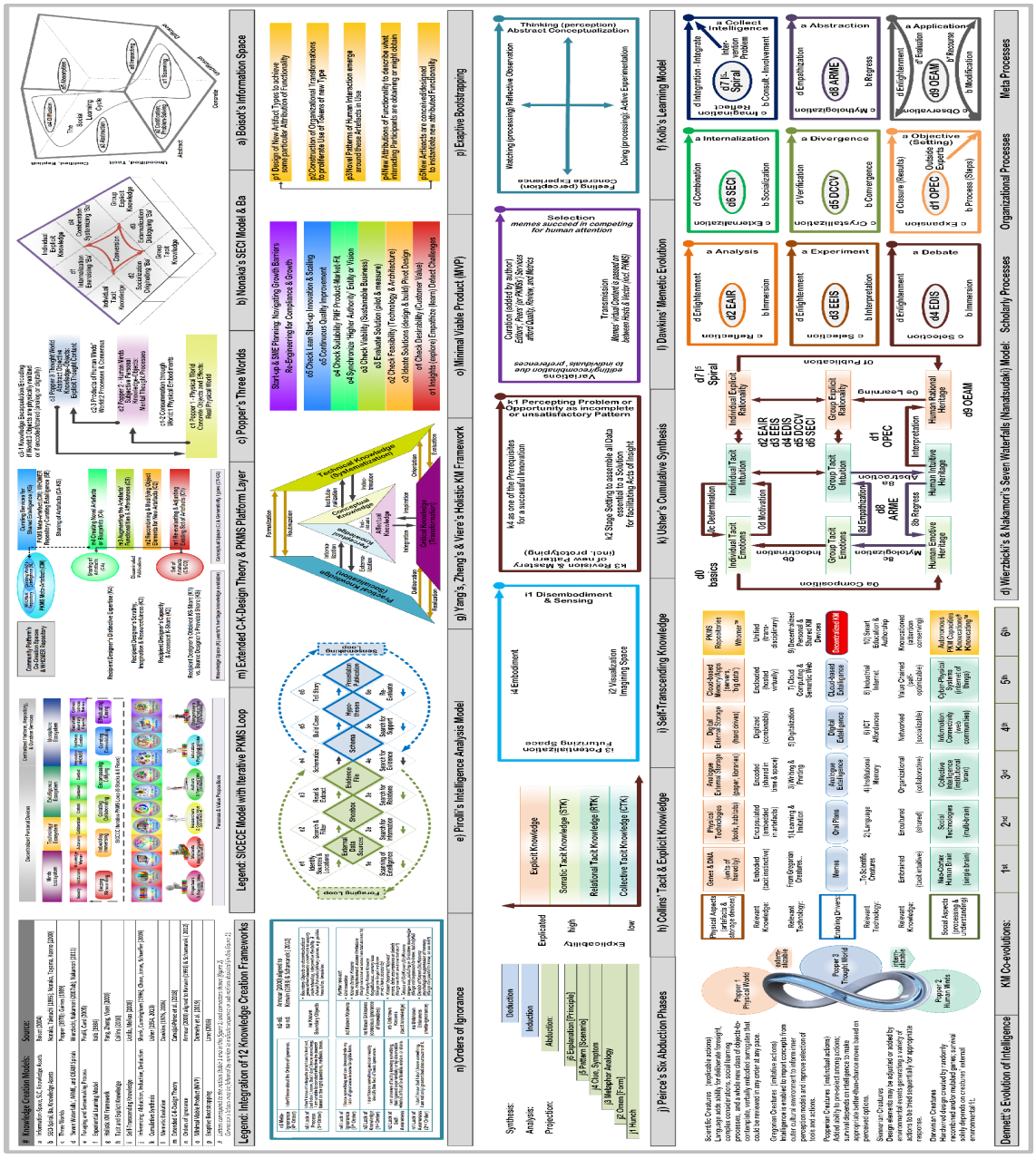


Figure 1: Extended original mapping of individual dynamic KM models (based on (Schmitt, 2019, Figure 2))

Figure 1 depicts the models covered in Table 1 individually, while Figure 4 provides the full 3-D mapping (synthesized theoretic dynamic KM model with their application in platform for knowledge co-creation). As even a full-page coverage presents a dense visualization, figures 1 and 4 are available in high-density poster format on the author's site for download (https://www.researchgate.net/profile/Ulrich-Schmitt/research). They are supplementary resources attached to this paper, and figure 4 is further provided as a version only showing the models and as a transparent overlay of the application (see thumbnail figures 2 and 3). Although the thumbnails 2 and 3 are illegible, their combined figure 4 and the downloads provided are, so the text further refers to them. With the downloads available, textual details have been added in smaller fonts.

The aim of the original article was to highlight the synergies between the dynamic KM models and to portray the intellectual capital landscape as a dynamic, multilevel, and complex ecosystem. It further served to 'think outside the box' of organizational knowledge management systems (OKMS) for easing the positioning and conceptualization of personal knowledge management systems (PKMS) approaches. OKMSs can be described as monolithic, centralized, top-down, heavy-weight, high-investment-and-maintenance systems with a fairly homogeneous user/client-base and a lacking integration of content-and-collaboration-focussed KM schools (as described by Earl's taxonomy (Earl, 2001)) (Schmitt, 2023).

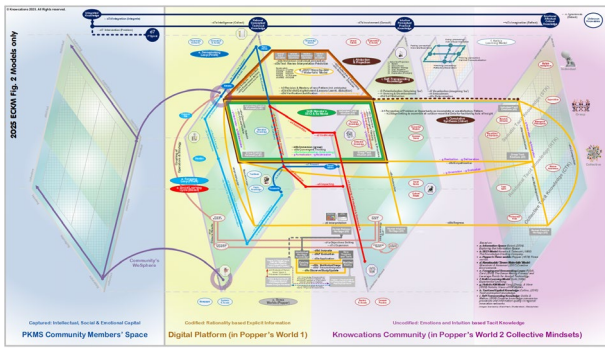


Figure 2: Modified original 3D-mapping of dynamic KM models (based on (Schmitt, 2019, Figure 3)

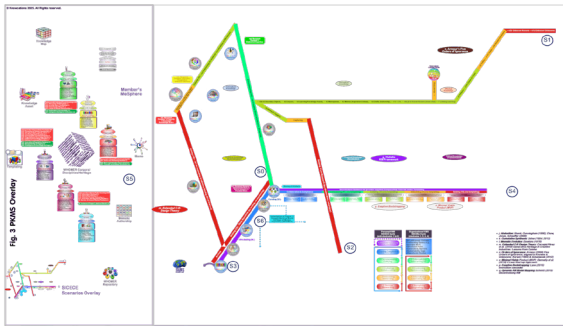


Figure 3: Overlay to be superimposed on original Mapping (Figure 2) for Consolidated Map (Figure 4)

The PKMS/CoCreation-Platform mission aims for an innovative KMS type of distributed, decentralized, bottom-up, affordable, knowledge-worker-centric application prioritizing personalization, mobility, generativity, and entropy reduction; its goal is to serve a knowledge-co-creating community characterized by highly diverse abilities, contexts, means, and ends (ACME) (Schmitt, 2023) facing increasingly volatile, uncertain, complex, and ambiguous challenges (VUCA) (Mack *et al.*, 2016).

As the research, design and prototyping have progressed (with a start-up complementing the academic project), it seems fitting to revisit and augment the original mapping to illustrate how the novel approach supports and impacts the various 3D-map-levels, from individual and team to institutional and societal scales. Visualizing the dynamics and interconnectedness of the digital ecosystem elements does not only guide and validate the development efforts but also establishes chains of evidence for compliance with standards. Although the PKMS differs considerably from OKMSs, a recent article (Schmitt, 2022) made the case that the maiden ISO 30401:2018-KMS Standard is still applicable (ISO.org, 2018); equally applicable is the recently introduced DQ standard (IEEE, 2021; DQ Institute, 2024) with its thirty-two 'Digital Intelligences' supporting sustainable personal and community development.

In addition to supporting the conceptual and visual communication, the contributions of this paper align theory, research, design, instantiation, and operational considerations and provide an updated boundary object (map) to analysts, designers, and implementors facing similar development and documentation complexities. The paper is structured as follows: After briefly recapitulating the prior dynamic KM models utilized (2.1), the adapted emphasis on former and new models is highlighted (2.2); an overlay is introduced to be superimposed on the existing map representing the PKMS internal and external flows and affordances as distinct user-related application scenarios (3.0-3.6), to be followed by a look at impact with conclusions (4).

2. Consolidated Dynamic KM Model Perspective

The initial map's "topography emphasizes how the models represent the external environment in which the PKM devices are expected to operate in and which of the workflows suggested are suitable for supporting the internal PKMS processes". Its initial aim has been "to proactively ease the challenging tension between the PKM and OKM perspectives […] for gaining system acceptance, [for] providing transparency of existing approaches with their shortcomings, and [for] instructions and visualizations of how new features fit into the current KM landscape" (Schmitt, 2019a, pp.115-116, 118).

2.1 3D-Map's Layout with Initially Integrated Twelve Models

This sub-section cites the introduction of the applied model layout (Schmitt, 2019a, pp.118-119); further details concerning the initial twelve models (a-l) are provided in the EJKM article. Due to the horizontal flipping of the map the positioning of components needed to be adjusted as indicated with [square brackets]:

- *Layout-defining Models:* "Boisot's three-dimensional Information-Space [a] forms the base of Figures [2, 3, and 4]. With its codification axis tipped horizontally and divided in four sections (from left to right: [captured: PKMS intellectual, social & emotional capital; codified: rationality based explicit information; uncodified: emotions and intuition based tacit knowledge]), its diffusion and abstraction axes provide the lattices for positioning the other eleven notions [b-l]. However, only Boisot's Social Learning Cycle (SLC) [a] and Pirolli's and Card's Foraging and Sensemaking Loops [e] align to the latter axis (from concrete to abstract) and appear dispersed over the full sections, whereas the remaining models are all placed in the middle of the abstraction axis and spread only across the diffusion dimension (from top to bottom: undiffused-individual, diffused-group, diffused-collective-organization-community-society). Eight icons (octagons) symbolize the relevant knowledge types in each corner (in line with the tacit/explicit, concrete-abstract, and diffused/undiffused combinations) supported by the exemplification of knowledge assets (ellipses). The three segments along the diffusion axis of the left section (uncodified-tacit-emotional) also corresponds to Collins' differentiation of tacit knowledge and its explicability [h]. Kolb's Experiential Learning Model [f] is displayed at the top between the two [right] sections to avoid illegible overlays, while Popper's Three Worlds Notion [c] is placed at the mid bottom and linked to the notions of Heritage Knowledge".
- *Transcending KM Models:* "Wierzbicki's and Nakamori's Spirals [d] which integrate Nonaka's SECI-Spiral [b] are stretching from top to bottom across all the three [right] sections. Yang's Holistic KM Framework complements the map by adding terminology and further connections [g] although some terms (namely: internalization, externalization, and indoctrination) are used differently. Uotila and Melkas link self-transcending knowledge [i] to the SECI Spiral by incorporating processes of disembodiment (sensing) and embodiment (located between the two left individual tacit sections) for visualizing (imagining 'ba') and subsequent potentializing (futurizing 'ba') the presence of potentials which do not yet exist. This emphasis on intuition leads straight to Shank's and Chow's conception of abduction with its six levels of inference [j] complementing the induction and deduction approach."
- An introduction of the *PKMS-shaping Models* (Usher's Cumulative Synthesis [k] and Dawkins' Memetic Evolution [l]) and of their *Memetic PKMS Context* is provided in the EJKM-article (Schmitt, 2019a).

2.2 Adapted Emphasis and Added Models

Further emphasis has been placed on model (g) Holistic KM Framework (HKMF)' (Yang, Zheng and Viere, 2009) as its terms and landscape supports the further segmentation as well as integration of the scenarios to be presented in section 3. With its focus on change, the HKMF provides a compass for navigating the interdependent technical (TK: explicit), practical (PK: tacit intuitive), and critical (CK: tacit emotional) knowledge domains.

The model m (Extended Concept-Knowledge Design Theory (CKDT) (Carvajal-Pérez *et al.*, 2018)) was not known to the author at the time of publishing the EJKM article. It segregates the CKDT approach into four steps which closely match the first four phases of the PKMS's SICECE cycle (see section 3.0). Its empirical findings motivating the CKDT's four-step-framing-refinement were based on a case study of three famous French "cuisine books, written by important chefs that were eager to share their knowledge heritage and generativity with their colleagues". The results promote the notion of "transfer of resources for creativity" by applying known objects in the "elaboration of still unknown objects" and by sharing knowledge resources as well as the capacities to use them ("creative spirit") (Carvajal-Pérez *et al.*, 2018, p.1523,1524 ; Schmitt, 2020).

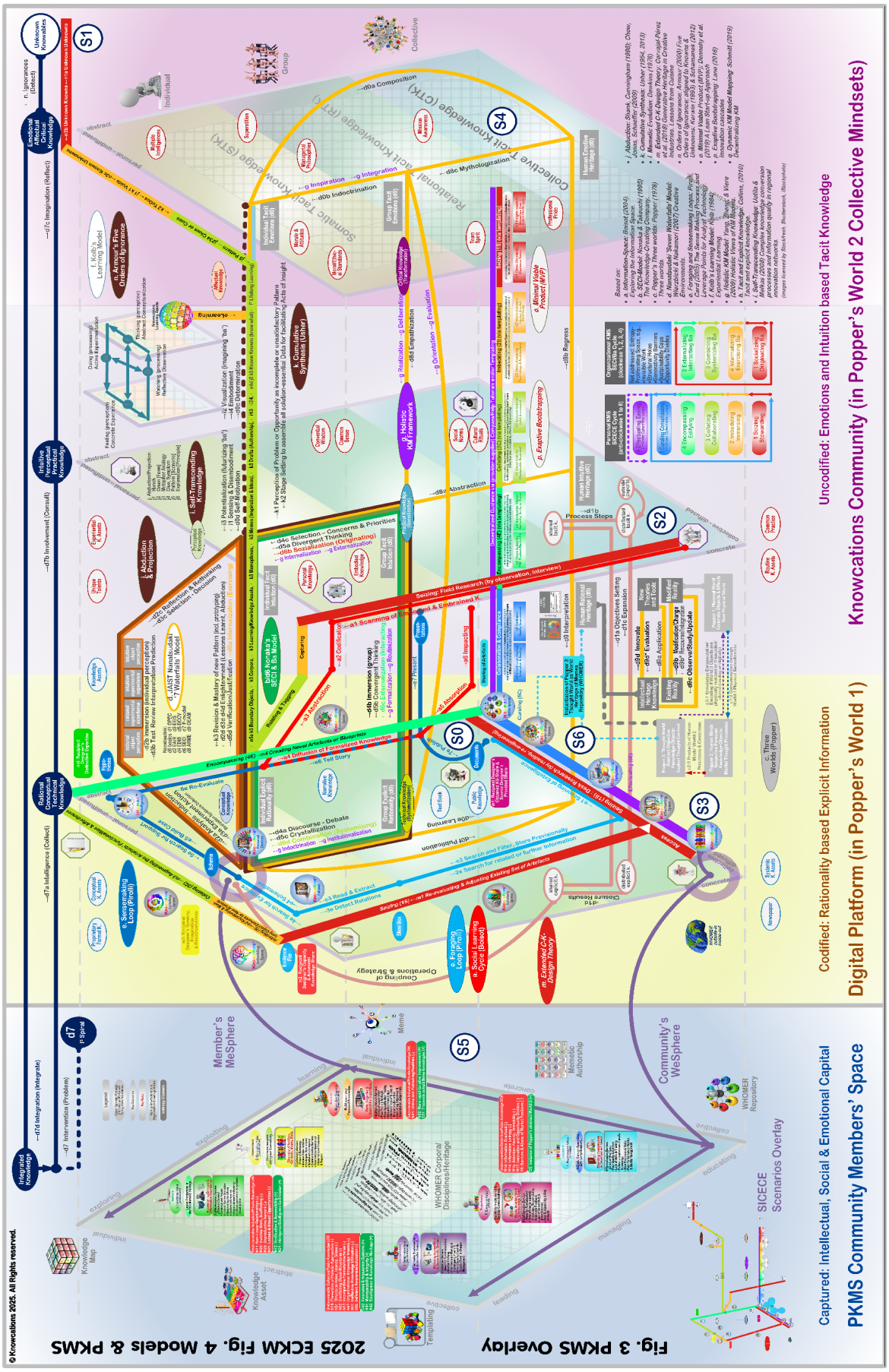


Figure 4: Original Mapping (Figure 2) with superimposed Overlay (Figure 3) based on (Schmitt, 2019a)

This creative-spirit-transfer-notion augments the concept of boundary objects (BO), defined as decontextualized generalized memetic constructs to amplify understanding, interpretive flexibility, and shared transdisciplinary spaces, e.g. guides, heuristics, templates (Star, 2010; Schmitt, 2020). The provision of BOs is a recent addition to the scope of PKMS features and is currently being integrated in the prototype. It is represented in the map as the S4 scenario (see section 3.4). The other three models (n, o, p) have been added to provide further insights and/or examples for the scenario presented in 3.1 (S1: *Individual Generativity and Creativity*). Scenario S1 extends the stand-alone or community version by focussing on generative and creative authorship. The relevant flows are depicted in the top-right sections utilizing three added frameworks (nop):

- (n): The original Ignorance Matrix (Kerwin, 1993) and Ignorance Map (Schamanek, 2012) to cross-reference Knowns and Unknowns have been expanded as 'Orders of Ignorance' by integrating process knowledge (Armour, 2000). It examines the dynamics of learning, knowledge transfer and wastes and provides a metaphor for self-reflection and managing the development of self and others.
- (p): The exaptive bootstrapping dynamic is addressing "cascades of changes in agent-artefact space" which "inextricably link innovations in artefacts, in organizational structure, and in attributions about artefact and organizational functionality" (Lane, 2011, pp.7-8). Its fourth step links with model k (Cumulative Synthesis (Usher, 2013; Schmitt, 2019b)) and, hence, adds a further dimension to the PKMS's meme-based constructivist knowledge asset/artefact/repository approach.
- (o): A recent case study suggested to amend the original Minimal Viable Product (MVP) heuristic to more easily liaise and 'synchronize' between lean-start-ups and partnering larger organizations (Dennehy *et al.*, 2019). The revised model has been added to exemplify a problem-solving and design-supporting approach and the boundary-object-logistics referred to. It adds one more dimension to the other iterative patterns which apply to both academic and entrepreneurial innovation spaces.

3. PKMS Overlay Representing a PKMS Base and six Application Scenarios

Figure 3 depicts and 4 integrates the overlay representing a PKMS base scenario S0 (users' internal iterative system flows) together with external application scenarios (S1-S6) to be detailed in the six sub-chapters. The visualized PKMS flows adopt the underlying dynamic KM model cycles (as seen in Figure 4's consolidated mapping). They detail the initial 'PKMS (Popper's concrete World 3)' section (left-hand Figure 2) which has been substituted to depict the fifth scenario termed 'PKMS Community Members' Space' (left-hand Figure 4).

The legend for the six-colour-wheel-code is shown in the middle lower section of Figures 2 and 4 headlined 'Personal KMS'; it depicts the (anticlockwise cycle 1 to 6) PKMS's SICECE cycle (Seizing, Imbedding, Collating, Encompassing, Curating, and Effectuating). On its right side, the clockwise SECI/Ba cycle (depicted as model b (Nonaka, Toyama and Konno, 2000) has been added for information only; the SICECE and SECI/Ba differences and synergies have been covered in prior publications (Schmitt, 2022).

The *base scenario S0* in the yellow section is represented by a quadrilateral which represents the SICECE phases as colour-referenced in the legend just referred to:

- 1 Red – Seizing: e1/1e e2/2e e3/3e m1 Re-evaluating & Adjusting Existing Set of Artefacts,
- 2 Yellow – Imbedding: e4/4e m2 Recombining & Modifying Object Elements for New Artefacts,
- 3 Light Green – Collating: e5/5e m3 Augmenting the Artefacts' Functionalities & Affordances,
- 4 Green – Encompassing: e6/6e a4 m4 Creating Novel Artefacts or Blueprints,
- 5 Blue – Curating - specific to PKMS centralized platform services (section 3.6),
- 6 Purple – Effectuating - specific to PKMS centralized platform services (section 3.6).

Bullets 1-4 are system interface options to be iteratively performed by the user during learning and authoring processes; they have been conceptually and empirically validated by complying with KM models e and m (Pirolli and Card, 2005; Carvajal-Pérez *et al.*, 2018) and also contribute to the I-spaces diffusion phase (a4).

While the decentralized steps 1-4 operate on the users' personal content (MeSpheres), the centralized steps 5-6 iteratively consolidate and curate the users' shared content (see 3.6) and make it in-turn available to the community together with added services (see 3.5).

The base scenario is common to all following scenarios as they mainly differ in the way content and knowledge may be obtained by the user. In the base scenario, the most basic PKMS version enables a user to obtain content and information via own enquiry from the outside world and to capture it in the PKMS MeSphere (depicted as the bottom-line 'Seizing: Desk Research (by reading, re-engineering' (e1/1e); it offers just a stand-alone version without the benefits of networking, sharing, and centralized services.

3.1 Scenario 1: Individual Generativity and Creativity

S1 extends the stand-alone or community version by focussing on generative and creative authorship. The relevant flows are depicted in the top-right sections:

- 1 Red – Seizing: ← n2b Unknown Knowns, ← n1a Unknown Unknowns,
- 2 Yellow – Imbedding: ← k2 ToDos ← j1 k1 Voids ← n3c Known Unknowns,
- 3 Light Green – Collating: ← j5 Clues or Cues, ←j234 Pattern,
- ← n4d j6 k3 Known Knowns (know what) ← f* Lifelong Learning)
- ←i3 Potentialization (futurizing 'ba') ←i1 Sensing & Disembodiment
  [→ i2 Visualization (imagining 'ba')] [→ i4 Embodiment]
- ← k3 Memes (Inspiration & Ideas), ← k3 Drafts (Authorship),
- ← k3 Learning/Knowledge Assets, ← k3 Memeplexes,
- ← n5e k3 Boundary Objects, ← k3 Corpora,
- 4 Green – Encompassing: same as in base scenario.

Bullets 1-3 depict the generative and creative value chain of individual knowledge workers starting with the awareness of one's ignorances over lifelong learning activities towards the creation of multifaceted documents (n (Armour, 2000; Kerwin, 1993; Schamanek, 2012); f (Kolb, 2014); j (Shank and Cunningham, 1996; Chow, Jonas and Schaeffer, 2009); k (Usher, 1954)). It also integrates not yet existing potentially utilizable self-transcending knowledge to emerge in the future (i (Uotila and Melkas, 2008)). The PKMS supports the incremental iterative knowledge detection and creation by providing dedicated storage and tags to strengthen cumulative knowledge synthesis from initial void to ever more complex artefacts.

3.2 Scenario 2: Field Research involving External Agents and Environments

S2 extends the stand-alone or community version by focussing on conducting hands-on field research with peers, other agents, or stakeholders in the external environment. The relevant flows are depicted in the middle bottom-up section:

- 1 Red – Seizing: Field Research (observing, interviewing), ←a1 Scanning Embodied/Embrained K.,
- 2 Yellow – Imbedding: Capturing ←a2 Codification,
- 3 Light Green – Collating: Relating & Tagging ←a3 Abstraction
- 4 Green – Encompassing: same as in base scenario.

Bullets 1-3 depict field-research-related activities which correspond best to the I-space's initial phases (a123) (Boisot, 2004). To accommodate this work, the PKMS is able to provide community-shared classification, tagging, and reference lists covering, for example, research subjects (e.g., research fields or socio-economic objectives), industry sectors (e.g. standard industrial classification codes), spaces (e.g., countries, zones, regions, cities, locations, languages, or organizations), and meta-services (e.g., research fields, courses, disciplines classification codes or activity types) which are further extendable by the users.

3.3 Scenario 3: Tapping into the Community's WeSphere

S3 is based on the PKMS community networking option and relies on the centrally consolidated and curated content voluntarily shared by users or offered as part of the provider's services (steps 5-6 in section 3.6). The relevant flow is depicted in the lower yellow section from where it connects to the left blue section representing the PKMS's knowledge base (see 3.5).

- 1 Red – Seizing: Access - specific to PKMS centralized platform services (section 3.6).

3.4 Scenario 4: Provision of Boundary Objects (BO)

S4 is based on the need to overcome barriers to knowledge access and creation. The newly added model m (Extended CKDT Model (Carvajal-Pérez *et al.*, 2018)) has been introduced in section 2.2 and 3.0; it empirically and conceptually determined (in regard to creative-spirit-transfer-proficiencies in the top-culinary-book-space) also substantiates the base scenario of the PKMS's digital space.

The enriching of the PKMS solution pursued involves the creation of BOs (in the initial phase just by the provider) so that users do not have to compose complex document from scratch but are guided and provided with assistance and examples all the way. One of the current cases involves creating a BO for system design documentations which is tested by crafting the specification for the PKMS itself. In this paper, model p and o have been added to the map to demonstrate the general principle. The flows depicted from the bottom-right

to the bottom-yellow section exemplify these KM-and-startup-related models o 'Minimal Viable Product (MVP)' (Dennehy *et al.*, 2019) and p 'Exaptive Bootstrapping' (Lane, 2011):

- 1 Red – Seizing via templating: p1 Conceiving and designing of new artefacts as virtual or physical embodiments for instantiation of newly attributed functionalities/affordances and feedback; o1 Insights (explore) Empathize (learn) Detect Challenges - Check Desirability (Customer Value)
- 2 Yellow – Imbedding via templating: p2 Designing/authoring new artefact types to achieve attributions of functionalities evidenced by content to investigate, innovate, inform, entertain; o2 Ideate Solutions (design & build) Pivot Design - Check Feasibility (Technology & Architecture)
- 3 Light Green – Collating via templating: p3 Constructing transformations [utilizing existing structures, functions, and processes for diffusion (e.g., conferences, publications, web pages)] to proliferate use of tokens of new type by ensuring availability, diffusion, and understanding; o3 Evaluate Solution (pilot & measure) - Check Viability (Sustainable Business)
- 4 Green – Encompassing via templating: p4 Novel interaction patterns [comprehension by audiences for discourses] emerge [altering prior perceptions to trigger new insights] around the artefacts in use [by also promoting other referenced sources and related ideas]; o4 Synchronize 'Higher Authority' Entity or Vision - Check Suitability PMF Product-Market-Fit
- 5 Blue – Collaboration & Compliance: p5 Generating new attributions of functionality by modifying elements and relationships via desk or field/lab research for describing outcomes by participants or observers and by testing newly devised content, blueprints, physical model; o5 Continuous Quality Improvement - Check Lean Start-up Innovation & Scaling

Bullets 1-5 exemplify how methodological guidance and entrepreneurial practices may be linked to generative authorship and design processes for further assisting and supporting cohorts, teams, or institutions including start-ups. The relevance of this PKMS feature is further addressed in section 3.5.

3.5 Scenario 5: The PKMS Community Member and Solutions Space

S5 is based on the client-based segmentation of the envisaged community. The goal is to serve a membership typified by highly diverse abilities, contexts, means, and ends (ACME) as well as to enlist and retain those members to achieve scaling and network effects (Cantner and Vannuccini, 2012). Rather than opting for a separation of customer segments, the PKMS recruitment and retention approach is focussing on career-spanning personas. By fitting the top-individual to bottom-collective partitioning of the map, the left blue upper section introduces three primarily self-focussed personas:

- 1. Students and Life-Long Learners eager to utilize community-shared content for fostering their own personal knowledge and ambitions,
- 2. Researchers who may engage in discourses to co-create new insights with their peers and community,
- 3. Authors who may further share their own novel contributions for leaving footprints in the world's memetic heritage.

While continuing to benefit from these affordances, the personas placed on the left blue lower section may also decide to step outside their personal comfort zones to take collective responsibility for empowering others or engage in matters of transcendental or altruistic impacts:

- 4. Educators for supporting their cohorts,
- 5. Projecteers for managing their teams or entrepreneurial endeavors,
- 6. Changemakers for leading campaigns, institutions, or society.

The sequence of these six personas further represents progressing career roles. As presented in the blue section, each persona has been furnished with specific further attributes including its key value proposition, its key outcome, and its key risks. From the systemic design perspective, each ascending level contributes its own progressing needs, wants, and desires which can be translated into specific functional requirements, physical design parameters, and operative services and performance indicators (which are all informing the system design documentations elaborated on in scenario S4).

The introduction of boundary objectives allows to substitute the main persona-career-steps-construct with other ascending-stepladders; as an example, the areas below the six personas show start-up growth barriers with their challenges of organizational knowledge wastes (Ferenhof, Durst and Selig, 2015). This flexibility

provides the basis for boundary-object-solutions which may address and benefit other entities than just the personas (like start-ups or SMEs who currently also lack access to affordable KMS).

3.6 Scenario 6: The PKMS's World Heritage of Memes Repository (WHOMER)

S6 focusses on the novelty of the knowledge connectedness facilitated by the cloud-based services which consolidate, curate, and feedback the voluntarily shared content and knowledge by and to the community members. Collective viabilities and advances depend on innumerable small knowledge-based 'nano-actions-and-contributions' by individuals (knowledge workers) which govern, if effectively combined, institutional and societal performances (knowledge economy and society) (Wiig, 2011). The PKMS's continuous iterative sensemaking and sensegiving cycles (as presented in scenarios S0 to S5) ensure that chronological chains (as-built genealogies) of original memes and their revised versions are utilized and repurposed by decentralized devices, while the centralized services – after eliminating redundancies and fusing traceabilities – aggregate the shared content and safeguard the associative memetic integrity of its knowledge base, termed World Heritage of Memes Repository (WHOMER). The relevant flows are depicted in the middle bottom-up section:

- 5 Blue – Curating: c* d0 d9* Instantiation of Popper 3: Thought World as WHOMER
- 6 Purple – Effectuating: - specific to PKMS centralized platform services.

In the real-world of models c (Three Worlds (Popper, 1978)) and d9 ('OEAM Spirals' (Wierzbicki and Nakamori, 2007a)) existing and modified realities are studied (c1-3, d9c) to update the heritage knowledge by creating an ever-increasing, attention-consuming, scattered, and entropic information abundance (c3-1). New hypotheses and tools are created (d9d) and evaluated (d9d*), applied and tested (d9a), to incrementally or radically change the reality (d9b, d9b*) in an iterative end-and-relentless cycle.

While most of these flows are also taken place in the (digitally-twinned) decentralized PKMS devices, the PKMS's platform component acts as a game changer: Its memetic knowledge base is constructed to evolve into a "steadily growing (expanding community sharing existent and novel content), single (cloud-noSQL-based), unified (transdisciplinary), negentropic (redundancy-eliminating), concrete, tangible, accessible, and interrogatable archive of an up-to-date knowledge heritage" (Schmitt, 2021, p.16). Consequently, Popper's abstract non-interrogatable World Three is transformed into its concrete tangible interrogatable WHOMER counterpart.

4. Projected Impact and Conclusions

The paper and mapping attempted to demonstrate the PKMS design's versatile potential to cater for people and knowledge connectedness. It argued that the benefits for knowledge workers provide value by supporting their absorptive capacities, generativity, functional facilities, psychological resilience, economic well-being, and transformative muscle (representing the personas' value propositions). A paper-under-review also exemplifies the synergies with the SDG's inner development goals, circular economy, and industrial symbiosis; a paper-in-press presents the platform as a construct of multiple twins. In the latter, the applied metaphor of memes as living organisms (able to represent not only abstract content but the aboutness of concrete agents and entities) is a key factor; it also allows for the repurposing and integration of further dynamic models (for example, from the organizational learning domain) in the future. A patent application is also envisaged.

The scope of this paper has been determined (and limited) by the visuality of mapping sixteen renowned KM-related dynamic models. However, prior papers and articles have already applied other complementing PKMS perspectives which in-turn informed the design efforts and mapping's interpretations, including fore-and-backcasting, visioneering and change, digital platform ecosystems, technologies and AI, entropy and scalability, evolution and sustainability, transdisciplinarians and entrepreneurship, and the future of work and education.

The original EJKM article highlighted the "knowledge worker's central position (marked by a transparent purple donut in the individual segment of the codified-explicit-rational section) [which theoretically] affords him/her full access to the methodological processes described" (Figure 1) (Schmitt, 2019a, p.11). The donut remained in the same position (Figure 4), but the knowledge worker may finally be provided with an adequate tool to use his/her potential - as the World development report (World Bank Group, 2016, p.2) summarized: While "digital technologies have been spreading, digital dividends have not".

Acknowledgements

I would like to express my deepest appreciation to the staff and institutions of the Economic Development Board (edbmauritius.org), the Mauritius Research and Innovation Council (mric.mu), and La Plage Factory

Africatech Business Incubator (laplage.io). The EDB's/MRIC's policies and National SME Incubator Scheme allow entrepreneurs from Mauritius or abroad (like me) to be considered for initially operating in partnership with one of the accredited Mauritian business incubators under the MRIC's aegis.

Ethics declaration: No ethical clearance for the research was necessary.

AI declaration: No AI tools in the development of the paper have been used.

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Operationalizing the Competency Assessment of Organizational Absorptive Capacity: A Case of a Government Organization

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Abstract: This study extends Senivongse's (2023) foundational work on organizational absorptive capacity (ACAP) competency profiling by operationalizing its theoretical insights into a pragmatic assessment framework. Grounded in knowledge management and organizational learning literature, the research develops an operational framework for competency profiling tailored to knowledge workers in organizations transitioning into learning-oriented entities. It synthesizes existing maturity models to propose a competency-based maturity framework, which informs the design of a dual-level questionnaire (managerial and operational) through a Delphi method involving experts in Thai public sector organizational development, human resources, and knowledge management. The methodology employs descriptive statistical analysis and visual analytics (e.g., radar charts, mean graphs) to evaluate competency alignment and gaps within a Thai government agency. Empirical testing reveals granular competency profiles across hierarchical tiers, identifying critical skill disparities and informing personalized development roadmaps for employees. Additionally, the assessment highlights organizational readiness for workforce mobilization and the strategic alignment of role assignments. By bridging theory and practice, this work advances actionable strategies for cultivating ACAP and fostering adaptive capacity in public sector institutions.

Keywords: Absorptive capacity maturity model, Competency assessment, Learning organization, Individual development plan

1. Introduction

Senivongse's (2023) seminal work advances competency scholarship by synthesizing fragmented theoretical perspectives into a unified framework designed to strengthen organizational absorptive capacity (ACAP). The study emphasizes identifying individual competencies to enhance organizational ACAP, offering actionable strategies for human resource (HR) practitioners to develop targeted training initiatives and cultivate a learning-oriented culture. These strategies aim to bolster organizational adaptability in volatile markets, extending practical implications grounded in Senivongse's (2023) research.

The study adopts Todorova and Durisin's (2007) ACAP framework, which refines the foundational constructs by Cohen and Levinthal (1990) and Zahra and George (2002). While ACAP is traditionally conceptualized as an organizational-level capability, Senivongse and Bennet (2024) posit that organizational ACAP emerges from the aggregation of individual competencies. Through recursive processes, these individual-level competencies evolve into organizational capabilities via knowledge creation, sharing, and feedback mechanisms, facilitated by socialization and structural integration.

Methodologically, Senivongse's (2023) draws upon established competency frameworks from prominent scholars, including Bloom (1956), Krathwohl (2002), and Simpson (1966), integrating these with contemporary models from (Hsieh et al., 2019) and Rocha Fernandes et al. (2021). Expert validation underpins the study's findings, advocating for competency management systems that align assessments, developmental interventions, and performance indicators with ACAP objectives. Such systems enable organizations to address skill deficiencies and sustain competitive advantage.

Building on Senivongse's (2023) absorptive capacity competency framework, this research extends its theoretical underpinnings through empirical application. The study seeks to operationalize the competency model within a real-world public sector context—specifically, a Thai government agency—to evaluate its practical efficacy in enhancing organizational ACAP.

2. ACAP Competency Management Model

Senivongse's (2023) competency management model is structured around four core domains: learning capability (cognitive domain), business orientation (affective domain), self-orientation (psychomotor domain), and social intelligence. Collectively, these domains encompass the full spectrum of ACAP development stages: *value identification, knowledge acquisition, assimilation, transformation, exploitation, socialization, appropriability, and feedback mechanisms*. Each ACAP stage is supported by specific competency elements derived from theoretical foundations across multidisciplinary scholarship, with subdomains thematically organized to reflect these interlinkages (see Figure 1).

The model was further refined through integration with Cripe et al.'s (2007) framework, which introduced granular sub-competency indices to enhance precision. To operationalize the framework, two distinct questionnaires were developed: one tailored for organizational leadership (e.g., top management) and another for staff members. Both instruments align with the four primary competency domains, facilitating a dual-perspective evaluation of ACAP alignment within organizational hierarchies.

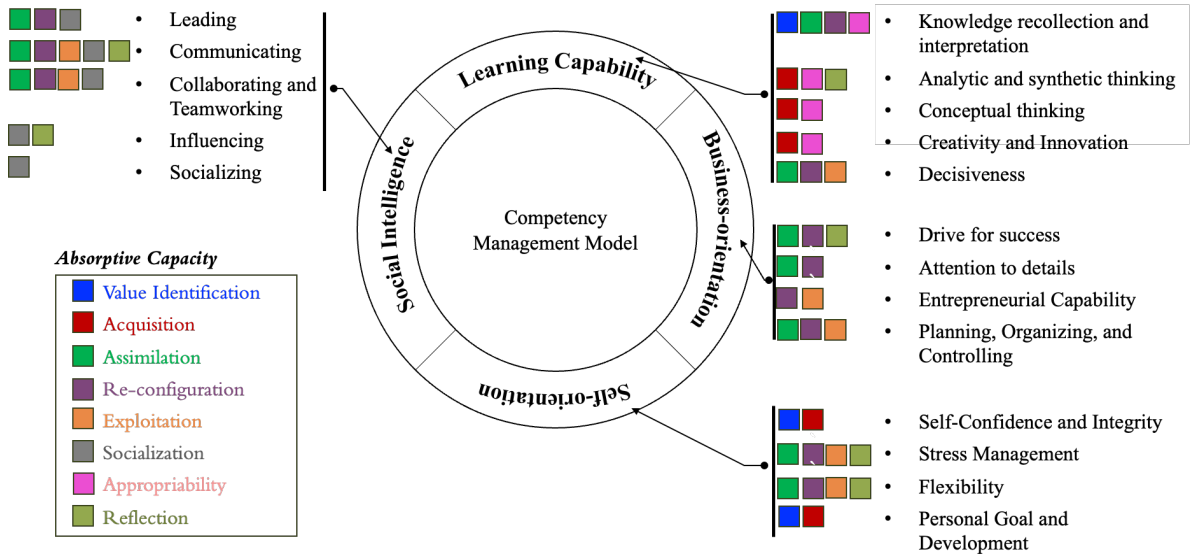


Figure 1: ACAP Competency Assessment Model [Source: Author's own construct from the work of Senivongse's (2023), p. 11-13]

3. Absorptive Capacity Maturity Model

Maturity in knowledge management (KM) refers to the extent to which organizations systematically manage knowledge assets to achieve strategic objectives (Šajeva & Jucevičius, 2010). While many scholars adopt maturity frameworks rooted in the Carnegie Mellon University's Capability Maturity Model (CMM) (Maisiri et al., 2021; Noor Hafizah Hassan & Noreen Izza Arshad, 2023; Portman, 2022; Siahaan & Gunawan, 2021), which is intended as a methodology used to develop and refine an organization's software development process, others propose alternative models, such as the GQC framework (Bougoulia & Glykas, 2023), SAMM Luftman Maturity Level (Dila et al., 2024), BIMM-Business Intelligence Maturity Model (Adekunle et al., 2022), and SPICE-ISO2023 Process Capability Maturity Models (Gökalp et al., 2020). Despite this diversity, the conceptualization of maturity levels remains contested, necessitating further theoretical refinement (Jesus et al., 2022)

The design of maturity scales significantly impacts data validity and respondent engagement. Simplified scales (e.g., 3–5 levels) reduce cognitive burden, particularly for populations with limited literacy or domain familiarity, by simplifying decision-making (Krosnick et al., 2015). However, overly concise scales risk oversimplifying complex constructs, masking nuanced attitudinal differences (Dawes, 2008). Conversely, extended scales (e.g., 7–10 points) enhance granularity, capturing subtle distinctions in psychological constructs like self-efficacy (Preston & Colman, 2000). Yet, excessive length may induce respondent fatigue, undermining reliability (Weijters et al., 2010). Empirical studies suggest 5-point Likert scales optimally balance precision and usability in social sciences, though domain-specific adaptations (e.g., 7-point scales for clinical contexts) may be warranted (Lozano et al., 2012).

The choice between odd- and even-numbered scales hinges on accommodating neutrality. Odd scales (e.g., 5- or 7-point) include a midpoint, reflecting ambivalence and reducing forced-choice bias (Garland, 1991). This aligns with natural decision-making but risks central tendency bias, as respondents may default to neutral options to avoid commitment (Johns, 2010). Even scales (e.g., 4- or 6-point) eliminate neutrality, compelling directional responses that enhance interpretability (Matell & Jacoby, 1971). While advantageous for actionable insights, this approach may frustrate respondents with underdeveloped opinions, increasing non-response rates (Sax et al., 2003). Researchers must align scale design with study aims: odd scales suit exploratory research prioritizing inclusivity, while even scales favor applied studies requiring decisive outcomes (Friedman et al., 1981).

In KM literature, maturity models typically employ 4–6 levels (Bayraktarlı & Topraklı, 2020). Johnson et al. (2008) advocate rubric-based assessments over Likert scales, arguing that descriptive criteria enhance reliability. Stemler (2004) identifies three maturity model development approaches: consensus, expert agreement on performance benchmarks; consistency, correlational validation of scores; and measurement, standardized scoring frameworks.

Given the absence of a universally optimal maturity framework, this study adopts a consensus-driven approach. Through expert deliberation, a 4-level, even-numbered maturity model was selected, aligned with the competency-based proficiency framework of Thailand's Civil Service (Royal Civil Service Commission, 2019). This model defines competency progression across four tiers: foundation, experienced, advanced, and expert. These levels, detailed in Table 1, operationalize organizational capability management for ACAP enhancement.

Table 1: Maturity Levels Used for This Study

Maturity Level	Name	Description
1	Foundation	Individuals at this level demonstrate an understanding of fundamental concepts and can apply them to their own work.
2	Experienced	Individuals at this level comprehensively grasp key concepts, understand the impacts of policy and operational process changes, recognize implications for related activities, and handle increasingly complex and autonomous tasks.
3	Advanced	Individuals at this level exhibit mastery of sophisticated concepts, can define and adapt methodologies, manage workflows, and demonstrate expertise in relevant fields.
4	Expert	Individuals at this level possess advanced knowledge, serve as domain-specific advisors, provide strategic and policy development insights, and act as agents of organizational change.

4. Questionnaire Design

The Delphi method is a structured, iterative research approach aimed at achieving consensus among experts through multiple rounds of questionnaires accompanied by controlled feedback. First conceptualized by the RAND Corporation in the 1950s, it emphasizes participant anonymity, iterative refinement of responses, and statistical synthesis of group input to mitigate biases such as dominant individual influence or groupthink (Best et al., 2025; Skulmoski et al., 2007; Staykova, 2019). Typically spanning two to five rounds—with three iterations being most common—the process continues until response stability or consensus is attained (Best et al., 2025; Skulmoski et al., 2007). Widely utilized in fields such as healthcare, education, and business, the Delphi method supports forecasting, policy formulation, and competency identification (Sablatzky, 2022; Skulmoski et al., 2007). Its adaptability allows customization of rounds or consensus criteria to suit specific research goals. However, its efficacy relies on selecting panelists with deep subject-matter expertise and openness to iterative deliberation (Best et al., 2024). While advantageous for synthesizing expert insights in complex scenarios, methodological rigor is critical to ensuring validity and reliability (Staykova, 2019).

In this study, the Delphi method informed the design of a dual-questionnaire instrument. A panel of three experts—specializing in organizational design, human resource development, and organizational learning—collaborated to delineate competency characteristics aligned with the four maturity stages. Through iterative discussions, the committee refined questions to a consensus, circumventing potential selection bias inherent in Likert-scale approaches. The final questionnaires comprised 42 items for senior leadership and 46 items for government staff, each offering four response tiers corresponding to maturity levels. Table 2 shows an example of a question on technology trends and applications under the creativity and innovation domain.

Table 2: An Example Question on Technology Trends and Applications under Creativity and Innovation domain with different levels of maturity

Maturity Level	Question's Choice Selection
Foundation	I am familiar with the technology that I am using and exploit it to the best of my ability.
Experience	Adoption of new technology is a matter of organization. I understand what it brings, but I will use it only when it is authorized.
Advanced	Staying abreast of technology trends is my preference, and I am always ready to experiment with new ideas.
Expert	I see technology as a way to improve my work and will not hesitate to adopt it and be the change agent

To enhance data robustness, four *probe questions* were embedded to cross-validate alignment between leadership and staff perspectives (see Table 3). These questions served as checks to ensure consistency in responses across hierarchical levels, reinforcing the reliability of the maturity assessment.

Table 3: The design of the Probe questions

Question#	Objective of the question	Top Management Question	Staff Question
1	Involvement in setting of performance measurement index	What criteria do you use to determine performance indicators for your subordinates?	Do you understand and agree with the performance indicators used to evaluate your own work?
2	Process detail understanding and explanation of complex task by management to staff under line of command	When assigned a complex task, are you able to clearly outline the work procedures for your subordinates?	When assigned a complex task, do you receive clear, step-by-step instructions from your supervisor?
3	Openness in giving and receiving critical comments	Are meetings held to gather feedback from subordinates in order to improve work processes?	In your department, are regular meetings held to gather feedback from everyone and use it to improve work processes?
4	Developing and motivating encouragement to reaching common target	Are you able to motivate your team members to perform their duties and achieve the organization's set goals?	Does your supervisor play a role in motivating you to perform your duties and achieve your goals?
5	Communication of strategy to create a shared vision	Do you communicate the vision, strategy, policies, procedures, and direction to subordinates effectively – with a strong emphasis on conveying the vision?	Do you clearly understand the impact of assigned tasks on the strategic direction and goals of the department and organization?

A pilot test was conducted with a sample of 10 respondents to evaluate the questionnaire's reliability. Internal consistency was assessed using Cronbach's Alpha (α)—a statistical measure of how closely related a set of items is as a group, reflecting their ability to evaluate the same construct reliably. Values approaching 1 indicate strong reliability. Results demonstrated exceptional consistency: the executive-level questionnaire achieved an α of 0.922 (92%), while the staff-level instrument yielded an α of 0.904 (90%). Both values denote the *highest reliability*, affirming the robustness of the assessment tools for capturing ACAP-related competencies.

5. Data Collection and Analysis

The Secretariat Office of the Prime Minister of Thailand (SPM) aspires to evolve into a high-performance organization by systematically evaluating the learning capabilities of its workforce. Tasked with formulating policies, advising affiliated ministers and committees, and overseeing human resource management, SPM operates through nine departments and three specialized units directly accountable to its executive leadership.

5.1 Data Collection Process

A self-assessment approach was employed, utilizing two distinct questionnaires: (1) a *competency assessment* instrument for 409 knowledge officers and (2) a *managerial competency assessment* tool for 17 executives. Of the 426 distributed surveys, 324 officers (79.2% response rate) and 15 executives (88.2% response rate) participated. Data collection spanned three months (December 2022–February 2023), ensuring alignment with organizational timelines.

5.2 Data Collection Steps

The assessment comprised two iterative rounds: (1) Baseline Establishment: The first round identified best performers across ten core work disciplines, nominated for their exemplary expertise. This cohort's competencies served as benchmarks for intra-organizational comparisons, enabling alignment of departmental and role-specific performance metrics. Executives were additionally evaluated against peer averages; and (2) Organization-Wide Assessment: The second round extended the survey electronically to all staff, with a one-week response window. Post-collection, data processing and reporting required one month, prioritizing efficiency and accuracy.

5.3 Data Processing and Interpretation

Quantitative analysis, leveraging descriptive statistics, elucidated competency disparities across individual, departmental, and disciplinary criteria. Results were visualized through radar charts and bar graphs to enhance

interpretability. Figure 3 illustrates comparative baselines: Figure 3a reflects average competencies of top management, while Figure 3b benchmarks top performers within each discipline.



Figure 1: Comparative baseline for competency benchmarking: (a) top management baseline; (b) Top performers from each work discipline

Figure 4 synthesizes the outcomes of individual competency assessments, differentiating between leadership and staff perspectives. Figure 4a illustrates the competency profile of top management, while Figure 4b reflects that of an individual officer. Each report is structured into three analytical segments.

Segment 1, Comparative Competency Benchmarking. Displays the individual's competency levels against reference benchmarks, including departmental averages, peer cohorts, and organizational top performers. This comparative lens highlights alignment or divergence from expected proficiency standards.

Segment 2, Priority Development Needs. Identifies and ranks competency gaps based on urgency, emphasizing areas requiring immediate intervention. These insights enable human resource (HR) teams, in collaboration with department heads and job-family specialists, to design targeted development plans aligned with organizational ACAP objectives.

Segment 3, Sub-Category Competency Mapping. Visualizes competency distributions across sub-domains (e.g., cognitive, affective, psychomotor) through comparative plots. This holistic view aids in diagnosing strengths and weaknesses at granular levels, informing strategic talent development initiatives.



Figure 2: Output Report of (a) Top Management Individual and (b) the Officer Individual (Note: the names appearing in this example are redacted.)

The five probe questions served to validate response consistency between top management and staff, ensuring alignment in perceptions of organizational competencies. Figure 5 juxtaposes the assessment results from both groups, facilitating a direct cross-hierarchical comparison. This analysis highlights congruence or divergence in perspectives, offering critical insights into organizational coherence and potential misalignments in ACAP-related practices. By contrasting leadership and staff evaluations, the study underscores areas of strategic unity or discord, informing interventions to harmonize competency development initiatives across tiers.

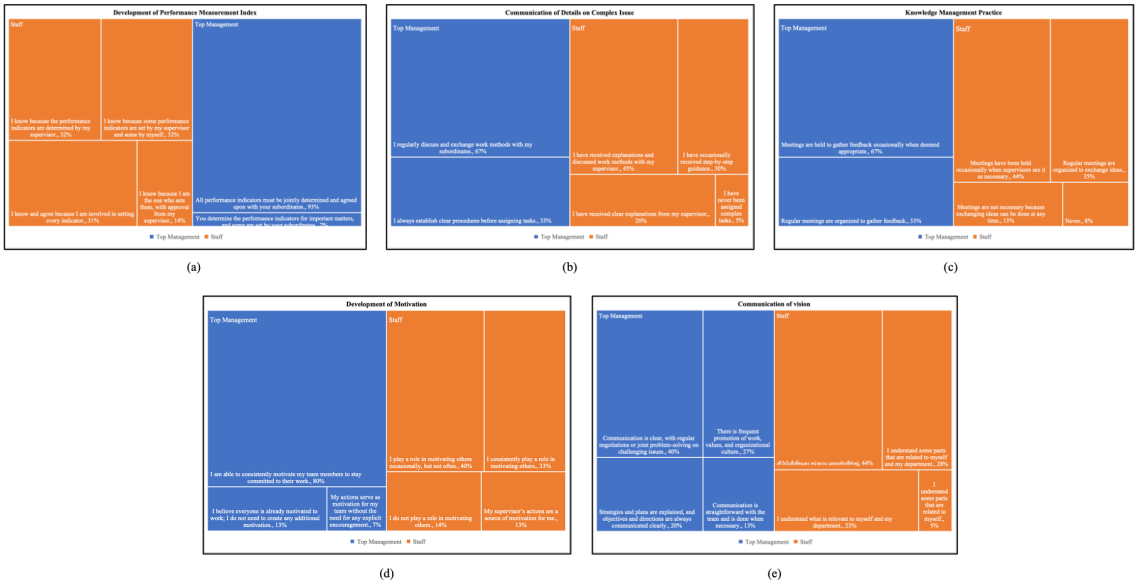


Figure 3: Probe Questions Comparative Results: (a) Development of performance measurement index; (b) Communication details on complex issues; (c) Knowledge management practice; (d) Development of motivation; and (e). Communication of vision and strategy

6. Discussion and Conclusion

Effective competency assessment and management yield dual strategic advantages. First, they facilitate a shift from traditional career ladder promotions, where advancement is based on tenure or vertical performance, to *career stream* readiness, which prioritizes alignment between an employee's competencies and the specific demands of target roles. This approach mitigates the fallacy that success in one role guarantees proficiency in another, fostering a dynamic, skills-based progression system. Second, competency frameworks provide a structured foundation for human capital development, enabling organizations to craft individualized growth plans that align with strategic objectives.

To enhance validity, the study eschewed Likert-scale responses, which risk oversimplification and selection bias. Instead, the Delphi method anchored questionnaire design to real-world behavioral indicators, requiring respondents to engage critically with scenario-based choices. While this increased cognitive load, it ensured responses mirrored actual competencies rather than aspirational self-assessments. Successful implementation necessitated clear communication with stakeholders to clarify that assessments were developmental tools—distinct from performance evaluations—to foster trust and participation.

6.1 Business Implications

The Secretariat Office of the Prime Minister (SPM) aspires to evolve into a High-Performance Organization (HPO), defined by sustained superior outcomes, adaptability, and strategic alignment (de Waal, 2012). HPOs prioritize five pillars: (1) *Leadership Integrity*, trust, accountability, participative decision-making; (2) *Openness and Learning*, risk tolerance, knowledge sharing; (3) *Long-Term Vision*, policy foresight, resilience; (4) *Innovation*, continuous improvement, inimitable practices; and (5) *Workforce Excellence*, diverse talent, targeted development (Manoharan et al., 2023; Paul Kintu & André de Waal, 2021).

The ACAP competency assessment aligns with these pillars by offering a systematic diagnosis of organizational adaptability. Annual assessments can track progress, identify resilience gaps, and inform workforce mobilization strategies, ensuring candidates' competencies align with role requirements before promotions or transfers.

From the fact that knowledge is context-specific and situation-dependent (Bennet & Bennet, 2008), benchmarking with the "best performers" reflects what the organization's efficiency is about. The model acknowledges that optimal competencies vary by role, avoiding unrealistic universal standards. Probe questions further validate alignment between leadership perceptions and staff experiences, particularly in vision communication, feedback mechanisms, and knowledge-sharing practices.

6.2 Limitations

While mitigating response bias, the four-level rubric-based maturity model remains contentious. Critics argue it may lack granularity for precise competency differentiation. However, its design—rooted in expert consensus via the Delphi method—balances cognitive accessibility with practical relevance, prioritizing real-world applicability over theoretical complexity.

6.3 Conclusion

This study operationalizes competency assessment as a catalyst for transforming organizations into learning entities. Mapping ACAP-driven competencies identifies skill gaps, informs personalized development plans, and enhances strategic workforce alignment. Annual implementation is recommended to sustain adaptability, monitor progress, and refine organizational resilience. Ultimately, the framework bridges individual growth with institutional agility, positioning competency analytics as a cornerstone of modern public sector excellence.

AI Declaration: This research employed generative AI in two supplementary roles. First, as the competency assessments were conducted in Thai, AI tools facilitated initial translation of qualitative data into English, with rigorous verification by the author to ensure semantic accuracy. Second, AI-assisted text refinement supported paraphrasing and grammatical precision during manuscript preparation. The author affirms the exclusivity of original content within this work and underscores that all AI-generated outputs underwent meticulous human oversight to align with scholarly standards and contextual integrity.

Ethics Declaration: This study adhered to ethical principles governing non-invasive, anonymized research in organizational settings. All participants were informed of the study's purpose, and their responses were anonymized to ensure confidentiality. Participation was voluntary, with no incentives or penalties tied to involvement. Data were aggregated to prevent individual identification and analyzed solely for academic purposes. The authors affirm no conflicts of interest.

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Accelerating Knowledge Acquisition with Help from Large Language Models: From Digital Documents to Database Models

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Abstract: Knowledge Management (KM) processes are essential for organizations, allowing them to effectively capture, store, and use their knowledge to make informed decisions. Modern enterprises use computerized systems and relational databases to manage their operational processes. However, a significant challenge remains in transforming insights found in digital documents into actionable data models without overloading business analysts or necessitating constant updates and modifications. This work introduces a method for modeling dynamic environments using a knowledge base. The approach involves creating a world model within a relational database that can be updated using Structured Query Language (SQL) expressions derived from documents that describe changes in that world. The techniques discussed include using agents and Large Language Models (LLMs) to generate SQL commands to keep the database current. The proposed world model aims to remain sufficiently generic and adaptable to handle a variety of entities and relationships across multiple organizational domains. Representing events, objects, and their interactions in a flexible structure ensures that real-world transformations are accurately mirrored in the database. This versatility allows the model to be implemented in different sectors without significantly modifying the underlying data architecture. Integrating these processes with advanced language models, such as ChatGPT, aims to improve the generation of data models and streamline the KM workflow by automating the interpretation of explicit knowledge. This integration of language models and relational databases is intended to enhance the organization, storage, and retrieval of insights, thereby reducing manual effort and improving the knowledge base's adaptability to changing needs. Overall, the proposed solution seeks to leverage LLMs to assist in modeling data and managing knowledge from explicit sources, providing a practical framework for organizations looking to stay competitive in evolving environments.

Keywords: Knowledge management, Data modeling, Automated knowledge extraction, Large language models, Dynamic world modeling

1. Introduction

In dynamic systems, knowledge is in a constant state of transformation, requiring a deep understanding of how it is represented, shared, and updated across evolving environments. World-building in such systems involves modeling complex relationships between regions, organizations, and individuals, all of which can shift due to internal developments or external events. These transformations must be coherently reflected within the structure of the world, ensuring consistency and narrative continuity. Typically, these changes are first internalized during interaction with the environment and later externalized through revisions that update the world's state. As complexity increases, managing this process manually becomes increasingly challenging, emphasizing the importance of automated methods for maintaining accurate and responsive representations. Fictional universes and simulation platforms often face these challenges—prominent examples include narrative-driven environments such as those found in Role-Playing Games (RPGs) (N.R and Ikhtiyorovna, 2023), where world states evolve through continuous player interaction and storytelling (Cook et al., 2003; Halliwell et al., 1986; N.R and Ikhtiyorovna, 2023).

However, recent advancements in Large Language Models (LLMs) offer a promising solution to this problem. These models, particularly Generative Pre-trained Transformers (GPT), have been increasingly recognized as general-purpose technologies capable of performing various tasks (Brown et al., 2020; Devlin et al., 2018; OpenAI, 2023). Their ability to process and generate human-like text allows them to streamline complex workflows by extracting key information from unstructured text and converting it into structured data (Hadi et

al., 2023; Raiaan et al., 2023). This makes LLMs powerful tools for automating tasks such as managing databases (Li et al., 2024; Zhou et al., 2023) and translating text into Structured Query Language (SQL) (International Organization for Standardization, 2016) commands (Dong et al., 2023; Sun et al., 2024; Tan et al., 2024), allowing for efficient and accurate data management in dynamic systems.

Recent advancements in LLMs have significantly improved SQL generation tasks, known as Text-to-SQL, making database interactions more accessible (Zhu et al., 2024). Key improvements stem from integrating expert knowledge (Hong et al., 2024), leveraging structural information (Zhang et al., 2024), and decomposing complex tasks into manageable subtasks (Pourreza and Rafiei, 2024). Additionally, benchmark evaluations reveal the need for more complex datasets to assess LLM capabilities effectively (Ma et al., 2024).

In this work, we propose an approach for modeling dynamic worlds using a knowledge base. Our methodology involves creating a dynamic world model in a relational database, continuously updated through SQL expressions derived from narrative documents detailing world changes. We employ a combination of agents and LLMs to generate SQL commands to manipulate the database's data, including altering and deleting data. This approach enables automated updates to the state of the world represented in the database, ensuring that it accurately reflects the evolving game narrative and maintains consistency across sessions.

Our work aims to make various contributions, including automating dynamic world updates and expanding the use of LLMs in managing complex systems. By combining LLMs with relational databases, the research introduces a new method for converting unstructured text into structured data, reducing the need for manual intervention in the update process. It has practical applications in real-world scenarios such as smart city simulations, where factors like population, infrastructure, and economics undergo continuous evolution. The proposed framework offers urban planners, policymakers, and professionals in dynamic fields such as project management and financial forecasting a reliable tool for precise, efficient, and scalable data management. Additionally, the research identifies potential avenues for improvement, such as multi-agent systems and advanced knowledge representation techniques, which could significantly enhance the model's scalability, precision, and applicability in more complex environments.

2. Theoretical Background

This section presents the theoretical background, introducing fundamental concepts related to role-playing games, world representation, and knowledge representation. These concepts are essential for understanding the developments discussed in subsequent sections.

2.1 World-building

Fictional world-building involves the creation of intricate environments populated by diverse regions, societies, and systems that interact in complex ways. These constructed worlds often feature detailed representations of cities, defined by characteristics such as population size, security dynamics, and economic conditions. A coherent and dynamic world requires careful modeling of interactions between regions, institutions, and inhabitants, as these elements collectively shape the setting's internal logic and narrative potential.

- **Regions**: These include cities, towns, and other locations. Each region has its own set of attributes, including but not limited to population size, economic resources, and security levels. Accurate modeling of regions is essential as they serve as the primary setting for most adventures and influence the narrative's direction and scope.
- **Organizations**: These encompass guilds, councils, and other groups that operate within the regions. Organizations play significant roles in the storyline, often serving as quest givers, antagonists, or support structures for the inhabitants. Understanding their hierarchies, goals, and relationships with other entities is vital for a nuanced world representation.
- **Inhabitants**: The non-player characters (NPCs) and player characters (PCs) interact within the regions and organizations. Inhabitants have various attributes, such as health, status, and affiliations, which are crucial for driving the narrative forward. Their interactions, statuses, and evolutions must be accurately tracked to maintain consistency and depth in the storytelling.

This work focuses on the relation between these entities, representing any changes during sessions. Modeling these entities and their relationships in SQL allows for a structured and dynamic representation of the world setting. This modeling enables updates and changes to be reflected accurately as the game progresses. SQL facilitates data manipulation, ensuring that the database can handle the complex and evolving nature of the game world. The entity-relationship model, illustrated in Figure 1, captures the relationships between these

entities by defining the tables and relationships necessary to represent regions, organizations, and inhabitants. This model includes schemas for each entity, outlining their names and how they interact.

Accurate and detailed modeling of these entities and their relationships is crucial for the integrity of the game. It provides a framework that can be adapted for other applications, such as intelligent city simulations. Understanding these entities' ontologies and interactions helps design systems that reflect complex, dynamic environments.

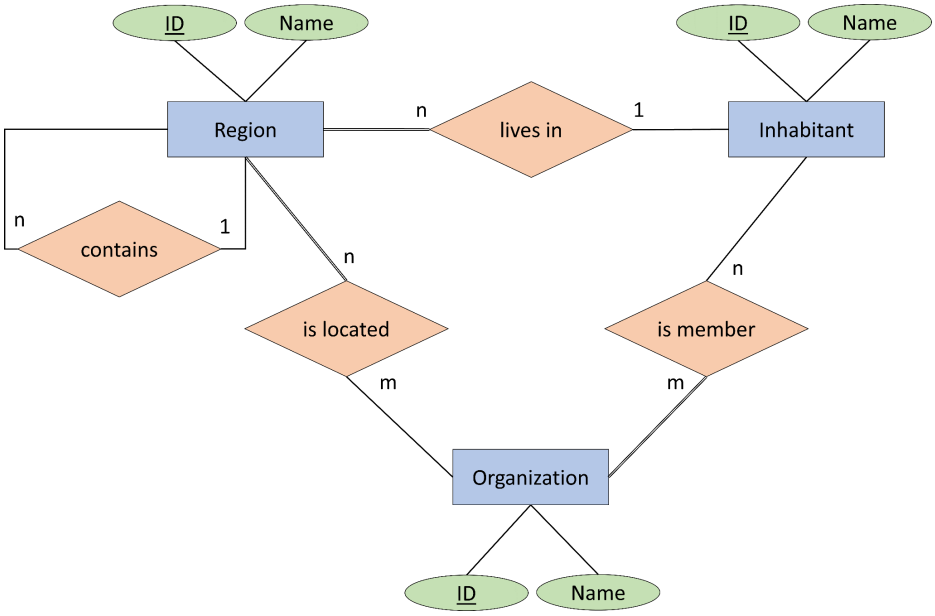


Figure 1: An Entity-Relationship model focused on the Region, Inhabitant, and Organization

2.2 Representing Worlds

Suppose a world W, in a state s, denoted by W^s, and a world model M_W that, when updated to represent W^s, is denoted by $M_W{}^s$. Since worlds are dynamic, at some point, there will be a state s+1, defining W^{s+1}, and it will be necessary to update M_W, i.e., calculate $M_W{}^{s+1}$.

If the changes in W from W^s to W^{s+1} are described by a set of documents $D = \{d_1, d_2, \ldots, d_n\}$, it is possible to extract information from D to discover a series of functions $\{f_1, f_2, \ldots, f_k\}$ that should be applied to $M_W{}^s$ to achieve $M_W{}^{s+1}$. For example, $M_W{}^s$ can be the map of a city (W_s), and D can be the set of documents describing civil engineering interventions that changed the city to a new configuration W^{s+1}. Those changes must be represented on the map. Extracting information from D can generate instructions to change the map accordingly.

The world W is a set of entities w_i modeled as objects o_i in M. Each object has, at the world and model state s, its own state o_s. While the world changes, some changes must be tracked so that the model can reflect them. These changes are modeled as events e. From e, one must calculate the necessary function f to make the transition from o_s to o_{s+1}, and from M_s to M_{s+1}.

An event e can create, destroy, or change the state of o from o_s to $o_{(s+1)}$. Events can change the state of an object o permanently, for a specific interval of time, or until another event happens. For example, suppose M is modeling transit in a city. In that case, an event e can represent the creation of a new road, a permanently closed road to pedestrians, or a temporary interdiction of a road. This interdiction, however, can have a specific time frame—such as closing a street for a one-day event—or require another event to return it to its original state, such as an accident that must be cleared, with the clearing time being uncertain. However, changes described in real-world documents are not guaranteed to be detected in the same order as they occur in the world. For example, an accident on a street can be detected on a social network seconds after it happens. Still, a report stating that the road is clear might arrive at a monitoring system hours after the road is actually cleared. This discrepancy would maintain incorrect information about the road being closed even though it is already evident. Moreover, a notice declaring the road clear may arrive before the notice that it was closed. Therefore, the system must understand the sequence of detected events and possibly implement virtual time or a similar algorithm (Jefferson, 1985). In this work, we will create a world model in a relational database and update it

with SQL expressions derived from documents describing the changes. Table 1 explains the terms introduced in this section.

Table 1: Term Descriptions

Term	Description
W	World
s	State
W^s	World W in state s
M_W	Model for world W
$M_W{}^s$	Model M_W that represents world W^s
D	Set of documents that describe the changes from W^s to W^{s+1}
d	Document that details a specific change
f	Function used to update the model from $M_W{}^s$ to $M_W{}^{s+1}$
w	Entity in the world W
o	Object that represents an entity w in the model
e	Event affecting the state of an object or the model

2.3 Representing Knowledge

Knowledge Management (KM) is a critical process that formalizes and disseminates the collective experiences, knowledge, and expertise within an organization, transforming them into accessible and actionable resources (Beckman, 1999). A key element in understanding and applying KM is recognizing the dual nature of knowledge, which is fundamentally divided into two types: tacit and explicit (de Castro Peixoto et al., 2022; Prat, 2006; Stollenwerk, 2001). Tacit knowledge represents individual experiences—context-specific and often difficult to formalize and communicate—encompassing skills, experiences, and insights. In contrast, explicit knowledge is codified, systematic, and easily transferable through formal languages, such as documents and databases (de Castro Peixoto et al., 2022; Nonaka, 1994; Prat, 2006; Stollenwerk, 2001).

Understanding how tacit and explicit knowledge interact is crucial for effective management. In this context, the SECI model outlines the dynamic knowledge conversion process through four modes: Socialization, Externalization, Combination, and Internalization. This model underscores the interplay between tacit and explicit knowledge, facilitating the continuous creation and sharing of knowledge within an organization. Socialization involves sharing tacit knowledge through direct interaction, while Externalization translates tacit knowledge into explicit forms. Combination synthesizes different bodies of explicit knowledge, and Internalization converts explicit knowledge back into tacit understanding through practice and reflection (de Castro Peixoto et al., 2022; Nonaka et al., 2000; Nonaka and Takeuchi, 1995).

To effectively manage and utilize knowledge, choosing an appropriate representation method is essential. There are many ways to represent knowledge, such as using an ontology (Noy and McGuinness, 2001) or Prolog (International Organization for Standardization, 1995). We have opted to represent knowledge using a relational database (Codd, 1970). A relational database is a structured system for managing data that organizes information into tables, also known as relations. Each table is defined by a schema, which specifies the structure of the data, including its attributes (columns) and their data types. The data within the table is stored as tuples, or rows, with each tuple representing a specific instance of the schema. This tabular structure supports complex queries and ensures efficient data management, retrieval, and manipulation (Mannila and Räihä, 1992; Yang et al., 2009).

- Schema - A schema R for a relation is defined as follows: $R(A_1, A_2, \ldots, A_n)$ where A_i (for $1 \leq i \leq n$) are the attributes of the relation.Each attribute A_i has a domain D_i, which specifies the possible values that the attribute can take: $A_i \in D_i$.

- Relation - A relation r on a schema R is a finite set of tuples: $r = \{ t_1, t_2, \ldots, t_m \}$ where each tuple t_j (for $1 \leq j \leq m$) is an ordered list of values: $t_j = (v_{j1}, v_{j2}, \ldots, v_{jn})$ such that $v_{ji} \in D_i$ for all $1 \leq i \leq n$.
- Database - A database $\mathcal{D}$ is a collection of relations: $\mathcal{D} = \{ r_1, r_2, \ldots, r_k \}$ where each r_i is a relation defined on its respective schema R_i.

Although there are theoretical models for database handling, such as relational calculus (Codd, 1972) and relational algebra (Codd, 1970), the standard language used to operate databases is SQL (International Organization for Standardization, 2016). SQL provides a comprehensive framework for managing and manipulating relational databases, encompassing several key components—the Data Definition Language (DDL), Data Manipulation Language (DML), Data Control Language (DCL), and Transaction Control Language (TCL) (Kumar et al., 2012). DDL defines and manages the database's schema and objects, such as tables, indexes, and views. The primary commands in DDL include CREATE, ALTER, DROP, and TRUNCATE. DCL is used to control access to the database's data, with primary commands GRANT and REVOKE. TCL manages transactions in the database, ensuring that operations are completed successfully and maintaining data integrity; its primary commands include COMMIT, ROLLBACK, and SAVEPOINT (Kumar et al., 2012). DML is the most relevant component of this article. It is used to retrieve, insert, delete, and update data in database tables (Kumar et al., 2012). The primary DML commands include SELECT (to query and retrieve data), INSERT (to add new rows), UPDATE (to modify existing rows), and DELETE (to remove rows).

3. Method

This research explores an approach to modeling dynamic worlds by leveraging a knowledge base. Our methodology entails constructing a world model using a relational database, which is subsequently updated with SQL expressions derived from documents that describe changes in the world. The approach includes employing agents and LLMs to generate DML commands used to update the state of the world represented within the database.

3.1 Web Scraping

This subsection presents the methodology used to extract structured data from a data source on a fictional universe, such as an encyclopedia. The collected information—covering locations, populations, and organizations—served as the foundation for building the knowledge base of our dynamic world model. Automated web scraping techniques were applied, including URL generation, HTTP requests, and HTML parsing, to retrieve and organize relevant data efficiently.

- URL Construction: URLs were dynamically constructed for each category (locations, inhabitants, organizations) and each city of interest.
- HTTP Requests: Requests were sent to these URLs to retrieve the HTML content of the web pages.
- HTML Parsing: The BeautifulSoup (Richardson, 2007) library was used to parse the HTML content and extract relevant data.
- Data Filtering: Specific HTML elements containing the needed information were filtered and processed. For example, the tags were examined to extract lists of names while ensuring that irrelevant sections (e.g., appendices) were excluded.
- Regular Expression Matching: Regular expressions were used to accurately extract the names of individuals and sub-categories from the text.
- Database Insertion: Extracted data was organized and inserted into an SQLite database, which involved creating tables and establishing relationships between entities.

3.2 Model Update

This subsection discusses the methodology used to update the model, using agents, tasks, and tools. Agents are units that execute tasks using available tools (Wang et al., 2024; Weng, 2023; Xi et al., 2023). By analogy, imagine hiring a Database Engineer (agent) who first reads the text (task 1) and then writes the SQL commands (task 2) while checking current data to verify the status (tool).

LLMs have emerged as transformative technologies in Natural Language Processing. These neural networks, with billions of parameters, are trained on vast amounts of text data to understand and generate human-like text. By employing deep learning techniques, LLMs can identify intricate patterns and relationships within data, enabling them to perform a range of tasks with proficiency. Their capabilities include text generation, translation, summarization, and few-shot question-answering. The sophisticated pattern recognition of LLMs allows them to produce responses that are both coherent and contextually appropriate (Brown et al., 2020; Devlin et al.,

2018; OpenAI, 2023). By employing an LLM as the agent, we leverage its advanced language understanding to interpret textual information and execute the required database operations. In this research, the model employed is llama3-70b-8192 (AI@Meta, 2024). This model's architecture and training enable it to handle complex text parsing tasks and perform precise data manipulations (Huang et al., 2024; Touvron et al., 2023).

To facilitate collaborative efforts within a multiagent system, we use CrewAI (crewAI, 2024), a framework designed to simplify the processes of generating thought, using tools, and communicating among agents. This framework creates agents with specific roles, backstories, and goals while defining tasks with detailed descriptions and expected outputs.

4. Discussion

As demonstrated in our results, LLMs' ability to manage, maintain, and optimize a relational database system aligns with the research of Zhou et al. (2023)—which explores how LLMs can enhance database maintenance through real-time diagnosis and optimization—and Li et al. (2024), which utilizes LLMs to optimize data management systems. Our findings suggest that LLMs have significant potential as database administrators.

Regarding the translation of natural language into SQL queries, our results demonstrate that LLMs can effectively generate SQL instructions corresponding to session summaries, accurately reflecting the described events and changes. This aligns with investigations by Sun et al. (2024), Tan et al. (2024), and Dong et al. (2023), who have used various prompting techniques to improve text-to-SQL performance. These findings highlight the growing versatility of LLMs not only as data management tools but also as efficient translators between natural language and structured database commands.

The convergence of our results with findings from various researchers underscores the growing capacity and applicability of LLMs as database administrators and text-to-SQL translators. The techniques employed—initially applied within the context of dynamic world modeling in games—have broader potential in areas such as project management, supply chain optimization, and financial forecasting, where constant data updates and dynamic decision-making are essential. For example, by modeling a smart city's dynamic nature—including inhabitants, organizations, and regions—it becomes possible to accurately represent and manage changes such as population growth, economic fluctuations, and infrastructure development. Consequently, urban planners and policymakers can leverage this approach to make informed decisions and optimize resource allocation. Moreover, the potential applications extend to other domains where managing complex and dynamic environments is crucial.

Limitations include the dependency of generated SQL commands on clear and precise input documents, with ambiguities potentially causing inaccuracies. Performance and scalability challenges may also arise in more complex scenarios, highlighting the need for further system improvements.

5. Conclusion

LLM models are general-purpose technologies capable of transforming and automating complex workflows by converting unstructured text into structured data. Dynamic systems require constant updates to reflect ongoing changes, necessitating methods that ensure accurate and efficient updates. This work proposes an approach for modeling dynamic worlds through a relational database continuously updated by SQL expressions derived from textual descriptions of changes. By employing agents and LLMs to generate SQL commands for inserting, altering, and deleting data, the system ensures minimal manual intervention.

Our research demonstrates that the proposed approach effectively automates dynamic updates, providing a robust framework for managing complex, evolving environments. Future work could explore advanced knowledge representation methods, integrate multiagent systems to handle complex updates efficiently, develop visualization tools for dynamic environments, and evaluate scalability in real-time, large-scale contexts.

Ethics Declaration: Ethical clearance was not required for the development of this research.

AI Declaration: AI tools such as Grammarly and ChatGPT were used solely for language revision. The authors' analysis and interpretations are their own.

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Predicting Business Vulnerability Using Neural Networks: Evidence From Brazilian SMEs

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Abstract: *Goal*: Analyze the performance of a business diagnosis prediction model. *Design / Methodology / Approach*: Business diagnostic interviews were carried out with 98 companies, using the IncubE methodology, to assess the level of maturity, based on six dimensions: general, management, business, market, technology and financial. The evaluations were discretized and used as input for a neural network model implemented with the Keras API from the Scikit-Learn library in Python. *Results*: The machine learning algorithm achieved an accuracy of 75%, enabling the identification of business failures that could lead to organizational vulnerability. *Limitations of the research*: The proposed model is applicable only to companies where consultants trained in the IncubE methodology have performed a prior organizational diagnostic assessment. *Practical implications*: This study supports consultants and business managers to anticipate critical business situations and prevent the occurrence of failure scenarios. *Social implications*: Possible reduction of organizational problems and consequent reduction in the number of companies in crisis or bankrupt. *Originality / value*: There are few works in literature that deal with prediction of business vulnerabilities and none were found that use a methodology which evaluates the five organizational dimensions of the CERNE methodology: entrepreneur, technology, market, management and financial.

Keywords: Business fault prediction, AI prediction, Business fault, Business failure, SMEs

1. Introduction

Brazil exhibits high annual demand for new business openings. In 2024, government data reported over 4.2 million new company registrations, yet the same period saw 2.4 million closures—97.6% of which were micro and small enterprises (Brasil, 2025). Consistent with the Brazilian Micro and Small Business Support Service's (Sebrae, 2020) Business Survival 2020 study, failure rates over five years remain stable: 29% of micro-entrepreneurs, 21.6% of micro-enterprises, and 17% of small enterprises discontinue operations.

Entrepreneurship serves as a critical income alternative during economic crises (Arantes, 2024; Fernandes & Braz, 2024) and for commercializing academic innovations (Cultri, 2024; Abreu, Lauricio & Baeta, 2023; Sousa & Florêncio, 2023). In both cases, founders often possess domain expertise and motivation. However, they often lack business management skills, which becomes the primary factor contributing to business failures, placing companies in a state of vulnerability (Leal, 2024; Pinto Junior, 2021c; Freitas, 2020; Kops, 2019; Drucker, 2007).

In a previous study, we developed the IncubE Methodology (Pinto Junior, Silvestro & Morais, 2021) to guide the incubation process of enterprises, from the initial business diagnosis and action plan development to the company's graduation with its problems solved. In this research, we will use entrepreneurial diagnostics conducted through the IncubE Methodology with 98 companies. An initial business diagnosis was carried out to assess the potentialities and challenges these companies faced across five dimensions: entrepreneurship, management, technology, financial, and market. Each of these dimensions was assigned a score according to the level of risk categorized in the methodology. Additionally, a sixth score was assigned by a senior consultant, reflecting the overall risk level in a category termed "general." This axis is the most critical, as it evaluates the likelihood of the business failing if no intervention is made to address the identified issues.

The current research applies machine learning techniques to this diagnostic dataset, focusing particularly on predicting general-axis assessments. This focus stems from two key factors: (1) while senior consultants provide rigorous evaluations (Mendonça, 2021), their expertise requires substantial training time and field experience (Oliveira, 2011), and (2) the prediction tool aims to enhance diagnostic accuracy for junior consultants who lack equivalent experience.

The predictive tool was developed using a Keras-based neural network model implemented in Python through the Scikit-Learn library. This framework enabled the development and evaluation of a deep learning model trained on business diagnostic data. Using a dataset of 98 companies representing various maturity levels, the

model achieved a predictive accuracy of 75%, sufficient to identify companies at risk of business failure according to the general axis evaluation.

The paper proceeds as follows: Section 2 reviews relevant studies on business diagnostics and failure prediction. Section 3 details the research methodology, while Section 4 presents and discusses the results. Finally, Section 5 summarizes the key findings and provides concluding remarks.

2. Related Works

The integrative literature review, conducted across Scopus and Web of Science databases, identified six relevant studies contributing to this research field through diagnostic models or predictive techniques. To contextualize the discussion, we examine the work of Kasiki (2017), who traced the genesis and global development of business diagnostics. Focusing on the Czech Republic and Slovakia, Kasiki analyzed emerging trends, approaches, and diagnostic models.

Hernández-Díaz et al. (2021) investigated SME sustainability through a Puerto Rican case study. Their study conceptualized business sustainability as maintaining organizational health across all dimensions, extending beyond environmental considerations. The researchers employed a 106-item questionnaire aligned with the 5 MOPSE dimensions, administered to 108 SMEs to generate their analytical framework.

Hoa and Tuyen (2021) developed an assessment model for digital transformation readiness in Vietnamese SMEs. Their approach applied linear and non-linear regression algorithms combined with fuzzy methods to analyze data from 510 SMEs.

The authors Santos and Martinho (2020) created a maturity model specifically designed to evaluate Industry 4.0 integration in enterprises. The model's validation involved case studies with two major Brazilian automotive companies, using questionnaire-based assessments.

The relationship between resistance to change and organizational performance was the theme of the work conducted by Metz (2017). The research implemented an organizational diagnostic framework applied to a multinational ICT company in Romania. The comprehensive diagnostic tool evaluated 14 organizational dimensions, encompassing: purpose and values, structure, relationships, conflicts, communication, decision-making processes, benefits, motivation, leadership, change resistance, support mechanisms, personal dynamics, operational transparency, and performance metrics. The study collected data through questionnaires administered to 776 employees, followed by statistical analysis to determine correlations between change resistance and performance outcomes.

Advancing predictive methodologies, Le et al. (2021) introduced a hybrid approach combining oversampling techniques with cost-sensitive learning for business failure prediction. Their analysis focused exclusively on financial indicators, leveraging the Korean bankruptcy database containing 307 failed companies and 120,048 solvent firms. Notably, their methodology incorporated multiple technologies: HAOC (hybrid approach using oversampling and cost-sensitive learning), CBoost (bankruptcy prediction algorithm), Python programming language, and the Scikit-learn library. This study stands out as the only reviewed research that implemented both statistical analysis and machine learning algorithms for scenario prediction.

Beyond the systematic review, additional relevant studies were identified through expert recommendations. Agrawal et al. (2024) complement our machine learning approach by demonstrating predictive modeling applications for employee turnover. While our research focuses on neural networks for business vulnerability prediction, their work explores machine learning algorithms for attrition pattern identification, illustrating predictive analytics' adaptability across organizational contexts.

The study by Dhar et al. (2022) established the critical relationship between leadership styles and strategic diagnosis in emerging markets. Their findings demonstrate how leadership heterogeneity directly impacts strategic flexibility and execution, highlighting strategic adaptation as a key success factor in dynamic environments. The study emphasizes that effective diagnostic tools must incorporate both quantitative metrics and qualitative assessments.

3. Methodology

Creswell (2010) asserts that projects require a philosophical design structure, research strategies, and research methods, which are interconnected and give substance and legitimacy to the research. This study adopts a

pragmatic approach, which seeks to solve real-world problems using both scientific and non-scientific knowledge and methods to find solutions.

The study employs a mixed-methods design with sequential strategy, selected for its capacity to integrate qualitative data collection with quantitative analysis while aligning with the researchers' expertise. This methodological choice enables the application of predictive techniques while maintaining theoretical consistency. Following Cupani's (2006) classification, the research qualifies as technological, as it applies existing knowledge to develop practical solutions.

This work represents an extension of previous studies that examined critical challenges facing micro, small, and medium-sized enterprises (SMEs), particularly the mediating role of business incubators. Building on findings from Morais et al. (2021) and Silvestro, Pinto Junior, and Duncke (2021), we developed the IncubE methodology (Pinto Junior, Silvestro & Morais, 2021) to standardize business diagnostics for vulnerable enterprises.

The methodology incorporates a comprehensive evaluation system based on five core business dimensions recognized by the Brazilian National Association of Entities Promoting Innovative Enterprises (Anprotec, 2018): entrepreneur, management, technology, financial/capital, and market. Each dimension receives a discrete maturity score according to standardized assessment criteria. Complementing these, a sixth comprehensive risk evaluation is provided by senior consultants. Figure 1 illustrates the diagnostic framework's six evaluation domains and their respective scoring criteria.

	1. ENTREPRENEURSHIP
5	No entrepreneurial training/knowledge.
4	Has an entrepreneurial profile, limited knowledge, and little time to dedicate.
3	Has an entrepreneurial profile, limited knowledge, but enough time to dedicate.
2	Has an entrepreneurial profile, good knowledge, but little time to dedicate.
1	Has an entrepreneurial profile, good knowledge, and adequate time.
	2. MANAGEMENT
5	Has no management control.
4	Knows some management variables, but does not control them.
3	Knows and controls some management variables.
2	Knows and reasonably controls all management variables of the business.
1	Knows and fully controls all management variables of the business.
	3. TECHNOLOGICAL
5	Has not implemented digital transformation and does not use any digital/technological resources for management or production flow.
4	Uses some resource to digitally structure the business OR uses some digital/technological resource for management or production flow.
3	Uses some resources to digitally structure the business AND uses some digital/technological resource for management or production flow.
2	The business is based on a digital platform and uses digital/technological resources for management or production flow.
1	Has implemented digital transformation and uses digital/technological resources for management or production flow.
	4. MARKET
5	Has a prototype and/or business model ready, but does not sell.
4	Is starting commercialization and needs to create/adjust pricing and sales strategies.
3	Has market insertion, but needs to increase it. The pricing policy may need adjustments and may require better strategies for customer and/or supplier relationships.
2	Has good market insertion, a mature pricing policy, and needs improvements in customer and/or supplier relationship strategies.
1	Has good market insertion, a mature pricing policy, and good strategies for customer and supplier relationships.
	5. CAPITAL
5	Has overdue debts, and monthly closures are in deficit.
4	Has debts in order, but monthly closures are in deficit.
3	Has lines of credit in order, and monthly closures are in surplus.
2	Does not have debts, and monthly closures are in surplus.
1	Does not have debts, has cash reserves and/or investments, and monthly closures are in surplus.
	6. GENERAL RISK (of closing)
5	The macro analysis of the company's problems/vulnerabilities indicates a HIGH risk of closure if no immediate intervention is made.
4	The macro analysis of the company's problems/vulnerabilities indicates a MEDIUM risk of closure if no immediate intervention is made.
3	The macro analysis of the company's problems/vulnerabilities indicates a LOW risk of closure if no immediate intervention is made.
2	The macro analysis of the company's problems/vulnerabilities indicates a possibility of entering a vulnerability zone.
1	The macro analysis of the company's problems/vulnerabilities indicates business stability (sustainability).

Source: Authors (2025)

Figure 1: Evaluation domains and scoring criteria

The research employed the IncubE Methodology along with its evaluation framework (Figure 1) to assess participating companies. For machine learning purposes, each company's diagnostic profile was represented as a 6-dimensional vector comprising scores from all evaluation areas.

Trained senior consultants conducted business diagnostic interviews with 98 companies. Following data collection, all evaluations were standardized through discrete scoring, enabling both risk-level ranking and subsequent machine learning analysis. The resulting dataset served as input for predictive modeling of business diagnostics.

3.1 Experiment Setup

To leverage historical business diagnostic data and enable predictive capabilities for new assessments, we developed an artificial intelligence system based on neural network architecture. The technical implementation details, including programming language, platform, libraries, and network configurations, are summarized in Table 1. This final configuration was determined through extensive parameter optimization, resulting in the highest predictive performance.

Table 1: Technical Specifications of the Experiment

Technical Specifications of the Experiment	
Programming Language	Python
Development Platform	Google Colab
Libraries Used	Scikit-Learn and TensorFlow
Data Balancing	Unbalanced
Training and Test Set Split	70% training / 30% testing
Type of Neural Network	Sequential, implemented by the Keras model
Layers and Neurons	Layer 1: 30 neurons, with ReLU activation function Layer 2: 10 neurons, with ReLU activation function Layer 3: 2 neurons, with Sigmoid activation function
Compilation	For model compilation, the parameters were set as loss="mean_squared_error", optimizer="adam", and metrics="accuracy".
Epochs / Batch Size	100 epochs, with batch size of 10

Source: Authors (2025)

The study employed Python for its robust scientific programming capabilities, extensive machine learning libraries, and comprehensive online support resources. Key libraries included Scikit-Learn for data loading and preprocessing, and TensorFlow to implement the Keras deep learning framework (Keras, 2025). The Keras Sequential model was selected for its ability to stack linear layers and provide integrated training and inference functionalities.

The dataset comprised diagnostic evaluations from 98 companies, as detailed in previous sections. All records were anonymized and assigned unique identification numbers for experimental control, with company identities remaining confidential. The data was structured in a CSV file where each row represented a company and columns contained:

- Scores (1-5) for five diagnostic dimensions (1 = lowest risk, 5 = highest risk)
- A binary label for the General axis (0 = "at risk", 1 = "not at risk")

This structured format enabled efficient preprocessing and model training while maintaining data integrity and confidentiality.

The anonymized company dataset used in this study, along with the implementation code, are available upon reasonable request from the corresponding author.

4. Results and Discussion

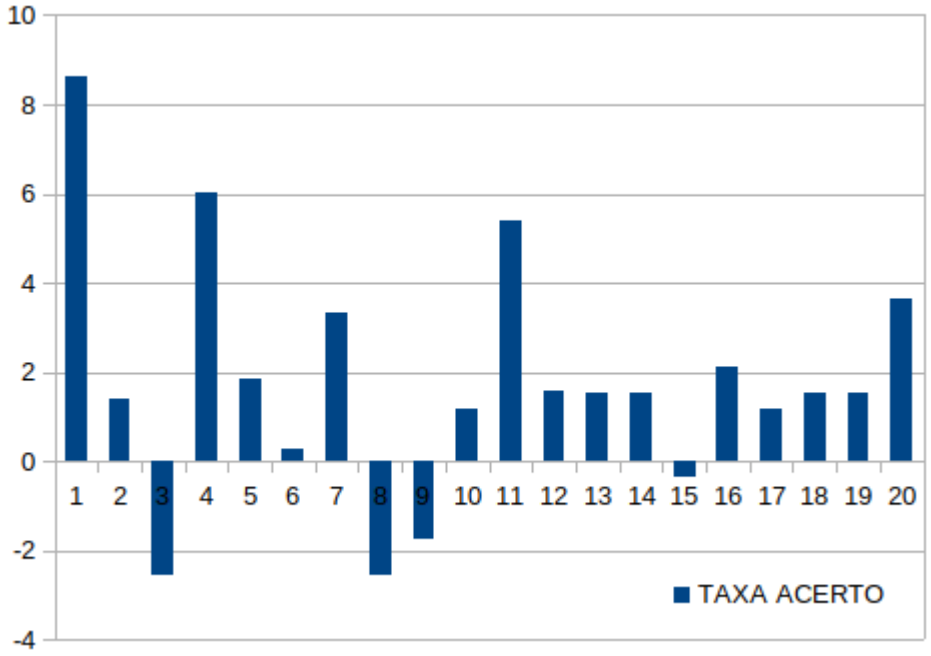
The experimental results identified optimal performance using data partitioning of 70% of the data for training and 30% for testing, with 3 network layers:

- Layer 1: 30 neurons with ReLU activation;
- Layer 2: 10 neurons with ReLU activation;
- Output layer: 2 neurons with sigmoid activation.

This architecture achieved convergence after processing 100 epochs with a batch size of 10.

The output of the network showed a total processing time of 70ms/step. The loss generated by the network was 28.7%, and the accuracy was 75%. We analyzed the 25% error caused at the output and observed that the margin of error was at most less than 4 percentage points. In Figure 2, it is possible to visualize the membership rates obtained for 20 elements of the test set. For each element, there is a probability distribution that, from the learning process, indicates how much an element belongs, percentage-wise, to the value 0 (in general risk) or 1 (not at risk), assigned to the label attribute, which determines if it is at risk.

On the 'y' axis, the value zero is the decision threshold, meaning that the positive values on the 'x' axis indicate correct predictions of the company's risk status, and the value specified on this axis corresponds to the difference between the value of the corresponding label column and the value of the non-corresponding column. In the same logic, negative values also correspond to the difference between these two columns, but they represent predictions that failed.



Source: Authors (2025)

Figure 2: Membership Rate

The machine learning framework presented in this study offers valuable decision-support capabilities for both junior consultants and entrepreneurs. It is important to emphasize that business risk assessment represents a complex analytical process that cannot be adequately performed through isolated diagnostic examinations alone. Effective evaluation requires contextual knowledge of vulnerability indicators, comparative analysis of multiple diagnostics, and informed interpretation of organizational data.

The implementation of this neural network allows learning from a series of previously conducted diagnostics, providing the consultant or manager with this knowledge as machine learning and offering a reasonably reliable business risk diagnosis, considering the algorithm's 75% accuracy rate. Therefore, consultants can use this tool to support their consulting efforts and combine the results of the algorithm with their personal analyses.

In cases where the diagnosis indicates that the company is not at risk, the organization receives feedback indicating its healthy status. In such cases it would be wise to develop plans to explore its potential, boost the successful areas, and focus institutional goals on growth and expansion.

On the other hand, if the diagnosis indicates a risk situation, it suggests that the company seek more specific assistance to perform a detailed diagnostic, allowing the identification of areas and activities that are putting the organization into risk and need analysis and restructuring. Professionals with specific expertise may be sought to help build an action plan focused on business recovery.

A key benefit of this predictive tool is its ability to help both senior and junior consultants arrive at consistent conclusions regarding risk assessment. This shared understanding enables collaborative efforts to mitigate business risks and prevent potential bankruptcy scenarios.

It should be noted that the tool offers a scalable solution for business diagnostics; however, its implementation must consider ethical concerns. Junior consultants or non-expert users should not rely on this tool as a definitive diagnostic method, as missing contextual analysis or expert validation could lead to misjudgments. To mitigate this, public deployment of the model will include a recommendation to use it as a supplementary risk indicator, supported by human oversight. Future iterations may also integrate explainability features to enhance transparency in decision-making.

5. Final Considerations

This paper analyzed the contribution of a business diagnostic prediction model to assist business consultants in decision-making. We interviewed 98 companies using the diagnostic methodology advocated by IncubE and used the responses as input for a Keras neural network model in Python.

Regarding project management and strategic success, this study offers a data-driven approach to mitigate business risks and enhance decision-making in SME incubation programs. By predicting vulnerabilities across key organizational dimensions, the model enables consultants and managers to prioritize strategic interventions, allocate resources efficiently, and design targeted action plans during the incubation process. For instance, integrating this tool into project planning workflows could help incubators identify high-risk ventures early, tailor mentorship programs, and optimize resource distribution—ultimately increasing the success rate of these enterprises.

The machine learning results led to an output with 75% accuracy, which enabled us to determine whether a company has business failures that may put it at risk. This paper presents the initial findings of our ongoing research, which shows promising potential for further refinement. Future work will focus on several processing improvements, such as: conducting more consulting sessions to expand the database and enable learning from a larger and more diverse dataset; adapting the techniques and methodologies proposed here to learn from a larger database of business diagnostics; balancing the load of input data; and testing the assignment of weights to the diagnostic dimensions according to their importance in risk analysis.

We can implement changes in our algorithms to seek higher accuracy and/or a greater margin of error tolerance, with a broader decision threshold. Some possible changes include: 1. conducting more consulting sessions and using these diagnostics to expand the database and allow learning from a larger and more heterogeneous dataset; 2. testing the same technique developed here and adapting the methodology to learn from another business diagnostic database; 3. balancing the load of input data, assigning the same proportional number of companies at risk and not at risk to the learning and testing data groups; 4. testing the assignment of weights to the diagnostic dimensions, considering that each axis may have a different weight for business sustainability and, consequently, a different risk level in the business diagnosis.

In the format presented here, the research is limited to being applicable only to consultants and managers trained in the IncubE methodology. However, the incorporation of this machine learning tool enables consultants to anticipate critical business situations and prevent potential failure or vulnerability scenarios.

In the future direction of the research, we aim for our tool to provide the diagnosis directly to the company's manager, using text and speech analysis techniques to automate the diagnosis for each business axis. Thus, the business manager can use the tool to obtain the machine learning diagnosis and consider it when making decisions and setting priorities in management, functioning as a virtual benchmarking tool with a company database.

Future research will include benchmarking the neural network model against traditional methods (e.g., logistic regression, decision trees) and other machine learning approaches (e.g., SVM, Random Forest) to further validate its predictive performance. This expansion will provide a more comprehensive evaluation of the methodology and its applicability across diverse business contexts.

Finally, considering that there are few studies in the literature addressing the prediction of business vulnerabilities and none employing a methodology assessing all five critical organizational dimensions examined here (entrepreneurial, technological, market, management, and financial), we hope this paper and its future developments can contribute to reducing organizational issues and consequently reducing the number of companies in crises or bankruptcy.

Acknowledgements

This work was supported by the Post-Graduate Program in Engineering and Knowledge Management (PPGEGC) of the Federal University of Santa Catarina (UFSC) - Brazil, the Federal Institute of Mato Grosso (IFMT) - Brazil, the Brazilian Coordination for Under-graduate Education Personal Improvement (CAPES) - Financial Code 001, the Foundation to Support the Research of the State of Santa Catarina (FAPESC) - Brazil and the FEESC (Fundação Stemmer para Pesquisa, Desenvolvimento e Inovação).

Ethics and AI Declaration: We declare that this research utilized the Keras neural network for machine learning. Furthermore, we affirm that the study did not involve the direct or indirect participation of human beings or animals at any stage. All methodologies applied were based on public data and previously published documents, ensuring compliance with ethical principles and good research practices. Therefore, the work fully respects the prevailing ethical guidelines for studies of this nature.

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Critical Success Factors for Strengthening the Relationship Between Incubators and Innovation Ecosystems

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Abstract: The relationship between business incubators and innovation ecosystems is crucial for fostering entrepreneurship and driving economic and technological progress. This study conducted a systematic bibliographic search to identify the critical success factors that influence this relationship, analyzing the role of business incubators in ecosystem innovation. The growing necessity to enhance incubators' strategic and operational effectiveness in generating, disseminating, and applying knowledge underscores the significance of this research. This study also highlights best practices and challenges in knowledge management faced by incubators. Additionally, by identifying critical success factors, it provides valuable insights into strategies that can strengthen collaboration among incubators, startups, and other ecosystem stakeholders. From a socio-economic perspective, the research underscores the role of incubators as key enablers of innovation and regional development. It also demonstrates how effective knowledge management can improve the sustainability and scalability of incubatees ventures. The findings aim to offer actionable recommendations for incubator managers and policymakers, reinforcing the role of incubators as catalysts for dynamic and resilient innovation ecosystems.

Keywords: Business incubators, Innovation ecosystems, Critical success factors, Business development

1. Introduction

Innovation ecosystems are composed of the interaction of various actors who collaboratively promote actions in favor of innovation. Based on a comprehensive analysis of the concept of an innovation ecosystem, it can be defined as a dynamic set of actors, activities, artifacts, institutions, and relationships, including both complementary and substitutive interactions, which are essential for the innovative performance of an actor or a population of actors (Granstrand & Holgersson, 2020).

In a given territory, city, or region, this interaction consists of multiple agents and their interrelations, which have the potential to transform localities into hubs of innovative entrepreneurship (Cai & Huang, 2018). In this context, business incubators play a crucial role by providing essential infrastructure and services to the ecosystem, enabling innovative entrepreneurship and establishing themselves as strategic elements of innovation ecosystems (Prokopenko, Eremenko & Omelyanenko, 2014; Peterková, Czerná & Zimmermannová, 2022; Matos, 2024).

Organizations that form part of the ecosystem's infrastructure, such as incubators, implement consulting and service provision activities, resulting in the generation of new viable proposals, the emergence of startups, the consolidation of emerging companies, and regional economic development (Peterková, Czerná & Zimmermannová, 2022; Silvestro et al., 2024).

In addition to providing favorable conditions for the creation and maintenance of innovative businesses, incubators leverage their networks to connect emerging enterprises with other ecosystem actors, fostering knowledge sharing and promoting innovation and entrepreneurship (Gerlach & Brem, 2015; Bereczki, 2019; Vaz et al., 2023; Silvestro et al., 2024).

In some cases, incubators play a fundamental role in driving the development of innovation ecosystems, particularly by boosting the business sector, acting as key agents in increasing urban competitiveness (Santos, 2022; Silvestro et al., 2022). For example, Santos (2022) highlights the role of a local incubator in strengthening the innovation ecosystem in the city of Coimbra.

Thus, the presence of incubators in an innovation ecosystem can enhance resources and make it more robust and resilient. However, it is essential to recognize that building an innovation ecosystem requires more than just financing accelerators or incubators. Innovative environments that operate without dense interconnection networks among entrepreneurs, coupled with a supportive and positive culture, have limited impact (Haines, 2016; Santos, 2022; Silvestro et al., 2022).

Although the literature highlights the positive effects of the relationship between the existence of incubators and the development of innovation ecosystems, there remains a gap in the systematization of the critical success factors influencing this relationship. Therefore, this study aims to analyze the critical success factors that strengthen the relationship between incubators and innovation ecosystems.

2. Methodological Procedures

To achieve the proposed objective, a systematic review was conducted covering the years 2014 to 2024, encompassing the last ten years of publications in the Scopus and Web of Science databases. The choice of these databases is justified by their representativeness in indexing high-impact journals. It is important to note that the research protocol followed was the one presented by Tranfield et al. (2003) and Kitchenham (2004).

Following this protocol, the search string used was: ("innovation ecosystem") AND ("business incubator"), identifying articles in titles, abstracts, and keywords from 2024 to 2014. The inclusion criteria applied were: (i) scientific articles written in English, (ii) published in peer-reviewed journals, and (iii) articles in which the search terms appeared simultaneously. Table 01 presents the results obtained from the search.

Table 1: Search Process

Steps Performed	Scopus	WoS	Total
Total searches	177	15	192
After removing redundancies	138	11	149
After reviewing abstracts, titles, and keywords, remaining articles	39	4	43

Source: Prepared by the authors.

Based on this, a review of the titles, abstracts, and keywords was conducted to assess the relevance of the selected articles, resulting in a final corpus of 43 documents used to construct the systematic review.

To analyze connections and the co-occurrence network, identifying relationships between keywords and key clusters, the VOSviewer software (version 1.6.18) was employed. This tool enabled the mapping of the theme's evolution, highlighting correlations such as keyword networks, the countries that most disseminate the topic, citation counts for theoretical support, and connections between articles, thus facilitating the construction of a synthesis to address the research problem.

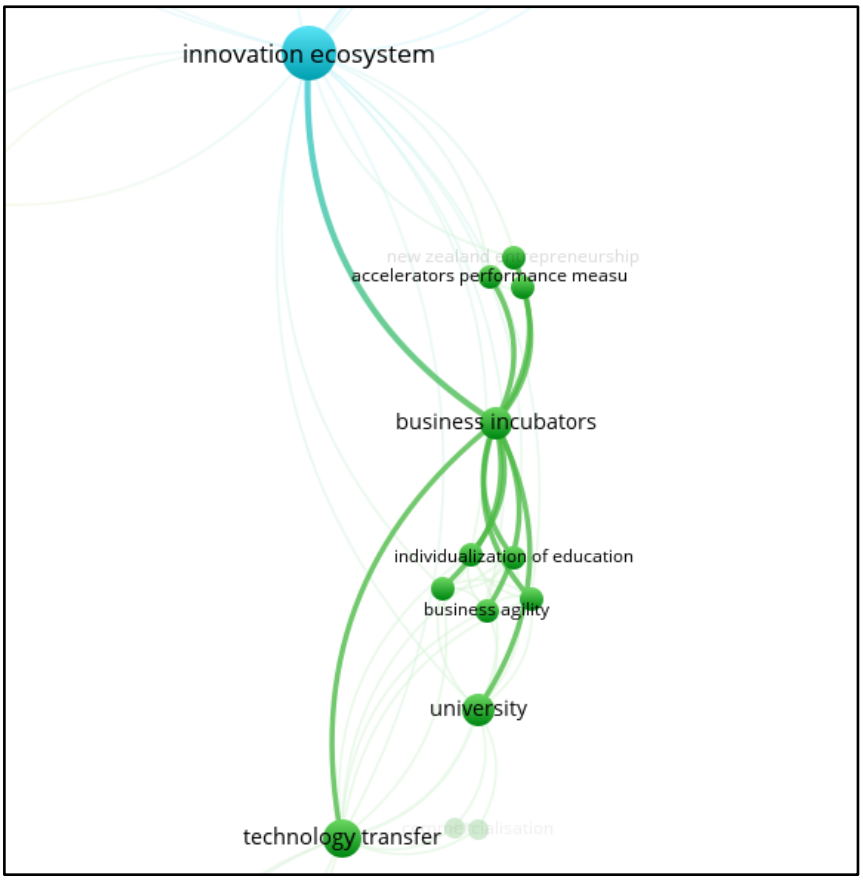
Additionally, a qualitative approach was applied, following the concept of Creswell (2010), which emphasizes the importance of purposeful selection of sources—including documents and visual materials—to support a deeper understanding of the problem and research question.

3. Presentation and Discussion of Results

This section presents the results obtained through the final textual corpus of this study. The analyses are based on the established protocol and research problem, providing a brief description of the sample.

3.1 Analysis of the Co-Occurrence Relationship Between Keywords

In Figure 01, the interaction formed by two major clusters is identified. The first cluster highlights the keyword "Innovation ecosystem" in blue, while the second cluster connects to "Business incubators" in green.



Source: Prepared by the authors.

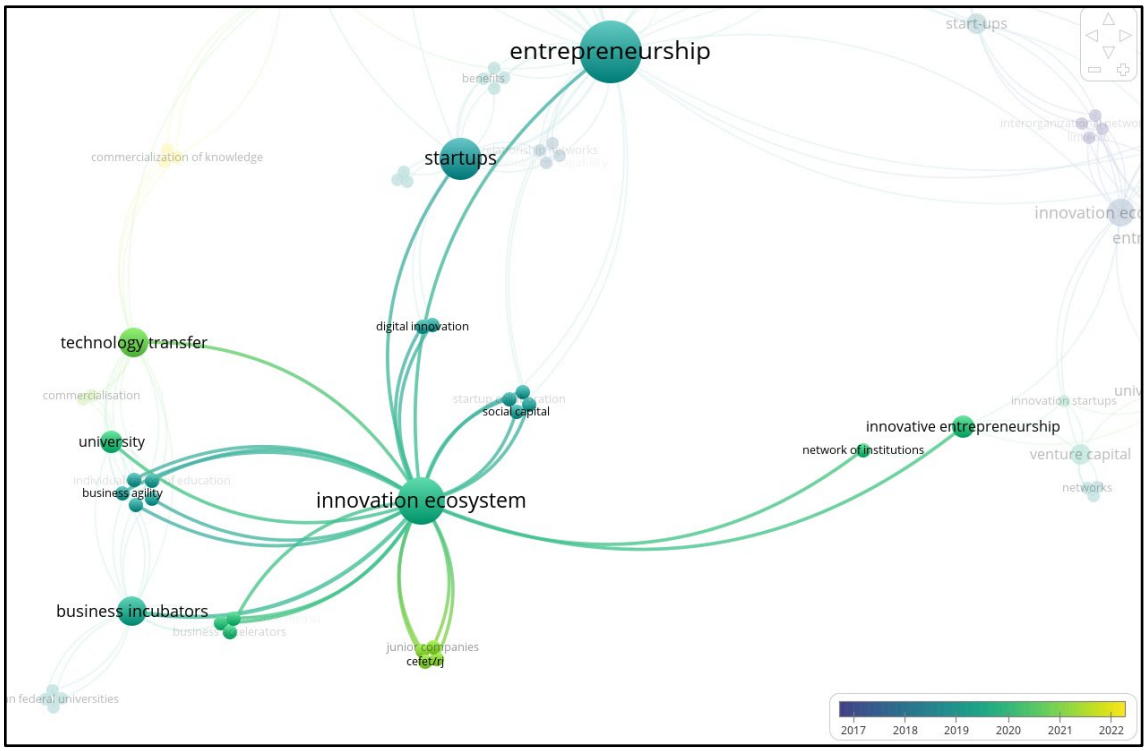
Figure 1: Keyword Co-Occurrence Network

The combination of these two clusters forms a crucial link for fostering and driving the entire ecosystem. When organizations are anchored in networks that collaborate towards common goals, the entire ecosystem benefits through innovation and entrepreneurship within their respective contexts (Machado Júnior, Felden & Teixeira, 2018).

Additionally, a well-developed innovation ecosystem provides the necessary infrastructure to support the evolution of actors in an entrepreneurial context (Romano, Passiante, Vecchio, & Secundo, 2014) and ensures continuous development for innovations (Gastaldi & Corso, 2016).

Furthermore, the innovation ecosystem comprises a network of entrepreneurs, mentors, service providers, and investors that can be leveraged to support the creation and development of businesses with more effective scalability (Haines, 2016). These businesses require new networks to facilitate knowledge transfer and optimize the use of available resources. Additionally, companies with superior open innovation niches within a given ecosystem gain advantages in technical resources and capital when they maintain strong ties with the innovation network (Xie & Wang, 2021).

Figure 02 illustrates the network formed by the year of publication of the keyword "innovation ecosystem", representing the first search string used in the research. As shown, it is directly connected to the "business incubator" keyword cluster, demonstrating important relationships between them. This connection also extends to other keywords such as "entrepreneurship," "technology transfer," "university," "business agility," "accelerators performance," "startups," "digital innovation," "social capital," "network of institutions," and "innovative entrepreneurship," all of which contribute to the development and findings of this research.



Source: Prepared by the authors.

Figure 2: Relationship Between Keywords and Year of Publication

The analysis of this figure highlights that when a network connects incubators and universities, there is a significant impact on economic viability, the entrepreneurial profile formation, and local and sectoral development. Moreover, this interaction facilitates the application and transfer of new technologies, promotes connections with research centers, and accelerates startup growth, contributing to job creation (Anprotec-MCTI, 2012).

In this context, incubators go beyond being shared workspaces; they function as networks of individuals and organizations that interact to ensure the smooth operation of the innovation structure. Their direct connection with universities and academic community members fosters the rapid transfer of knowledge and technology (Hackett & Dilts, 2004). Additionally, through structured methodologies, incubators strengthen interactions between resident companies and other ecosystem actors, promoting networking and collaboration (Felizola, Gomes & Almeida, 2019).

Thus, incubators play an essential role in supporting the innovation ecosystem, facilitating strategic partnerships, business model validation, training, and capacity building, and creating an environment conducive to innovation and sustainable growth (Mwandosya, Apiola & Lahde, 2016).

3.2 Analysis of the Relationship Between Incubators and Regional Economic Growth in the Innovation Ecosystem

Incubators serve as drivers of innovation for regional economic development and promote the sustainable growth of businesses. According to Barbe, Green, and Chang (2010), these institutions facilitate the creation of new companies and strengthen the entrepreneurial environment, directly impacting the local economy. By providing technical support, infrastructure, and strategic connections, incubators help entrepreneurs overcome initial challenges, enabling their businesses to achieve greater stability and market competitiveness (Ojaghi Mohammadi & Yazdani, 2019; Etzkowitz & Zhou, 2017; Ho & Yoon, 2022).

Additionally, incubators stimulate economic growth by enhancing competition and optimizing resource allocation. According to Ho and Yoon (2022), these institutions foster a dynamic ecosystem, allowing innovative startups to compete more effectively with established companies. This environment strengthens product and service diversification, creates new business opportunities, and increases productive efficiency. Another crucial factor is technology transfer and the development of new products, as highlighted by Ismail, Kamel, and Wahba (2018), who emphasize the interaction between incubators and universities as a catalyst for innovation and

patent generation. This relationship facilitates the co-commercialization of science, enabling startups to develop market-oriented technological solutions, thereby enhancing local economic competitiveness (Ojaghi Mohammadi & Yazdani, 2019; Etzkowitz & Zhou, 2017; Ho & Yoon, 2022).

Job creation is another significant impact of incubators. Mungila (2020) highlights that these institutions generate new employment opportunities by supporting startup growth and encouraging the hiring of skilled professionals, contributing to lower unemployment rates and human capital development. Furthermore, incubators act as key agents in identifying international market demands and structuring innovation networks, which are fundamental to the advancement of the entrepreneurial ecosystem (Ojaghi Mohammadi & Yazdani, 2019).

Santos (2022) and Ojaghi, Mohammadi, and Yazdani (2019) emphasize that maintaining and fostering innovation within startups is essential for global competitiveness. By promoting a collaborative and technology-driven environment, incubators ensure that new businesses gain access to strategic markets, solidifying their role as pillars of economic growth and sustainable innovation.

3.3 Analysis of the Role of Incubators in Boosting Companies Within the Innovation Ecosystem

Incubators play a strategic role in strengthening the innovation ecosystem by maintaining continuous relationships with their graduated companies, fostering a collaborative and supportive environment. This post-incubation support encourages knowledge exchange, expands networking opportunities, and enhances cooperation among entrepreneurs, companies, and academic institutions (Chan, Krishnamurthy & Sadreddin, 2022). This way, incubators not only drive startup development but also contribute to the sustainable evolution of the innovation ecosystem (Etzkowitz & Zhou, 2017; Ho & Yoon, 2022).

Beyond ongoing support, incubators facilitate startups' integration into business networks, providing access to investors, customers, and strategic partners. This assistance enables new ventures to position themselves more competitively in the market, adapt to sector demands, and ensure sustainable growth (Felizola, Gomes & Almeida, 2019). Thus, incubators act as bridges between startups and the market, ensuring that entrepreneurs have the necessary resources to establish their businesses (Santos, 2022; Mungila, 2020).

Another critical aspect is the business management support provided by incubators. Through mentorship programs, training, and consulting, they equip entrepreneurs with essential managerial and strategic skills. This guidance reduces risks and enhances the likelihood of startup success (Etzkowitz & Zhou, 2017). By strengthening the foundations of innovative businesses, incubators ensure their long-term sustainability.

Moreover, incubators serve as key environments for entrepreneurial development and innovation diffusion, offering structured programs and essential infrastructure to support new business development (Etzkowitz & Zhou, 2017; Ho & Yoon, 2022). Their initiatives create an environment conducive to experimentation, learning, and technological advancement, fostering entrepreneurial culture in the regions where they operate (Theodoraki, Messeghem & Rice, 2018). Thus, incubators transcend their role as business support entities, evolving into knowledge and innovation hubs (Etzkowitz & Zhou, 2017; Ho & Yoon, 2022).

Finally, the collaboration between incubators and other innovation ecosystem agents facilitates resource optimization, reduces redundancies, and strengthens connections among participants (Ho & Yoon, 2022). Studies indicate that engagement with incubators influences 70.6% of companies' technological capabilities, making it easier for them to integrate into financial and technological networks (Tumelero et al., 2018). Furthermore, these institutions foster new technological arrangements and open innovation processes, enhancing a more dynamic and competitive ecosystem for the development of innovative businesses (Mungila, 2020; Ismail, Kamel & Wahba, 2018; Castro et al., 2021; Santos, 2022).

3.4 Analysis of the Relationship Between Business Incubators and Universities in the Innovation Ecosystem

In academia, incubators support startups from their initial phases, promoting the practical application of knowledge generated in laboratories and research centers (Carvalho et al., 2020; Etzkowitz & Zhou, 2017; Ho & Yoon, 2022). This support allows the transformation of scientific discoveries into innovative and economically sustainable solutions, consolidating the concept of entrepreneurial universities (Castro et al., 2021; Barbe & Greene Chang, 2010; Cukier Fox & Rahnama, 2012; Etzkowitz & Zhou, 2017; Ojaghi, Mohammadi & Yazdani, 2019; Santos, 2022).

These institutions are crucial for developing entrepreneurial skills and attitudes in young people, preparing them for market challenges and fostering an innovation-oriented mindset (Carvalho et al., 2020; Etzkowitz & Zhou,

2017; Ho & Yoon, 2022). According to Cukier, Fox, and Rahnama (2012), in addition to training qualified professionals, entrepreneurial universities promote a culture of innovation, allowing students to acquire essential competencies for creating and managing new businesses.

Strengthening an innovative culture within the academic environment is a central aspect of this process. Hayter (2016) highlights that innovation does not occur secluded, but within a collaborative ecosystem that stimulates creativity and experimentation. By integrating entrepreneurship into university education, institutions empower students to transform ideas into sustainable businesses (Carvalho et al., 2020; Etzkowitz & Zhou, 2017; Ho & Yoon, 2022). Entrepreneurial learning, driven by academic initiatives, provides young people with essential practical experiences for their education. Mwandosya, Apiola, and Lahde (2016) emphasize that exposure to real market challenges facilitates the assimilation of management concepts and methodologies, a process enhanced by university incubators that offer support through internship and training programs.

Furthermore, universities play a role in generating spin-offs that strengthen the business ecosystem, as noted by Carvalho et al. (2020), who highlight that this interaction increases the competitiveness of emerging startups by providing access to contact networks, mentorship, and investment opportunities. The creation of technology hubs is also strategic for talent development and the growth of new specialized markets. Castro et al. (2021) also points out that these hubs foster employability in the technology sector, amplifying the impact of innovation in the market. Thus, business incubation emerges as a tool to support innovative businesses in their initial phases.

Finally, the continuous monitoring of entrepreneurs and startups by university incubators allows for the evaluation of their progress and the provision of strategic guidelines, ensuring their sustainability and consolidation within the innovation ecosystem (Ho & Yoon, 2022; Ismail, Kamel & Wahba, 2018; Castro et al., 2021; Tumelero et al., 2018).

3.5 Connection Axes Between Business Incubators and the Innovation Ecosystem

In summary, the articles identified a synergy among three axes that represent how incubators connect their hosted enterprises with the innovation ecosystem: support, network, and fostering.

Each axis seeks to elucidate the connections built by incubators to foster their activities in supporting entrepreneurs, as well as to demonstrate how this relationship occurs. These connections often serve to address existing gaps in the integration of ecosystem actors (Carvalho et al., 2020) with incubatees companies.

The "support" axis relates to how incubators, within their own structures and methods, corroborate these arrangements, utilizing their own operations to provide support to incubatees and connect them to ecosystem resources (Chan, Krishnamurthy & Sadreddin, 2022), and how, through these actions, they build an entrepreneurial culture (Cukier, Fox & Rahnama, 2012).

Business incubators play a strategic role in strengthening the innovation ecosystem by adopting diagnostic methodologies to assess the maturity of startups over time (Castro et al., 2021). This continuous monitoring allows emerging companies to receive adequate support at different development stages, from creation to growth. Furthermore, the presence of these startups boosts the local economy, attracting new commercial activities and generating jobs, which reinforces the positive impact of incubators on socioeconomic development (Barbe, Green & Chang, 2010).

Another essential factor is the support for market and product development, promoting innovation initiatives that connect entrepreneurs to different collaboration networks (Etzkowitz & Zhou, 2017). Through structured programs, incubators offer infrastructure, technical advice, and financial incentives, such as grants and tax benefits, facilitating the consolidation of startups (Ismail, Kamel & Wahba, 2018). Additionally, by providing benchmarking and sharing best practices, these institutions create an environment conducive to continuous innovation, allowing talents with promising ideas to access qualified support (Mwandosya, Apiola & Lahde, 2016).

Incubators also play an essential role in technology transfer and supporting the internationalization of startups (Tumelero et al., 2018). The provision of infrastructure and specialized technical knowledge enables startups to develop innovative and scalable solutions. Moreover, the strategic location of incubators favors access to emerging markets, attracting investments and expanding business opportunities (Carvalho et al., 2020). Thus, these initiatives drive the sustainable growth of startups and strengthen the competitiveness of the innovation ecosystem.

The "network" axis seeks to elucidate the channels through which incubators converge with other companies in their environment to maintain good relationships with their residents. Some means are presented by the authors, such as the construction of creative dialogues for relationship maturation. Another similar form of conversation between companies is that incubators build these creative conversations in their relationships between individuals and legal entities, in aspects with the convergence of interests (Tumelero et al., 2018).

Incubators play a strategic role in assisting international companies seeking to enter new markets, creating mutually beneficial partnerships with local and established companies (Chan, Krishnamurthy & Sadreddin, 2022). As bridges between different actors, they leverage talent and resources, influencing laws, values, and norms of the entrepreneurial ecosystem (Barbe, Green & Chang, 2010; Cukier, Fox & Rahnama, 2012). Furthermore, by subsidizing the growth stage of startups and providing access to strategic networks, incubators drive innovative development in various regions, with the support of municipalities, universities, and industrial associations (Etzkowitz & Zhou, 2017; Ojaghi, Mohammadi & Yazdani, 2019).

The connection between startups and innovation ecosystems occurs through the interaction between different actors, promoting strategic collaborations and facilitating open innovation processes (Santos, 2022; Ismail, Kamel & Wahba, 2018). Building solid networks is essential for developing partnerships, ensuring the exchange of knowledge between entrepreneurs, investors, mentors, and academic institutions (Ho & Yoon, 2022; Felizola, Gomes & Almeida, 2019). Additionally, the size of incubators and the breadth of their external networks directly influence investments in research and development, impacting the creation of new products and services (Mungila, 2020; Theodoraki, Messeghem & Rice, 2018).

Incubators also function as catalysts for regional innovation clusters, promoting peer interactions and strengthening collaboration within the ecosystem (Chan, Krishnamurthy & Sadreddin, 2022; Carvalho, Bersani, Maldaner & Piqué, 2020). The use of digital technologies and social media has been a strategy to expand external communication, connecting incubatees, investors, mentors, and the community in general (Tumelero, Sbragia, Borini & Franco, 2018). Thus, incubators not only strengthen local innovation but also create international networks that expand opportunities for startups and companies, promoting a dynamic and sustainable environment for business growth (Chan, Krishnamurthy & Sadreddin, 2022).

Finally, the "fostering" axis reports an important advancement for companies regarding financial capital. The authors report some ways in which incubators influence the financial aspect, leveraging the technological capacity of companies through their networks (Tumelero, Sbragia, Borini & Franco, 2018).

One of the ways is through connection points with other external companies, which help and contribute to incubatees obtaining funding, such as financial and social capital (Chan, Krishnamurthy & Sadreddin, 2022), both in the company's creation phase and in the validation of the business model (Carvalho, Bersani, Maldaner & Piqué, 2020), significantly contributing to the development of companies and the state's economy (Barbe, Green & Chang, 2010).

It also connects startups to external companies, facilitating access to essential resources such as financial capital, social capital, and market knowledge (Barbe, Green & Chang, 2010; Ojaghi, Mohammadi & Yazdani, 2019; Felizola, Gomes & Almeida, 2019; Ismail, Kamel & Wahba, 2018; Castro et al., 2021; Tumelero et al., 2018). This interaction enables incubatees to overcome challenges in the initial phases of creation and launch, ensuring strategic support for sustainable growth (Chan, Krishnamurthy & Sadreddin, 2022). Furthermore, the financial support offered through these connections strengthens the structure of startups, enabling investments in innovation and technological development (Carvalho, Bersani, Maldaner & Piqué, 2020).

The influence of incubators on the technological capacity of incubatees companies occurs through their financial and technological networks, promoting the absorption and application of new knowledge and innovative practices (Tumelero, Sbragia, Borini & Franco, 2018). This articulation allows startups to expand their competencies, reduce market entry barriers, and increase their competitiveness (Ojaghi; Mohammadi & Yazdani, 2019; Etzkowitz & Zhou, 2017; Ho & Yoon, 2022). Thus, incubators not only support structural provision but also drive the creation of a dynamic and collaborative ecosystem, important for investments in innovative businesses (Ojaghi, Mohammadi & Yazdani, 2019; Ho & Yoon, 2022).

4. Conclusion

When analyzing the results, critical relationship factors are highlighted in the research findings. Incubators play a strategic role in the dynamics of innovation ecosystems, structuring their actions around three main axes: support, network, and fostering. The support offered by incubators includes the provision of infrastructure,

specialized consulting, and access to financial incentives, creating a conducive environment for the consolidation and expansion of startups.

The construction and maintenance of solid networks are equally essential, as they allow the convergence of interests between different ecosystem actors, fostering collaboration and the development of new businesses. Financial fostering is a crucial factor for the sustainability of emerging companies, enabling incubators to act as catalysts for technological development and business competitiveness.

Moreover, the role of universities deserves attention, especially through the work of university incubators that can drive the transformation of knowledge into innovation through technology transfer and the internationalization of incubatees companies. Additionally, incubators contribute to the development of the ecosystem by generating jobs and providing access to strategic and international markets, connecting companies to global ecosystems.

Finally, the creation of networks between incubatees companies and post-incubation follow-up builds a unique innovation ecosystem and fosters a sense of belonging to a community, strengthening connections among participants in this environment. Understanding and fostering these factors that influence this relationship is essential for improving strategies and enhancing the synergy between incubators and innovation ecosystems.

Acknowledgement

This work was supported by the Post-Graduate Program in Engineering and Knowledge Management (PPGEGC) of the Federal University of Santa Catarina (UFSC) - Brazil, the Federal Institute of Mato Grosso (IFMT) - Brazil, the National Council for Scientific and Technological Development (CNPQ), the Brazilian Coordination for Undergraduate Education Personal Improvement (CAPES) - Financial Code 001, the Foundation to Support the Research of the State of Santa Catarina (FAPESC) - Brazil and the Stemmer Foundation for R&D and Innovation (FEESC).

Ethics and AI Declaration: We declare that the present research utilized the VOSviewer software, version 1.6.18, for co-occurrence network analysis and mapping connections between keywords and bibliographic references. This software was used exclusively for organizing and visualizing data extracted from secondary sources, without any interference in the integrity or veracity of the analyzed information. Furthermore, we affirm that the study did not involve the direct or indirect participation of humans or animals in any of its stages. The entire methodology applied was based on public data and previously published documents, ensuring compliance with ethical principles and good research practices. Thus, the work fully adheres to the current ethical guidelines for studies of this nature.

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The Dynamics of Knowledge Social Sharing in the Major Wikipedia Language Versions

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Abstract: The creation of Wikipedia, which is the most popular free culture project, involves the sharing of knowledge by hundreds of thousands of volunteers. In general, Wikipedia as a virtual community of practice is inclusive space and open to anyone who has access to the Internet. Active Wikipedians, however, try to control the contribution to the common work, referring to the developed rules, including those related to the verifiability of content, while maintaining a neutral point of view and respecting copyright. Nevertheless, in communities, the problem of limiting editing for users who often act against these rules sometimes comes to the fore. In some language versions, the possibilities of co-creating knowledge for unregistered users have been limited. There is no general plan for actions taken in relation to the amount and type of content posted on it. Despite this, certain regularities can be observed. The article presents an analysis of the dynamics of user activity, which influences into the growth of content in the largest language versions of this project. Previous studies have shown a number of factors that can affect the involvement of Wikipedians. In most cases, these were limited to the analysis of the state in a short period. In the presented article, the author tried to capture certain regularities occurring over a longer period. For this purpose, a statistical analysis was made of the number of edits (content modifications); the number of active users; the size of added content; and the number of edited pages over 8 years in 50 largest language versions of Wikipedia. The statistical data was not limited to a specific sample of users but covered the entire database of these language versions. The initial analysis of the results prompted the author to undertake a further part of the study, of a qualitative nature. A sentiment analysis was made for 240 comments in the English and Polish versions: 50 comments from registered users and 50 comments from anonymous users were compared in both versions, as well as 20 discussions on technical topics and general issues. Statistical data analysis shows that despite very significant differences between the individual language versions in terms of activity and the amount of content provided, the amount of content per edit is more or less constant. On average, it is between 200 and 700 bytes, with larger deviations occurring in the case of edits by anonymous users and those made by bots. Moreover, it was observed that the largest versions of Wikipedia studied are characterized by lower variability, taking into account the number of edits per article. It was also assumed that anonymous edits and automation of actions may be perceived as less predictable and therefore more likely to evoke negative emotions. However, sentiment analysis did not confirm this hypothesis in relation to the two selected language versions studied. The results of the presented research may be useful for virtual communities of practice in the context of creating policy regarding automated and anonymous actions.

Keywords: Dynamics of knowledge sharing, Wikipedia language versions, Virtual communities of practice, Sentiment analysis, Volunteers activity

1. Introduction

The development of digital technologies, and in particular the Internet, has fostered grassroots collaboration and the sharing of information. Alongside techno-elites, communities aligned with countercultural values emerged, including communitarian circles and hacker groups (Castells, 2009). The latter played a pivotal role in the emergence of the free software movement, which subsequently evolved into the broader free culture movement. From these milieus, members of the movement drew a set of values and a distinctive hacker ethic, grounded in the freedom to collaboratively create and share produced content (Castells and Himanen, 2002). The most recognisable project of the free culture movement became Wikipedia, which at the same time has been described as the largest collaborative undertaking in human history (Jemielniak, 2020). The phenomenon of spontaneous self-organisation aimed at producing a high-quality product, exemplified by the online encyclopaedia, captivated scholars across the social sciences, from media and communication studies to economics (Benkler, 2008; Tapscott and Williams, 2008; Levis, 2010). Particular attention was devoted to the dynamics of its growth, the exponential increase in users, articles, and the volume of edits, which collectively contributed to the progressive improvement in content quality (see Stvilia, Al-Faraj, and Yi, 2009).

After 2007, the exponential growth observed in the largest language versions of Wikipedia began to plateau, accompanied by a decline in the number of active Wikipedians (Morgan et al., 2013). The earlier period of rapid expansion gave way to a phase marked by stabilization, routinization of practices, and institutionalization of editorial procedures (Arazy, Lifshitz-Assaf, and Balila, 2018). Despite this, significant disparities remain, both between Wikipedia language versions and in terms of user engagement within them. Only a relatively small subset of editors continues to be responsible for the majority of Wikipedia's content (Shimada et al., 2023).

As growth metrics began to decline in the largest versions, attention shifted more substantially toward the social and cultural aspects of the project (Kukowska, 2022; Karczewska, 2023). This shift revealed a gap in understanding the evolving dynamics of change within Wikipedia. The aim of this article is to examine the dynamics of knowledge sharing under conditions of relative social and organizational order. The author poses the question of whether it is possible to identify certain common features within mature Wikipedia versions that point toward stabilization and increased predictability. The following sections of the paper provide a literature review focused primarily on editorial activity across various language versions of Wikipedia. The methodology section outlines the adopted research methods, formulated hypotheses, and data collection strategies. The research findings shall indicate that editorial activity tends to be more stable in older and larger language versions, while it is comparatively lower when edits are made by unregistered users or bots.

2. Literature Review

In the early years following Wikipedia's inception, the rapid increase in the number of articles across various language versions was paralleled by the expansion of the project's community. Although the platform gained widespread popularity, it also faced criticism for its reliance on amateur contributors and the perceived lack of oversight (see Keen, 2007). Nevertheless, the active involvement of internet users in the collaborative creation of the online encyclopaedia led not only to a growth in the number of articles, but also to a significant rise in the volume of revisions made to existing articles. Wilkinson and Huberman (2007), in their comparative analysis of articles rated as high quality by Wikipedians versus randomly selected articles, identified a positive correlation between the number of edits per article and the assessed quality of content. Subsequent research by Stvilia, Al-Faraj, and Yi (2009), focusing on three language versions (Arabic, English, and Korean), suggested that the number of edits may serve as a content quality factor, depending on specific cultural contexts.

In addition to the issue of quality, scholarly investigations have frequently addressed the matter of egalitarianism, particularly regarding the accessibility of participation in the project. This was due to the fact that disproportions in user activity among those contributing to Wikipedia began to emerge quite early on. Research by Priedhorsky et al. (2007) within the English Wikipedia version revealed that approximately 10% of the most active contributors (power users) were responsible for nearly 90% of the platform's persistent word view (PWV). This metric refers to the number of views of any word introduced by a single edit. Each displayed word in an article is multiplied by the number of times the article is viewed after the word is added. Since power users also enjoy a higher reputation, their edits are less frequently reverted. As a result, they have a potentially greater advantage over other editors than in a situation where only the number of edits would be considered. The cited research, conducted in 2006, involved 4.2 million users and 58 million edits.

The dynamics of change in the early years of the project not only influenced the development of its social structure, but also shaped the types of activities undertaken by Wikipedians. Kittur et al. (2007) observed that despite the exponential growth in content quantity and overall user activity, the amount of direct work put into editing articles decreased relative to other activities. In 2001, 90% of activity was devoted to editing articles, but this proportion had dropped to 70% by 2006. Meanwhile, the percentage of edits related to policies, procedures, and other Wikipedia-specific pages rose from about 2% to approximately 12%.

Moreover, cultural factors may influence the uneven development of Wikipedia. Different versions were created at different times, which resulted in varying growth curves depending on when the research was conducted. At the time of writing this paper, the English Wikipedia version was nearly six times larger in terms of the number of edits than the second-largest, the German, version, while almost seven times larger in terms of active users. In a 2012 study that analysed 25 language versions, one in four articles created by Wikipedians was written in more than one language. However, only 12% of articles were created in all the researched versions. A significant portion of the remaining articles was related to regional topics, often pertaining to societies that speak the given language as their native tongue (Massa and Scrinzi, 2012). These are typically articles about towns and biographical entries about representatives of the ethnic group to which the Wikipedians belong.

Variables related to article quality and the number of edits may be interconnected due to the perception of the status of the collaborating Wikipedians. As Adler et al. (2008) indicate, the dynamics of editing can reflect the credibility of the authors. Analysing the editing history of individual articles facilitates the determination of whose edits were modified by subsequent Wikipedians. It is assumed that the fewer the edits of an author are modified or reverted, the higher their reputation. The credibility of an article and the trust in its quality can, in turn, be indicated by the editing history of authors with a given reputation. However, this approach to credibility might suggest that an unmodified text can be considered trustworthy. Niche articles, which are also

unevenly edited, could present a challenge in this context. In these cases, sections of text may not undergo necessary editorial revisions, which can affect the perception of the entire article as having a flawed style (see Korsgaard and Jensen, 2009).

What ultimately contributed to Wikipedia's success as a collective endeavour was its openness to newcomers and the encouragement of bold editing, prominently promoted through the “be bold” guideline. However, as the number of policies and guidelines increased, initiating participation in the project became more challenging. The initial enthusiasm, driven by a sense of empowerment, gradually gave way to negative emotions. This shift is reflected in qualitative research conducted among students, which explored their reactions and emotional responses to Wikipedia guidelines (Vetter et al., 2024). As novice Wikipedia users, students frequently reported feelings of fear, anxiety, and frustration when encountering the policies and procedures they were expected to master. Nonetheless, they also expressed a desire to influence and improve the Wikipedia environment. Negative emotions often arise in situations of uncertainty, particularly when individuals must adapt to a new environment and acquire the technical competencies necessary for effective engagement.

Research on Wikipedia primarily highlights the diversity of its language versions and the unevenness of their development. Capturing this diversity enables the proposal of solutions that could be applied locally, as well as fostering greater sensitivity to the differing needs of Wikipedia communities. However, a notable lack of studies focusing on the similarities that emerge from the activities of Wikipedians still remains. Pursuing research in this direction could help identify stabilizing factors that mitigate feelings of anxiety and uncertainty among contributors.

3. Materials and Methods

The study was conducted among the 50 largest language versions of Wikipedia, ranked by the number of active users, covering the period from 2017 to 2024. Previous research indicated that during this timeframe, bureaucratic rules became more firmly established, and the Wikimedia Foundation, which supported the projects, developed frameworks for fostering user participation (Rijshouwer, Uitermark, and de Koster, 2023). In the first stage of the study, publicly available data *(Wikimedi*a Statistics) was analysed. The variables examined included user editing activity (number of edits), contribution size measured in bytes (net bytes difference), number of active users, and number of edited pages. The analysis accounted for user categorization into registered users, anonymous contributors, and bots. Data for the analysis was acquired in January 2025.

Subsequently, the presence and strength of relationships between the afore-mentioned variables were examined for data collected in January and July of each year from 2017 to 2024. Wikipedian activity typically increases at the beginning of the calendar year, while it tends to decline during the summer months (particularly in the Northern Hemisphere, whose communities dominate the platform). Spearman’s rank correlation coefficients were found to be statistically significant, with values exceeding 0.8 for $p < 0.05$ between nearly all variables. The strength of the correlations was weaker only when the number of bot edits and the volume of contributions made by bots were compared with other variables, and in four of the examined periods no correlations were found between activity, primarily that of bots, and the contribution volume of anonymous users.

The ratio of average contribution size per single edit on a monthly scale was analysed in the subsequent phase of the study. In this context, contribution size refers to the change in page size measured in bytes. The analysis focused on this ratio in light of findings by Shimadaa et al. (2023), which demonstrated that over time, the number of edits consisting of editorial corrections tends to increase at the expense of content-adding edits. In mature Wikipedia versions, one can therefore assume a tendency toward smaller increases in page size, as editorial corrections typically add fewer bytes to articles. This trend may also contribute to reduced variability over time.

Based on preliminary research findings, two hypotheses were formulated:

H1. The variability of contributions measured in bytes per edit (BPE) decreases as the size of the Wikipedia language version increases.

H2. The variability of contributions measured in BPE is lower for edits made by registered users and higher for edits made by bots and anonymous users.

To verify both hypotheses, data was collected for each month from January 2017 to December 2024 (a total of 96 consecutive months) regarding net bytes difference and the number of edits in each of the 50 analysed language versions. Subsequently, monthly average bytes per edit (BPE) values were calculated, followed by the computation of the average BPE per language version, the variance, and the coefficients of variation - $CV_{(BPE)}$. For H1, only edits made by registered users were taken into account, as they constitute the core of the Wikipedia community and significantly influence the formation of its rules and standards. The assumption stated in H2 regarding higher variability in bot edits stems from the nature of bot activity which involves irregularly introduced large-scale operations, such as mass content additions, deletions, editorial modifications, or technical adjustments carried out by bot operators. Bots are created for these tasks by Wikipedians with the appropriate knowledge and programming skills, and the experience of Wikipedians determines the scope of the bots' activities and the type of software used. Bot edits are by default invisible in the recent changes log, which means that the changes they make may not be quickly noticed by the authors of individual pages. Editing of multiple pages within a short timeframe by bots occurs sporadically and often provokes negative reactions among Wikipedians. In the case of anonymous users, unpredictable shorter or longer episodes of activity may also arise, sometimes defined by Wikipedians as engaging in disruptive behaviour such as article destruction (vandalism) or trolling.

An analysis was conducted of the emotional load appearing in discussions in two language versions, Polish and English, taking into account the findings from studies on the importance of emotions in actions within Wikipedia (Vetter et al., 2024). For this purpose, 50 comments from registered users and 50 comments from anonymous users were compared in both versions, as well as 20 discussions on technical topics (including those related to bot activities) and general issue. The CLARIN-PL application (Pawełoszek and Wieczorkowski, 2023) was used, which facilitated sentiment analysis in both of the afore-mentioned languages. In this part of the study, an additional hypothesis was assumed:

> *H3. More negative emotions, such as fear, sadness, or anger, appear in discussions conducted by anonymous users and during discussions on technical topics.*

4. Results

The size limit for Wikipedia pages is approximately 2 million bytes, meaning that one edit can add a contribution of up to that size or remove it if such large pages exist. Throughout years of observing the recent changes log in several language versions, the author noted that most edits involve adding or removing just a few or several bytes. Larger edits occur relatively less frequently, although on a daily basis, users also expand articles or other pages by adding several thousand or even tens of thousands of bytes at once. There is also a significant difference in the overall number of edits made in different versions. The English Wikipedia sees approximately 200,000 edits daily, while the Swahili Wikipedia sees only a few hundred. One might therefore expect considerable variability in the BPE values. However, the multi-year averages (calculated using monthly averages) were quite similar across the analysed language versions of Wikipedia. In particular, small differences were observed in the edits made by registered users: from 165 BPE in the Swedish version to 654 BPE in the Tamil version (Tab. 1). Furthermore, it should be noted that the larger the language version, the smaller the $CV_{(BPE)}$. For $p < 0.05$, there was a statistically significant relationship both between $CV_{(BPE)}$ and the number of articles on Wikipedia (Spearman's rho equals -0.578961) and between $CV_{(BPE)}$ and the number of active users on Wikipedia (Spearman's rho equals -0.642831). Therefore, H1 was accepted. The data on the number of articles and active users refers to December 2024, which was the time when the language versions of Wikipedia could have reached their greatest maturity relative to the analysed period.

Table 1: The multi-year average BPE and BPE coefficient of variation for the 50 largest Wikipedia versions based on the activity of registered users, anonymous users, and bots. The first column contains the language codes of the Wikipedia versions.

Lang.	Reg. users		Anon. users		Bots		Lang.	Reg. users		Anon. users		Bots	
	x	$CV_{(BPE)}$	x	$CV_{(BPE)}$	x	$CV_{(BPE)}$		x	$CV_{(BPE)}$	x	$CV_{(BPE)}$	x	$CV_{(BPE)}$
en	172	6.7%	32	141.9%	286	162.0%	**ca**	348	17.0%	-234	-150.3%	26	307.5%
de	191	8.0%	107	65.8%	554	66.3%	**vi**	436	21.3%	98	81.3%	1219	117.4%
fr	214	12.2%	6	886.0%	512	62.2%	**hu**	278	9.9%	53	220.7%	141	101.4%

Lang.	Reg. users		Anon. users		Bots		Lang.	Reg. users		Anon. users		Bots	
	x	$CV_{(BPE)}$	x	$CV_{(BPE)}$	x	$CV_{(BPE)}$		x	$CV_{(BPE)}$	x	$CV_{(BPE)}$	x	$CV_{(BPE)}$
ru	325	9.8%	73	69.2%	287	78.3%	th	423	18.6%	30	501.8%	810	89.0%
it	212	11.6%	65	38.7%	809	53.7%	bn	619	19.6%	155	105.2%	2207	105.1%
es	219	10.5%	80	55.0%	250	92.3%	el	496	18.8%	15	766.2%	1105	253.1%
nl	220	16.1%	-11	-858.6%	423	191.9%	eu	319	37.7%	251	203.3%	225	258.6%
pl	322	11.0%	132	132.8%	100	130.1%	hi	426	29.4%	331	46.0%	394	258.3%
sv	165	19.1%	-35	-303.3%	155	191.3%	ms	434	64.2%	157	188.4%	2090	100.6%
ja	261	12.3%	89	60.5%	115	126.5%	bg	371	14.0%	-11	-1068.3%	245	447.2%
pt	417	19.6%	231	189.2%	845	321.3%	zh-yue	277	37.9%	112	65.0%	462	49.1%
uk	463	27.1%	62	214.5%	567	181.3%	et	209	59.4%	228	251.2%	415	301.9%
ar	405	33.7%	129	178.5%	297	60.3%	uz	469	86.5%	256	267.6%	117	289.6%
zh	273	12.2%	74	42.6%	465	58.6%	sk	415	23.3%	34	272.8%	2212	575.6%
fa	637	10.3%	15	366.5%	108	102.2%	az	219	34.1%	138	72.0%	155	138.1%
he	210	14.3%	-3	-2706.5%	206	180.9%	hr	336	27.3%	62	172.6%	362	155.8%
tr	242	37.3%	186	76.5%	292	118.6%	sw	332	50.2%	1357	190.6%	369	162.1%
ko	219	23.2%	55	109.8%	144	89.9%	hy	650	30.2%	121	378.3%	239	371.9%
cs	335	14.3%	87	168.1%	118	214.1%	sl	473	24.3%	-31	-426.9%	565	248.9%
id	362	20.7%	37	208.6%	933	61.5%	lt	168	59.9%	135	389.1%	92	156.9%
no	243	45.4%	-112	-150.9%	488	143.9%	kk	383	25.7%	509	323.1%	243	27.0%
ro	334	35.9%	124	64.7%	414	184.4%	lv	292	25.0%	2	19873.1%	297	284.1%
sr	470	39.3%	263	55.4%	461	488.4%	be	505	51.1%	275	134.7%	198	385.5%
da	338	23.6%	74	136.0%	475	170.5%	ta	654	29.3%	205	124.1%	387	119.6%
fi	250	89.4%	265	379.5%	897	118.6%	mk	626	56.7%	206	79.6%	831	169.6%

The research also allowed to accept H2. In all language versions, the $CV_{(BPE)}$ was higher for edits made by bots compared to the $CV_{(BPE)}$ of registered users. The situation was similar when comparing the $CV_{(BPE)}$ between the activity of registered and anonymous users. The value of this coefficient was lower for the editing activity of anonymous users only in seven versions of Wikipedia, created in Dutch, Swedish, Hebrew, Norwegian, Catalan, Bulgarian, and Slovenian languages. However, this is due to the fact that the $CV_{(BPE)}$ took on a negative value. Yet, if the absolute value were to be considered, it would be higher in these cases as well. Nonetheless, the negative value of this coefficient results from the fact that anonymous users more often removed content from pages than added new content. Such removals are often associated with acts of vandalism, which also destabilize projects. In the case of monthly average BPE, this value was negative only five times, three of which were in a single language version for the activity of registered users. For the edits of anonymous users, in only four language versions did the negative value for the monthly average BPE not appear at all.

The sentiment analysis conducted using the CLARIN-PL application did not support the acceptance of H3. In the case of the Polish version, relatively more negative emotions were observed in comments from

anonymous users compared to registered users, while more frequently in general discussions compared to discussions on technical topics. In the English version, no differences were observed in either case. Among positive emotions, joy was the most frequent, while the most common negative emotions were sadness and anger.

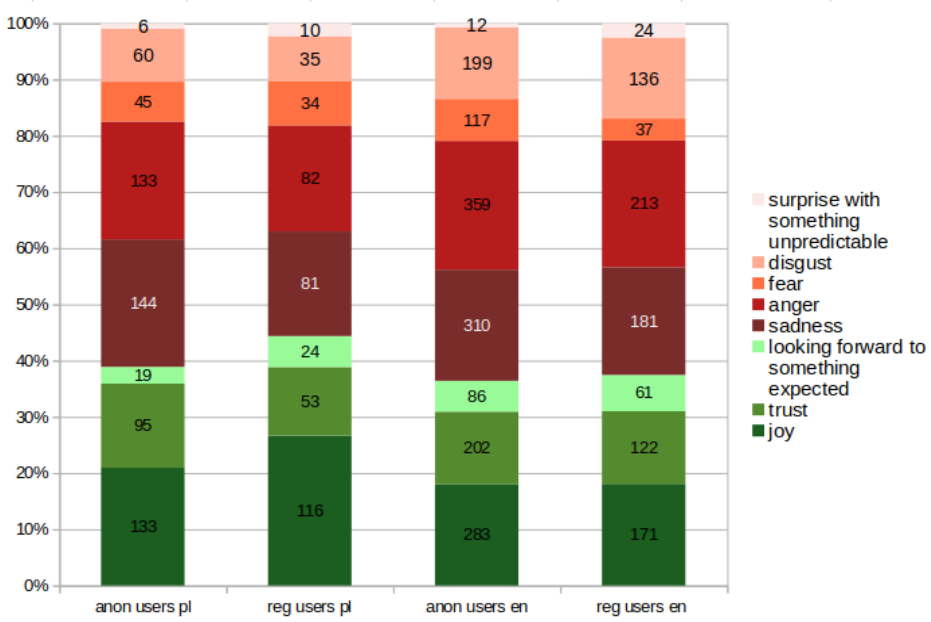


Figure 1: Comparison of the frequency of negative and positive emotions in entries made by registered users and anonymous users in the Polish and English versions of Wikipedia

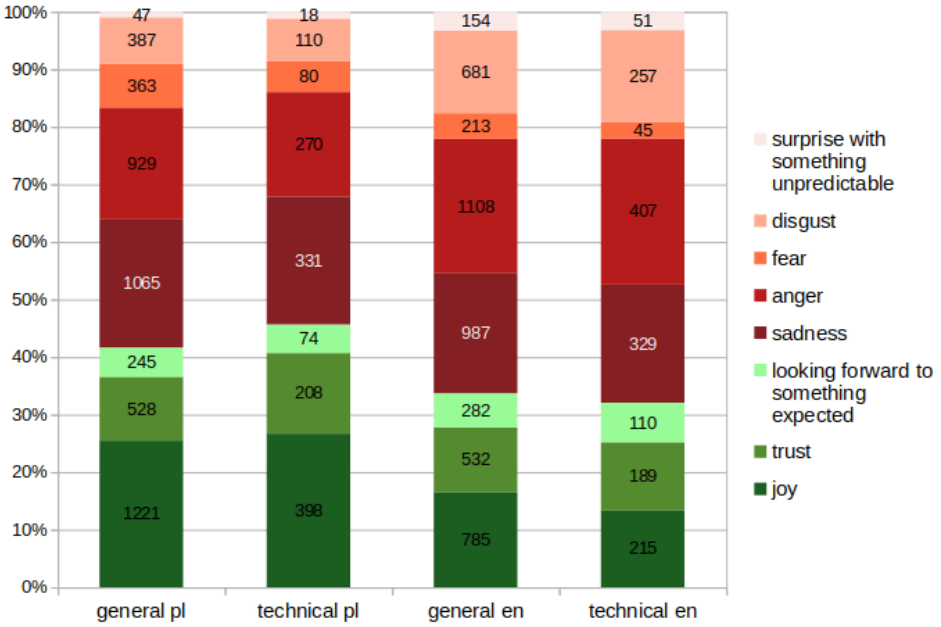


Figure 2: Comparison of the frequency of negative and positive emotions in discussions on general and technical topics in the Polish and English versions of Wikipedia

The lack of expected emotional differentiation may be due to certain limitations of the tool used. Emotional loads assigned to individual words are based on the probability of the word's usage in different contexts in the Polish and English language corpora. As such, some words may be associated with multiple emotions, both negative and positive. Detailed data is presented in Figure 1 and Figure 2. The numerical data refers to the sum of emotional loads generated by individual words.

5. Discussion and Conclusions

In earlier studies, the focus was primarily on the quality of content. It was noted that over time, Wikipedians tend to focus more on improving existing content rather than adding new content. A higher number of edits in a given article tends to result in better quality. These studies were conducted on a limited scale, mainly focusing on English Wikipedia (Kittur et al., 2007; Wilkinson and Huberman, 2007; Shimada et al., 2023). The Wikipedia language versions were created at different times and reached different sizes of communities and articles, which also depended on the overall number of people using a given language as their native tongue. Previous research showed certain correlations between editorial activity and cultural conditions (Kukowska, 2022; Karczewska, 2023).

The findings presented in this paper, however, indicate that the differences in terms of individual contributions are minimal. Although the English version has approximately 300 times more active users than the Lithuanian version, the multi-year average BPE value is almost the same in both versions. One might assume that both have reached a certain "maturity," and their contributors primarily focus on editing. On the other hand, the Lithuanian version has a significantly higher $CV_{(BPE)}$ (59.9%) compared to the English one (6.7%). It can be assumed that the considerably larger number of users and edits made each month also leads to less variability. It is also plausible that activities are increasingly subject to routinization in mature Wikimedia projects, where the core consists of power users with a large number of edits (Skolik, 2023). Although occasional spontaneous actions of mass article creation or, at times, removals occur, these tasks are typically performed by bots. The higher $CV_{(BPE)}$ in the case of bot activity results from the fact that their actions are executed over a short period, sometimes taking a few days or weeks, although planning such activities and obtaining consensus takes significantly more time.

A high dynamics of changes is also evident in the edits made by anonymous users. Not only is there a high $CV_{(BPE)}$ in this case, but the monthly average BPE values also frequently become negative. This indicates the relatively frequent removal of content by unregistered users on Wikipedia, which is a factor that more strongly destabilizes projects. In various language versions, restrictions are considered for individuals "editing from an IP address." In the English version, unregistered users are not allowed to create new articles, while in the Portuguese version, they cannot even edit existing ones.

The author assumed that the variability resulting from the activity of anonymous users and bots could lead to the emergence of negative emotions among the project participants. However, sentiment analysis did not confirm this assumption. It may have been more reliable if the texts had been analysed by independent judges. However, even in such cases, it is often difficult to determine the intent of the individuals posting comments. For example, texts with a positive emotional tone might be a form of sarcasm, making them hard to capture. Moreover, while anonymous comments could be emotional, bot actions themselves do not carry any emotional charge. Therefore, an attempt was made to find a metric related to the potential revelation of technophobia among Wikipedians. However, in discussions on technical topics, where irresponsible actions related to the deployment of bots are sometimes pointed out, the tool used did not detect any specificity compared to discussions on general topics.

The aim of the conducted research was to capture the constant elements of dynamics in the largest language versions of Wikipedia. One of these elements turned out to be the average contribution size of users, measured in bytes per edit, especially for registered users. Searching for additional metrics with low variability over time and across the entire Wikimedia environment may help shape strategies within this environment towards greater stability and predictability.

AI Declaration: I declare that I did not use AI in this article, all the text was manually written.

Ethics Declaration: I declare that the study is based on publicly available data and open-source data and as such, the nature of this study did not warrant a review by an ethics committee.

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Comparative Analysis of the Efficiency of High-Quality Intellectual Capital Formation in Various Scientific Sectors

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Abstract: In the present situation of the formation of high-quality intellectual capital at scientific institutions in Latvia, the theme of the research is highly topical. The object of the research is the formation of high-quality intellectual capital at scientific institutions in various scientific sectors while the subject of the research is the comparative analysis of the efficiency of high-quality intellectual capital formation at scientific institutions in various scientific sectors of Latvia. The objective of the research is the comparative analysis of the efficiency of high-quality intellectual capital formation at scientific institutions in various scientific sectors of Latvia in the period from 2013 to 2018. The following tasks were determined to reach the objective: to study the formation of high-quality intellectual capital at scientific institutions in various scientific sectors of Latvia; to identify the concept of the efficiency of high-quality intellectual capital formation in various scientific sectors; to calculate main indicators thereof, and, to carry out the comparative analysis of indicators characterising the efficiency of high-quality intellectual capital formation at scientific institutions in various scientific sectors in Latvia. Research methods used in the paper are content analysis, economic analysis, and economic experiment.

Keywords: High-quality intellectual capital, Efficiency indicators, Comparative analysis, Scientific institutions, Latvia

1. Introduction

Every six years, the Ministry of Education and Science of the Republic of Latvia (IZM) shall organise an international evaluation of the scientific institutions (SIs) registered in Latvia (IESI). The last IESI took place in the period from 2013 to 2018. In order to establish the dynamics of the efficiency indicators of the academic staff involved in the formation of high-quality intellectual capital (HQIC) at the SIs of Latvia (IZM, 2021), the authors used the output data of findings across the set of SIs evaluations per period from 2013 to 2018 offered by "Technopolis-group" (TG). It provides an opportunity for the authors to calculate the HQIC indicators at the SIs of Latvia and to compare their dynamics during the period from 2013 to 2018.

Data of the comparative analysis will help to develop support and motivation programs to increase the efficiency of involvement of the academic staff in the HQIC formation. In addition, the comparative analysis will reveal whether the score on quality of research at the SIs of Latvia in the IESI of TG coincides with the place of the SI of Latvia in the ratings of the HQIC indicators, and whether the quality of research score of the SI of Latvia also reflects the efficiency of the involvement of the academic staff of the SI of Latvia in the HQIC formation.

> *Hypothesis: The quality of research scores of the SIs shows the efficiency of the HQIC formation in the SIs of Latvia.*

2. Theoretical Background

The authors rely on research of understanding, adapting, applying IC in universities (Mercado-Salgado et al, 2016), and research of the role of human capital in educational-training process at the university (Contu, 2017) presented different aspects of IC. Spica et al (2017a) state that IC is an economic category, the spiritual value created by the human potential, and it can be accumulated and converted into the value of other capitals. By investigating certain information about the management of education, we can increase the capacity and significance of the country's total economic capital movement.

Scientific articles, monographs, and national and international patents form the totality of the IC of each SI. Rondeau et al (2022) remind that peer reviewed publications remain a traditional form of academic productivity. From this set of IC, scientific publications included in the international databases "Web of Science" (WoS) and "SCOPUS" are conventionally considered HQIC. Such scientific publications provide an opportunity to determine the international competitiveness of various scientists, SIs, and sectors of science in Latvia.

Spica et al (2017a; 2017b) have worked out four indicators of the efficiency of the formation of IC in the higher education establishment: (1)The efficiency of the involvement of academic staff in the formation of IC per year in percentages (AIK); (2)The efficiency of the involvement of academic staff with a Doctorate degree in the formation of IC per year in percentages (DIK); (3)The efficiency of the involvement of students in the formation of IC per year in percentages (SIK); (4)Mutual efficiency of the involvement members of the academic staff with Doctorate degrees and the academic staff without Doctorate degrees in the formation of IC per year in times, (DE).

In order to calculate the AIK, DIK, SIK, and DE of the HEE Spica et al (2017a; 2017b) have worked out four formulas: (1) AIK = (ZPS : AS) x 100; (2) DIK = (ZPS : DS) x 100; (3) SIK = (ZPS : SS) x 100; (4) DE = DIK : AIK. Where: ZPS represents the number of scientific publications of the HEE per year; AS represents the number of academic staff in full-time jobs per year; DS represents the number of academic staff with Doctorate degrees holding in full-time jobs per year; SS represents the number of students per year.

3. Methodology

In their study, the authors will conduct a comparative analysis of SIs involved in the formation of HQIC in various sectors of science in Latvia. It comprised evaluation of SIs of six sectors of science: 1)Engineering and Computer Sciences (E&CS); 2)Natural Sciences (NS); 3)Medical and Health Sciences (M&HS); 4)Agriculture, Forestry, and Veterinary Sciences (A&F&VS); 5)Social Sciences (SS); 6)Humanities and Art Sciences (H&AS).

The authors modified the above mentioned formulas for the purposes of the study. Namely, calculate HQIC efficiency indicators for total numbers of full time equivalent (FTE) academic and research personnel (KIK), for FTE academic personnel (AIK), for FTE academic research personnel (PIK) and for PhDs completed at the SI (SIK). In addition, all the authors of the above-mentioned HQIC efficiency indicators were calculated for total number of self-reported outputs of articles in peer reviewed scientific edited journals and conference proceeds included in WoS or SCOPUS (WS). The authors calculated mutual efficiency indicators (PE) regarding involvement of the FTE academic research personnel (PS) and the FTE academic personnel (AS) in the formation of HQIC in times.

In the present research, the authors used the following data from the IESI: output data on the number of FTE academic personnel (AS), the number of FTE academic and research personnel (PS), the total number of FTE academic and research personel (KS), the number of PhDs completed (SS), the number of articles in peer reviewed scientific edited journals and conference proceedings included in WoS or SCOPUS (WS) in period 2013-2018 per SI in Latvia. Authors revised the above WS for the year. TG analysed 62 SI of Latvia.

In this study, one WS are accepted as one unit of HQIC. Further, using the modified formulas 1; 2; 3; and 4, were calculated: KIK, AIK, PIK, SIK, PE. Then, according to the results obtained through the author's calculations, a corresponding rating place was assigned to each SI of Latvia per year and each of the above indicators KIK, AIK, PIK and SIK.

Each rating location was then assessed with an appropriate score, where the lowest score is 1 point, while the highest score is 5 points. The above mentioned assessment system makes it possible to compare the quantitative efficiency indicators of SI of various scientific sectors in Latvia calculated by the authors with IESI overall assessment criterion - quality of the research performance of the SI. The relevant Panel of the TG was a score of the research performance of each SI using the scale, where score 5 means outstanding level of research, score 4 means very good level of research, score 3 means good level of research, score 2 means adequate level of research, score 1 means poor level of research (IZM, 2021).

Next, the unified overview of all six sectors of science in Latvia was created. Here, the SIs were arranged according to the obtained rank in their sector of science. Furthermore, indicators of the efficiency of the involvement of academic staff of each SI in the formation of HQIC were added. The authors then selected one SI with the highest efficiency indicator of the involvement of academic staff in the formation of HQIC from the unified review of the sectors of science in Latvia, accepted it as the basic indicator, and equated it to 100%. Further, the authors calculated the proportion of the efficiency of the involvement of academic staff of each SI in the base indicator.

After that, a rating scale of the results obtained was created on five-score system, where the highest rating is five score, and the lowest rating is one score. The new efficiency rating system for the involvement of academic staff of SIs in the formation of HQIC created by authors provides for granting of one score for the obtained efficiency indicators from 1% to 20%, 2 scores - for the obtained efficiency indicators from 21% to 40%, 3 scores

- for the obtained efficiency indicators from 41% to 60%, 4 scores - for the obtained efficiency indicators from 61% to 80%, and 5 scores - for the obtained efficiency indicators from 81% to 100%,

The follow-up authors compared the results of their own estimates of SI quantitative indicators to the relevant Panel of the TG's results of qualitative indicators, calculated the difference between the indicators and the changes. For this purpose, the authors calculated for each SI sore of indicators recording efficiency of HQIC and average score of each scientific sector. After that, authors compared these scores with scores of quality of the research of each SI developed by Panel of the TG.

4. Results

To calculate the efficiency of the involvement of academic staff in the formation of HQIC, the authors used formulas that were developed and approbated already before and now modified.

AIK = (WS : AS) x 100 (1)

PIK = (WS: PS) x 100 (2)

KIK = (WS : KS) x 100 (3)

SIK = (WS: SS) x 100 (4)

PE = PIK : AIK (5)

Table 1: Performance indicators of the involvement of academic personnel of SIs in the formation of HQIC in a year and their comparative analysis in various sectors of science in Latvia in period from 2013 to 2018

AIK rating	E&CS AIK (%)	E&CS AIK (%) of base indicator	E&CS AIK score	NS AIK (%)	NS AIK (%) of base indicator	NS AIK score	M&HS AIK (%)	M&HS AIK (%) of base indicator	M&HS AIK score	A&F&VS AIK (%)	A&F&VS AIK (%) of base indicator	A&F&VS AIK score	SS AIK (%)	SS AIK (%) of base indicator	SS AIK score	H&AS AIK (%)	H&AS AIK (%) of base indicator	H&AS AIK score
1	1584	100	5	550	35	2	519	33	2	191	12	1	596	38	2	54	3	1
2	1264	80	5	494	31	2	426	27	2	0	0	0	556	35	2	49	3	1
3	933	59	3	415	26	2	230	15	1	0	0	0	345	22	2	39	2	1
4	833	53	3	389	25	2	21	1	1	0	0	0	289	18	1	23	3	1
5	706	45	3	0	0	0	0	0	0	0	0	0	226	14	1	19	1	1
6	467	29	2	0	0	0	0	0	0				217	14	1	10	1	1
7	301	19	1	0	0	0	0	0	0				169	11	1	9	1	1
8	274	17	1				0	0	0				109	7	1	5	0	0
9	236	15	1										105	7	1	4	0	0
10	221	14	1										92	6	1	0	0	0
11	201	13	1										77	5	1	0	0	0
12	74	5	1										76	5	1			
13	14	1	1										59	4	1			
14	0	0	0										0	0	0			
15	0	0	0										0	0	0			

AIK rating	E&CS AIK (%)	E&CS AIK (%) of base indicator	E&CS AIK score	NS AIK (%)	NS AIK (%) of base indicator	NS AIK score	M&HS AIK (%)	M&HS AIK (%) of base indicator	M&HS AIK score	A&F&VS AIK (%)	A&F&VS AIK (%) of base indicator	A&F&VS AIK score	SS AIK (%)	SS AIK (%) of base indicator	SS AIK score	H&AS AIK (%)	H&AS AIK (%) of base indicator	H&AS AIK score
16	0	0	0															
Average	392	25	2	733	46	3	456	29	2	478	30	2	144	9	1	23	1	1

According to Table 1 the highest AIK indicator in the formation of HQIC in a year is 1584% and was accepted by the authors as the basic indicator or 100%. The above indicator has been achieved by a SI representing the E&CS. Consequently, the efficiency indicator of the SIs of other sectors of science in Latvia were attributed to this higher efficiency indicator in order to determine their proportion as a percentage. Then, according to the new rating system developed by the authors, each SI was assigned a certain number of scores.

Table 2: Performance indicators of the involvement of academic research personnel of SIs in the formation of HQIC in a year and their comparative analysis in various sectors of science in Latvia in period from 2013 to 2018

PIK rating	E&CS PIK (%)	E&CS PIK (%) of base indicator	E&CS PIK score	NS PIK (%)	NS PIK (%) of base indicator	NS PIK score	M&HS PIK (%)	M&HS PIK (%) of base indicator	M&HS PIK score	A&F&VS PIK (%)	A&F&VS PIK (%) of base indicator	A&F&VS PIK score	SS PIK (%)	SS PIK (%) of base indicator	SS PIK score	H&AS PIK (%)	H&AS PIK (%) of base indicator	H&AS PIK score
1	833	4	1	173	1	1	20256	100	5	338	2	1	1650	8	1	354	2	1
2	627	3	1	159	1	1	485	2	1	80	0	0	729	4	1	121	1	1
3	468	2	1	128	1	1	472	2	1	77	0	0	556	3	1	73	0	0
4	337	2	1	113	1	1	252	1	1	70	0	0	545	3	1	53	0	0
5	292	1	1	74	0	0	199	1	1	51	0	0	514	3	1	52	0	0
6	234	1	1	66	0	0	82	0	0				474	2	1	44	0	0
7	219	1	1	26	0	0	70	0	0				290	1	1	42	0	0
8	202	1	1				52	0	0				242	1	1	41	0	0
9	202	1	1										218	1	1	35	0	0
10	194	1	1										155	1	1	28	0	0

PIK rating	E&CS PIK (%)	E&CS PIK (%) of base indicator	E&CS PIK score	NS PIK (%)	NS PIK (%) of base indicator	NS PIK score	M&HS PIK (%)	M&HS PIK (%) of base indicator	M&HS PIK score	A&F&VS PIK (%)	A&F&VS PIK (%) of base indicator	A&F&VS PIK score	SS PIK (%)	SS PIK (%) of base indicator	SS PIK score	H&AS PIK (%)	H&AS PIK (%) of base indicator	H&AS PIK score
11	180	1	1										136	1	1	22	0	0
12	161	1	1										92	0	0			
13	141	1	1										90	0	0			
14	124	1	1										89	0	0			
15	76	0	0										15	0	0			
16	54	0	0															
Average	242	1	1	109	1	1	160	1	1	96	0	0	256	1	1	39	0	0

Comparing the figures collected in Table 2, the authors conclude that the highest PIK indicator of 20256% is for the SI of the M&HS, while the lowest PIK indicator of 15% is for the SI of the SS. It follows that only one SI get the highest rating of 5 score, thirty six SIs get 1 score, but other SIs get 0 scores.

Table 3: Performance indicators of the involvement of PhDs completed at SIs in the formation of HQIC in a year and their comparative analysis in various sectors of science in Latvia in period from 2013 to 2018

SIK rating	E&CS SIK (%)	E&CS SIK (%) of base indicator	E&CS SIK score	NS SIK (%)	NS SIK (%) of base indicator	NS SIK score	M&HS SIK (%)	M&HS SIK (%) of base indicator	M&HS SIK score	A&F&VS SIK (%)	A&F&VS SIK (%) of base indicator	A&F&VS SIK score	SS SIK (%)	SS SIK (%) of base indicator	SS SIK score	H&AS SIK (%)	H&AS SIK (%) of base indicator	H&AS SIK score
1	654	98	5	659	99	5	494	74	4	547	82	5	667	100	5	450	67	4
2	516	77	4	625	94	5	336	50	3	477	72	4	647	97	5	344	52	3
3	467	70	4	606	91	5	284	43	3	354	53	3	550	82	5	130	19	1
4	413	62	4	578	87	5	209	31	2	303	45	3	327	49	3	58	9	1
5	360	54	3	255	38	2	188	28	2	237	36	2	236	35	2	49	7	1
6	288	43	3	239	36	2	171	26	2				222	33	2	42	6	1
7	279	42	3	179	27	2	127	19	1				156	23	2	36	5	1
8	257	39	2				75	11	1				148	22	2	34	5	1
9	252	38	2										103	15	1	24	4	1
10	247	37	2										81	12	1	13	2	1

SIK rating	E&CS SIK (%)	E&CS SIK (%) of base indicator	E&CS SIK score	NS SIK (%)	NS SIK (%) of base indicator	NS SIK score	M&HS SIK (%)	M&HS SIK (%) of base indicator	M&HS SIK score	A&F&VS SIK (%)	A&F&VS SIK (%) of base indicator	A&F&VS SIK score	SS SIK (%)	SS SIK (%) of base indicator	SS SIK score	H&AS SIK (%)	H&AS SIK (%) of base indicator	H&AS SIK score
11	209	31	2										71	11	1	0	0	0
12	202	30	2										61	9	1			
13	185	28	2										58	9	1			
14	154	23	2										0	0	0			
15	133	20	2										0	0	0			
16	0	0	0															
Average	296	44	3	241	36	2	209	31	2	316	47	3	112	17	1	51	8	1

In Table 3, according to the SIK indicators the first place and highest score is taken by the SI of the SS, while the lowest SIK indicator of 13% is for the SI of the H&AS. According to Table 3 follows that, at the SIs of the H&AS and the A&F&VS no one get 5 scores. In the E&CS and A&F&VS, only one SI get the highest 5 score, in the SS - three SIs get 5 score, but in the NS - four SIs get 5 score.

Table 4: Performance indicators of the involvement of total academic staff of SIs in the formation of HQIC in a year and their comparative analysis in various sectors of science in Latvia in period from 2013 to 2018

KIK rating	E&CS KIK (%)	E&CS KIK (%) of base indicator	E&CS KIK score	NS KIK (%)	NS KIK (%) of base indicator	NS KIK score	M&HS KIK (%)	M&HS KIK (%) of base indicator	M&HS KIK score	A&F&VS KIK (%)	A&F&VS KIK (%) of base indicator	A&F&VS KIK score	SS KIK (%)	SS KIK (%) of base indicator	SS KIK score	H&AS KIK (%)	H&AS KIK (%) of base indicator	H&AS KIK score
1	449	2	1	128	1	1	20256	100	5	122	1	1	278	1	1	53	0	0
2	417	2	1	128	1	1	485	2	1	80	0	0	276	1	1	47	0	0
3	312	2	1	113	1	1	247	1	1	77	0	0	234	1	1	28	0	0
4	198	1	1	94	0	0	158	1	1	70	0	0	192	1	1	20	0	0
5	141	1	1	66	0	0	107	1	1	51	0	0	160	1	1	19	0	0
6	134	1	1	63	0	0	70	0	0				107	1	1	15	0	0
7	131	1	1	27	0	0	52	0	0				92	0	0	14	0	0
8	130	1	1				17	0	0				89	0	0	8	0	0

KIK rating	E&CS KIK (%)	E&CS KIK (%) of base indicator	E&CS KIK score	NS KIK (%)	NS KIK (%) of base indicator	NS KIK score	M&HS KIK (%)	M&HS KIK (%) of base indicator	M&HS KIK score	A&F&VS KIK (%)	A&F&VS KIK (%) of base indicator	A&F&VS KIK score	SS KIK (%)	SS KIK (%) of base indicator	SS KIK score	H&AS KIK (%)	H&AS KIK (%) of base indicator	H&AS KIK score
9	124	1	1										71	0	0	8	0	0
10	121	1	1										69	0	0	5	0	0
11	119	1	1										58	0	0	3	0	0
12	116	1	1										58	0	0			
13	114	1	1										49	0	0			
14	54	0	0										35	0	0			
15	53	0	0										15	0	0			
16	12	0	0															
Average	150	1	1	95	0	0	118	1	1	80	0	0	92	0	0	14	0	0

According to Table 4, the highest KIK indicator is 20256% and representing the SI of the M&HS. In the six scientific sectors twenty seven SIs get 1 score, but the other thirty four SIs get 0 score. It folows that total academic staff of SIs in various sectors of science in Latvia in period from 2013 to 2028 did not competitive in the formation of HQIC on international scientific environment.

Table 5: Performance indicators of the mutual efficiency indicators regarding involvement of total academic research personnel and total academic personnel of SIs in the formation of HQIC in times a year, quality of research (QTG) scores by TG, new total quantity KIK scores of SIs, and their comparative analysis in various sectors of science in Latvia in period from 2013 to 2018

KIK rating	E&CS PE	E&CS QTG score	E&CS KIK score	NS PE	NS QTG score	NS KIK score	M&HS PE	M&HS QTG score	M&HS KIK score	A&F&VS PE	A&F&VS QTG score	A&F&VS KIK score	SS PE	SS QTG score	SS KIK score	H&AS PE	H&AS QTG score	H&AS KIK score
1	0,4	4	1	0,4	3	1	0	2	5	1,8	2	1	1,0	1	1	0	4	0
2	1,0	1	1	0	4	1	0	3	1	0	3	0	0,9	3	1	6,6	4	0
3	0,5	3	1	0,4	1	1	0,9	3	1	0	4	0	2,1	3	1	5	0	0
4	0,2	2	1	0,2	3	0	0,6	4	1	0	3	0	7,6	2	1	1,1	1	0
5	0	2	1	0	4	0	0,9	3	1	0	4	0	2,4	3	1	5,2	3	0
6	1,5	3	1	0,2	3	0	0	4	0				1,7	3	1	0,5	3	0
7	0,2	4	1	0	3	0	0	5	0				0	3	0	2,7	3	0
8	0,4	3	1				3,8	2	0				4,3	3	0	4,5	2	0
9	0	3	1										2,1	3	0	8,4	4	0

KIK rating	E&CS PE	E&CS QTG score	E&CS KIK score	NS PE	NS QTG score	NS KIK score	M&HS PE	M&HS QTG score	M&HS KIK score	A&F&VS PE	A&F&VS QTG score	A&F&VS KIK score	SS PE	SS QTG score	SS KIK score	H&AS PE	H&AS QTG score	H&AS KIK score
10	0,7	3	1										0,3	3	0	6,8	3	0
11	1,5	4	1										1,7	2	0	11,6	4	0
12	0,7	2	1										3,2	2	0			
13	0,9	2	1										1,8	2	0			
14	0	4	0										1,5	2	0			
15	2,6	2	0										0	2	0			
16	5,5	1	0															
Average	0,6	-	1	0,2	-	0	0,4	-	1	0,2	-	0	1,8	-	0	1,7	-	0

In Table 5, the PE indicators rests in the range from 0,2 to 11,6 in respect of the SIs in Latvia. The highest PE is held by the SI in the H&AS, while the lowest PE belongs to two SI's in the E&CS, and, to two SI's in the NS.

The highest average rate of the PE indicators is 1,8 in the SS, the second highest average rate of the PE indicators is 1,7 in the H&AS. It follows that academic research personnel of the SIs of the SS and the H&AS is more effective as theirs academic personnel in the formation of HQIC. Lowest average rate of the PE indicators is 0,2 in the NS and the A&F&VS. It follows that academic personnel of above scientific sectors is more effective in the formation of HQIC to compare with academic research personnel at the SIs of the NS and the A&F&VS. When comparing QTG scores by TG to new total quantity KIK scores calculated by authors, it can be concluded that they differ from 1 score to 5 scores in total. The assessment of the QTG scores and new KIK scores of each SI in various sector of sciences in Latvia results in a conclusion that new KIK scores were too lower, and, exept tor the one SI in the E&CS, one SI in the NS, and one SI in the SS, where QTG, KIK scores coincided.

Table 6: The summary of performance indicators of the involvement of total academic staff of SIs in the formation of HQIC in a year and their total margins of AIK, PIK, SIK, and KIK indicators comparative analysis in various sectors of science in Latvia in period from 2013 to 2018

Scores	Total margins of AIK (%)	Total margins of PIK (%)	Total margins of SIK (%)	Total margins of KIK (%)	Total average margins of AIK (%)	Total average margins of PIK (%)	Total average margins of SIK (%)	Total average margins of KIK (%)
0	4 - 5	15 - 92	-	3 - 94	-	39 - 96	-	14 - 95
1	9 - 301	113 - 1650	13 - 130	107 - 485	23 - 144	109 - 256	51 - 112	118 - 150
2	345 - 596	-	133 - 257	-	392 - 478	-	209 - 241	-
3	706 - 933	-	279 - 360	-	733 - 733	-	296 - 316	-
4	-	-	413 - 516	-	-	-	-	-
5	1264 - 1584	-	547 - 667	20256 - 20256	-	-	-	-

From the results summarised in the tables 6, authors conclude that for all AIK, PIK, SIK, KIK indicators whose score is 1, the total margins of PIK indicators and total average margins of PIK indicators are the highest. They are followed total margins of KIK indicators and total average margins of KIK indicators. Total margins for all indicators whose score is 5, belongs to KIK, AIK and SIK indicators. Total margins for all scores from 1 to 5, which finded is only for SIK indicators.

5. Conclusions

The study of the authors did not result in confirming hypothesis. The quality of research scores of the SIs do not shows the efficiency of the HQIC formation in the SIs of Latvia. When comparing the QTG scores of TG group to the new KIK scores by the authors, it can be concluded that they differ from 1 to 5 scores in total.

The study shows that new performance indicators KIK of the involvement of total academic staff of SIs in the formation of HQIC in various sectors of sciences in Latvia in period from 2013 to 2018 were lower as shown by the results compiled by the relevant Panel of the TG exept for the one SI of the M&HS, where the KIK score was highest per 3 scores.

The authors is encoraged to supplement the methodology for international evaluation of scientific institutions with the quantitative efficiency indicators AIK, PIK, SIK, KIK of the involvementof academic staff and PhDs completed at the SIs in the formation of HQIC per year in percentage, and, PE in times, and performance indicators of their comparative analysis in various sectors of sciences in country developed by the authors.

The methodology developed by the authors included five phases: (1)according to formulas previously developed by the authors, the efficiency indicators of each SI were calculated for AIK, PIK, KIK, SIK; (2)efficiency indicators for AIK, PIK, KIK SIK were ranked from higher to lower indicator, and each SI was given the rating in its science sector; (3)the comparative analysis of the individual efficiency indicators of each SI was carried out for the AIK, PIK, KIK, SIK between all scientific sectors, and the highest efficiency indicators of the AIK, PIK, KIK, SIK as a whole on the science were finded out; (4)the highest efficiency indicators for AIK, PIK, KIK, SIK were accepted as base indicator, equated its to 100%, and calculated the proportion of the efficiency indicator of each SI in the base indicator; (5)according to the rating scale developed by the authors, each SI was awarded an appropriate score based on the previously calculated efficiency indicators of the proportion of AIK, PIK, KIK, SIK in science as a whole.

Ethical Declaration: The authors declares that there are no ethical issues related to the research presented in this paper.

AI Declaration: The authors declares that no significant AI tools or technologies were used in the conduct the research for this paper.

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Knowledge Strategies Facilitating Future Port Development and Management

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Abstract: The European transport network is extensive and integrated, encompassing major ports, roads, airports, and rail systems. However, global demand proactive perspectives and measures. Europe is facing emerging developmental challenges, including increased geopolitical instability, climate changes, shortage of energy and natural resources, and intensified trade competition with China and US (Draghi, 2024). Transport plays a vital role in the European economy, prompting efforts to enhance integration between transport modes - for example through the Trans-European Transport Network (TEN-T). This paper focuses on ports as critical nodes in a multimodal transport system, and Its main objective is to explore how two theoretical perspectives – strategic knowledge management and resilience – can support planning and decision-making. Central in both approaches is the concept of "known and unknowns", referring to how organisations can prepare for and respond to future changes, events, and disruptions. The study is based on semi-structured interviews and addresses themes such as current collaboration and coordination of plans and practices, anticipated challenges and threats, and potential regional impacts of climate changes and geopolitical instability. The informants are key port stakeholders in Norway. The discussion reflects on how the two theoretical perspectives can inform the transformation of current management practices to better address future changes, disruptions and crises.

Keywords: Strategic knowledge management, Resilience, Integrated planning, Inter-organizational coordination, Emerging rends and challenges

1. Introduction

Europe is currently facing a range of emerging developmental challenges, including increased geopolitical instability, climate changes, shortage of energy and natural resources, and growing trade competition with China and United States (Draghi, 2024). Transport is a vital component of the European economy. The European transport network is extensive and integrated, encompassing major ports, roads, airports, and rail systems. In response, efforts are being made to enhance the integration between different transport modalities - for example through the Trans-European Transport Network (TEN-T). The TEN-T policy serves as a key instrument for planning and developing a coherent, efficient, multimodal, and high-quality transport infrastructure across the EU (European Commission, 2025). The network includes railways, inland waterways, short sea shipping routes, and roads that connect urban nodes, maritime and inland ports, airports and terminals.

This paper is a contribution in the MARMAN (Maritime Resilience Management of an Integrated Transport System) project financed by the Norwegian Research Foundation for the period 2021 – 2026. The overall objective is to develop a resilience-based knowledge foundation for governance, management and work practice that ensure a safe and secure integrated Maritime Transport Systems (MTS), particularly in the context of implementing connected and automated vessels (CAV).

Ports and terminals are critical nodes in a multimodal transport network. However, global trends point to significant future challenges, necessitating proactive perspectives and measures. The main objective of this paper is to explore and reflect on how knowledge management theory may support planning and decision-making in addressing these emerging trends and challenges.

2. Theory

This chapter presents two theoretical perspectives – strategic knowledge management and resilience – emphasising a proactive approach to address future scenarios, along with associated challenges and opportunities. Central to both perspectives is the concept of "knowns and unknowns", referring to how organisations can prepare for and respond to future changes, events, and disruptions. As such, both frameworks can support managerial preparedness and responsiveness in face of both anticipated and unforeseen scenarios.

2.1 Strategic Knowledge Management

This presentation of organisational strategic knowledge management is generally based on Bratianu (2022), with additional references specified where relevant. Strategic thinking is inherently future-oriented, and its core elements are uncertainty and the absence of knowledge. Therefore, it must be complemented with imagination

and creativity. Moreover, an organisation's strategies aim to bridge the knowledge gap between known and unknown.

Past, present and future. Time is a complex construct, and several theories emphasise the interplay between past, present and future in the process of knowledge creation and management (e.g. Nonaka & Takeuchi, 1995; Vygotsky, 1978). In line with this, Bratianu (ibid) argues that strategies should seek to reduce the gap between knowledge of the current situation and desired future state. Understanding the past involves interpreting previous events and their consequences, while imagination can help compensating for the absence of knowledge and reduce uncertainty. Risk management – by considering the potential effects of decisions – aims to exert some control over potential outcomes through using foresight and scenario thinking:

> *"By designing many probable futures, we can learn how to reduce uncertainty and the absence of knowledge – how to "create" knowledge and move faster from the state of known-knowns toward unknown-unknowns." (Bratianu, 2022)*

Generic knowledge strategies are assumed to be designed and implemented in any organisation in accordance with specific needs and dynamic capabilities. One of the perspectives presented is Dalkir's (2005) *Known-Unknown Matrix*, which outlines various knowledge states(see Figure 1. The knowledge states encompass both explicit knowledge (rational and conscious) and tacit (implicit, emotional or spiritual) knowledge.

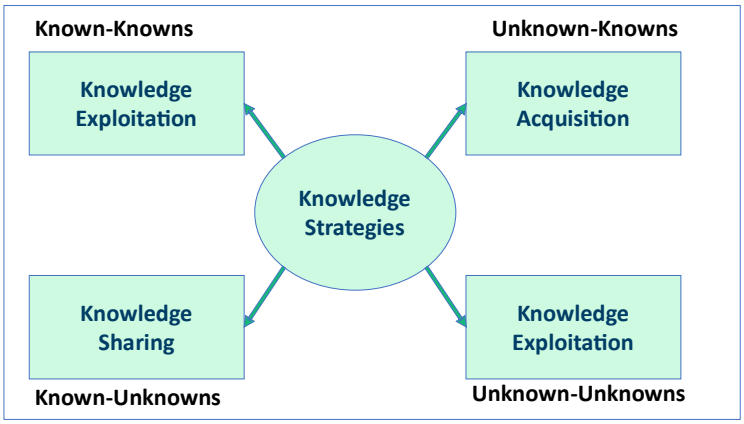


Figure 1: Generic Knowledge Strategies

Explicit knowledge is primarily associated with *known-knowns* and *unknown-knowns*. In contrast, *known-unknowns* and *unknown-unknowns* may involve both explicit and tacit knowledge. Bratianu argues that, since tacit knowledge is acquired through direct experience and processed by our cognitive conscious, *known-unknowns* reflect situations where we possess incomplete knowledge about the future. Furthermore, *unknown-unknown* represent events that are entirely unforeseen and cannot be anticipated.

Strategic approaches to each of the four knowledge states may differ: (1) *Knowledge Exploration* is a recommended management strategy for addressing known-knowns – knowledge embedded in for example an organisation's procedures, regulations or culture. Relevant management tools and processes include the integration of existing knowledge; codification which involves transforming knowledge into messages (often language-based) that can be understood across the organisation; and creation of knowledge maps to identify bottlenecks and prevent knowledge loss. These maps may distinguish between operational and strategic knowledge management. (2) *Knowledge Acquisition* strategies are suitable for addressing unknown-knowns, such as lack of knowledge about available resources. To identify what knowledge is missing, organizations can implement processes such as establishing learning networks or capturing knowledge from current and departing employees. (3) A *Knowledge Sharing* strategy is recommended for known-unknowns, when complete knowledge is distributed among different actors or individuals). Bratianu emphasizes that knowledge sharing is a central aspect of knowledge management, aiming to bridge the gap between individual and the organisational knowledge. Constituting individual knowledge with application and values can enhance innovation. This strategy should foster a supporting culture and a climate of trust. Management tools to facilitate this include training programs and Communities of Practice (eighter in-person or online). Lastly, (4) a *Knowledge Exploration* strategy may be used in face of innovations and knowledge absence. Identification of unknown-unknowns includes to imagine problems and possible solutions. Exploration processes include knowledge creation at the individual, team, and organisational levels. These strategies may assist managers to explore new knowledge alternatives

along main trends in e.g. science, technology, and economics. Bratianu describes that knowledge dynamics as a continuous interaction between rational, emotional, and spiritual fields, and argues that learning involves the integrated functioning of the total organism – thinking, feeling, perceiving, and behaving. In addition to rational knowledge, innovations today are also based on non-rational forms of knowledge including intuition and emotional insight.

2.2 Resilience

Resilience represents a proactive management, offering principles for handling both normal operations and unexpected events. To support future transformation in response to technological and societal changes, resilience emphasizes the design and maintenance of systems that can withstand, adapt to, and rapidly recover from disruptions. This approach is particularly relevant in complex and critical systems – such as aviation, healthcare, transportation, and information technology, where reliability and security are essential.

Management levels. Like strategic management theories, resilience perspectives aim to reduce the gap between the current and the desired state. In resilience terminology, this is often framed as the distinction between *Work-as-Done* (WAD) and *Work-as-Imagined* (WAI). WAD relates to work is actually done, while WAI describes how work is prescribed through management systems, regulations and standards. WAI typically reflects strategic-level management — what designers, managers, and authorities believe is or should be happening. WAD pertains to operational-level management.

Temporal insight. Understanding the past, present and future is essential for managing both foreseen and unforeseen events. Over the past decades the resilience concept has gained increasingly attention in scientific literature, resulting in numerous definitions (Stene & Skuggevik, 2024). The definition adopted in the MARMAN project is:

> *"A system is resilient if it can adjust its functioning prior to, during, or following events (changes, disturbances, and opportunities), and thereby sustain required operations under both expected and unexpected conditions" (Hollnagel, 2019).*

Some resilient approaches limit the focus to rebound capabilities, i.e. how a system recover from disrupting or traumatic events and returns to previous or normal activities. The emphasise is not on the rebound period itself, but rather on the capabilities and resources were present prior to the disruption (Woods, 2015). Measuring resilience in terms of rebound capabilities includes analysing how the system has adapted to past disruptions and changes. Consequently, the focus is placed on knowledge of past events, rather than on anticipating future ones.

However, it can be argued that after socio-technical systems rarely return to the exact pre-event state (bounce back) but instead undergo transformation to something different (bounce forward). In this view, understanding historical events is important but so is also recognizing *current* challenges and anticipating *future* trends —both of which are essential for identifying, updating and developing critical competences (Stene & Skuggevik, 2024). Resilience also involves mechanisms of transformation (Rocchetta, 2024), referring to the system's adaptive capacity to reorganize its structure or function in anticipation of, or in response to, destabilizing shocks. In addition to the ability to recover, this also includes the ability of its industrial and technological structure to evolve by creating an innovative growth path.

Further, it's important to distinguish between two related concepts – resilience and robustness (Woods, 2015). The term *robustness* refers to systems that are designed to effectively handle known failure modes. *Resilience*, on the other hand, describes how well the system also can handle troubles that were not foreseeable by the designer. You can think of robustness as being able to deal well with *known unknowns*, and resilience as being able to deal well with *unknown unknowns*. Foresight studies, trend-analysis and scenario design may be used to gather knowledge about potential future outcomes.

In addition to foreseen (known-unknowns) and unforeseen events (unknown-unknowns), resilience performance should cover competences to handle future normal variations (known-knowns) and vulnerability (unknown-knowns). The latter are related to risks and brittleness. Resilience should strive to minimize system vulnerability. Potential management measures may be to create arenas for experience transfer between relevant actors or stakeholders, e.g. networks, Community of Practices, workshopsor education.

Woods argues that a key characteristic of resilient system performance is *adaptive capacity* — the ability to adjust functions, including the ability to adapt to *future* surprises across multiple cycles of change. Resilient

performance, therefore, implies a dynamic approach: the ability to modify in response to situational changes and to adapt the performance as the situation evolves.

Hollnagel (2009) proposed four cornerstones regarding key abilities of organisational resilient performance, both for learning from historical events and detecting future anomalies:

- *Learn* – Knowing what has happened – To analyse and understand both successful and unsuccessful past events. An organisation adopts a plan for continuous learning, including analysis, communication and sharing of reflections regarding reasons for performance.
- *Anticipate* – Knowing what to expect – To look far ahead in time to identify events that need to be prevented from occurring. The organisation looks at the future and performs safety assessment with methods able to account for emerging phenomena.
- *Monitor* – Knowing what to look for – To understand when a situation, in the short term, is becoming to get critical and therefore start preparing for it. An organisation defines meaningful indicators and performs measurements of significant changes.
- *Respond* – Knowing what to do – To detect that something has happened, to recognise the relevance, and to respond to it. An organisation defines a set of critical events and allocates appropriate resources (competence, technology etc.) to respond if they occur.

3. Method

This study explores the significance of ports as nodes in a transport system through a qualitative approach, based on semi-structured interviews conducted in spring 2025 with seven significant port stakeholders in Norway. The interviews cover three main themes: (1) The current situation, including roles, responsibilities and coordination of plans and practices; (2) New technologies and increased automation in ports or terminals, including transition challenges and mitigation measures; and (3) Two future scenarios – climate changes and geopolitical instability – that may impact transport systems and regional communities.

The informants were contacted by e-mail informing about the project and an invitation to participate. Those who responded positively were subsequently contacted by phone to provide further details about the purpose of the interview and main topics, as well as to schedule the interview.

Each interview lasted between 60 to 90 minutes. Microsoft Teams was used both for dialogue and recording. Two interviewers were present at each session: one led the conservation, while the other took notes and ensured relevant follow-up questions.

The interview themes were used to structure the transcript and guide the initial coding process. The two theoretical perspectives – strategic knowledge management and resilience – were then applied to organise the findings and analyse the participant's statements.

4. Results

The structure of this chapter is according to the main themes.

4.1 Status – Multimodal Traffic and Transport Management

(A) Current maritime operations – How is the transportation from sea and from land to the port? Most Norwegian ports act as both infrastructure owners and logistic providers, investing in terminal equipment and port area development. However, coordination between onshore and offshore operations – such as between vessels, cranes, terminal operators, shipping companies – is generally limited. Most port directors are unaware of the total transportation cost through the terminal, although they are familiar with the crane service costs.

(B) Multimodal operations – Are the transport logistics of different modalities and actors coordinated? Ports serve as nodes in the transport chain and may constitute several modalities (sea, road, rain, air). A political goal is to shift more freight from road to sea or rail. Improved information sharing between actors at sea, in port, and on land is seen as beneficial, as is greater use of European transport corridors. Some ports participate in R&D projects, innovations initiatives and demonstration pilots to support port development. One interviewee described offering route planning services for individuals, aiming to create a seamless multimodal transport system.

(C) Integrated planning – How is transport coordinated within the port and with external transport systems? Ports lacking a comprehensive overview may face operational challenges. While involved actors often have their own operational plans, these may diverge. There is a strong need for coordination in planning large

infrastructure projects, such as terminals and roads. Some ports, as infrastructure owners, have outsourced the transport operations. They are planning for future electrification, including docking systems and cargo handling logistics. Efforts are being made to involve both internal and external operational managers in workshops and pilot projects related to strategical port development. However, strategical planning can be difficult to coordinate due to fragmented or insufficient knowledge. Political ambitions also influence definitions of visions and goals – for example a zero-emission vision affect prioritizing electrification, docking infrastructure, and automated transport.

(D) Handling of disturbances, threats or unforeseen events – Do ports have management strategies to prepare for and to respond to disturbances? Several informants highlighted challenges related to ownership and financial constraints. Ports often compete for national-level, strategic investments. Additionally, as most ports are municipality owned, investment decisions must be balanced against other local priorities such as healthcare or education. Ports also have limited influence over investments in other critical infrastructures – such as roads and hospitals – which may be owned by different agencies, neighbouring municipalities, or the state.

There are significant variations between ports. Some have established crisis teams and maintain dialogue and training exercises with local stakeholders as the military, fire and rescue, and water suppliers. These ports have emergency plans in place for identified threats, such as fire and collisions within the terminal area. However, they do not always fully account for the nature of hazardous goods being transported. Some informants argue that proactive evacuation plans should be developed whenever new potential hazardous products or services are introduces. In addition to workers, these plans should include local residents and fleet managers – both at sea and on land.

One company offering transport route service operates an operational control centre that manage all public transport in the area. This centre collaborates closely with traffic managers from rail and road networks, as well as with the police, fire and rescue services.

4.2 Ports as Critical Nodes

4.2.1 Improvements

Compared to today's practise – What aspects have the largest improvement potentials? A key area identified by all stakeholders is the need for better *coordination* between actors to avoid silo-thinking. This includes collaboration across the entire logistic chains - from large to small scale actors – such as cooperation between ports, ship operators and shipping companies. It also involves engaging local area agencies, citizens and end users as well as fostering collaboration between infrastructure owners and terminal operators.

Innovation topics are linked to several areas, including management structures and governance models, information and data sharing through digital platforms, city development and integrations addressing challenges faced by end users, regulations of transport, standards for digital data exchange, electrification and docking infrastructure .

4.2.2 Challenges related to future digitalisation, new technology and increasing automation

(A) Future trends and changes. Digitalisation will imply more automation of port operations and management. This includes exchange of information and data related to transport demands, port capacity, resource available, time slots, schedules, request for assistance. Automation aims to reduce costs improving operational effectivity and orchestration across transport modes. However, the use of digital platforms also includes cyber risks and may complicate the coordination of transport to and from the port.

The role of managers will shift from manual tasks to greater reliance on digital platforms, tools and automated processes. Mobility patterns will change, with new actors and new roles emerging, and more tasks transferred to control centres. Control centres will be used to manage, support and monitor traffic and transport operations. Thus, the managers will need to have insight in data sharing, knowledge of coordination between actors, standards and regulations, and technical tools supporting decisions.

(B) Measures to manage vulnerability. It is argued that greater emphasise must be placed on digitalisation, electrification and climate neutral solutions. Key measures include ensuring robust backup functions, as well as standardising and regulating of new products and services. Continuous development of legislation, aligned with global changes is also recommended.

To reduce silo thinking, increased collaboration between actors in the transport value chain is essential. Alternative routes and multimodal transport systems could include coordination between ports, costal administration and traffic surveillance .

Bridging the gap between strategic and operational management is highlighted as a critical need. One measure may be to identify potential hazards and What-If scenarios.

To be prepared for future changes, two of the interviewed agencies have established a department dedicated to R&D and innovation. Others are actively participating in pilot projects and demos international at international, national and local.

(C) Transition of knowledge management. Knowledge is emphasized as one key component. One important aspect is *knowledge sharing* of past, current and upcoming events. This can be facilitated through various arenas such as meetings, working groups, or digital information channels. Another aspect is to develop *new competence* by sharing information and knowledge. Relevant arenas may be training, pilots or demos, workshops, or meetings.

It is argued that the transformation will be successive, step-by-step, including both changes of procedures, people and technology. This requires change in expertise, training and exercises. Management will benefit from increased use of scenario planning to prepare and to adequately respond to changes. This includes coordinating ongoing activities, prioritizing between alternative solutions and procedures, and engaging in joint planning of investments, standards and legislation.

Integrated planning can be achieved when strategical managers come together and discuss shared visions, goals, ambitions and risks.

4.3 Scenario Planning

In the context of scenario planning, handling of both known and unknown events are important. This section presents reflections on two scenarios – climate change and geopolitical instability. Both may have huge impact on transport in general and in a regional context. The interviews explored whether these scenarios influence planning and preparedness, as well as coordination of regional actors and activities.

4.3.1 Climate change and natural hazards

Most relevant hazards affecting ports are flooding and extreme rain and snow-falls, followed by heavy wind affecting the tide. Harbours are considered critical infrastructures in the supply chain, and effective coordination across stakeholders, transport modes and actors is important. If one port is attacked, others must be prepared to support or take over transport.

Regional planning and scenario coordination are crucial and should involve a wide range of actors, infrastructure owners (as ports), road authorities, citizens, municipalities and county council, urban planners, emergency agencies, in addition to service providers of public transport, city bikes and car sharing. To reduce vulnerability, transport providers must conduct individually risk analysis and assessments.

There must be a strong focus on the sustainability of key critical functions as electricity, water and fuel. Emergency preparedness is important and should include learning from past events, e.g. chaos caused by heavy snowfall within a few hours. One example mentioned is how local actors together planned for future incidents using What-if scenarios - clarifying who does what, in what order, and which locations should be prioritized.

Defined scenarios should serve as the basis for pilots, demos and emergency training. Participation and dialogue with affected actors in preparation and execution should be emphasized. In some cases, significant time has been invested on surveys and outreach activities involving district committees, politicians, school and kindergarten visits.

4.3.2 Geopolitical instability

Ports are important geopolitical locations, serving as key nodes connecting different transport modes, logistic corridors and transport networks. Thus, ports may become targets in the event of war. The role is to ensure supply safety, maintaining safety and preparedness for major accidents, protecting industrial infrastructure, and providing information to users and the public.

Although planning for war scenario is increasingly relevant, such plans are generally not yet fully developed. Scenario planning should include potential hazards, risk and vulnerability analysis, the port’s role as digital node,

alternative routes and corridors, inter-port collaboration, multimodal transport, handling of dangerous goods, emergency preparedness and responsiveness, as well as clearly defined roles and responsibilities. Potential hazards identified are damage to electricity and water supplies, management system and communication infrastructure, as well as fire and leakage of hazardous fluids or gasses. Security policy is challenging today, as ports may be vulnerable, cyberattacks from hostile nations. Key actors in planning and emergency exercises include the military sector, Coastal Authority, Norwegian Directorate for Civil Protection, local emergency services, municipal authorities, infrastructure owners, tele suppliers, industry and citizens.

5. Discussion

Knowledge strategies are often linked to organizational outcomes and implemented within an organization. In the context of Multimodal Traffic Management, strategies should include inter-organisational outcomes – particularly the synchronizing of management systems (Stene & Skuggevik, 2024).

5.1 Can the Theoretical Perspectives – Strategic Knowledge Management and Resilience – Facilitate Port Development and Management??

Table 1 presents examples of port management practices categorized according to strategic knowledge management and resilience perspectives. The examples are based on tools and processes recommended by the participants in this study. Overall, the theories provide a useful framework for identifying potential measures, depending on the port's current level of knowledge and insight.

Knowledge exploitation supports a holistic ecosystem insight of current management. The findings indicate a significant potential for ports to optimize port operations, improve coordination with regional actors, and enhance multimodal transport and network efficiency. Management strategies may include knowledge mapping, identification of current practices and planning measures, and the use of historical data from successes and failures – such as experiences with changes, accidents, exercises and training.

Knowledge acquisition includes identification of future gaps, risks and vulnerabilities. Ports are recognized as critical nodes within a transport network. The results suggest that management can be improved through collaboration and integration of planning, including a shared understanding of knowledge and needs and interaction between actors.

The two latter strategies – *Knowledge sharing* and *Knowledge exploitation* - are more strongly characterized by uncertainty and the absence of prior knowledge. These, strategies require a degree of imagination and foresight. The findings highlight that scenario thinking, training, integrated planning, experimentations and innovations are essential management tools in this context.

Table 1: Strategic knowledge management and examples of resilient and strategic port management

Dimensions	Strategy	Examples of resilient and strategic port management
Known-Knowns **(Existing procedures, regulations, culture)**	*Knowledge Exploitation* (Messages, knowledge maps)	*Use historical data* from successes and failures related to changes, accidents, exercises and training *Map existing transport corridors and networks* in the logistic value chain to improve efficiency and reduce cost *Planning*: Consider future changes in *normal variation* of practise and management due to global trends as digitalisation
Unknown-Knowns **(Available resources)**	*Knowledge Acquisition* (Learning networks, knowledge capturing of individuals)	*Dynamic planning:* Involve internal and external actors to identify potential vulnerabilities and coordinate plans. Use experts to supplement specialized knowledge *Invite relevant multimodal* stakeholders to workshops, seminars etc *Research:* Map and get an overview of standards, legislation and potential local resources and actors
Known-Unknowns **(Knowledge distributed on different individuals)**	*Knowledge Sharing* (Training programs, CoP, Meetings)	*Meetings, workshops or seminars* to share expertise and experiences within and across actors *Digital platforms for information and data sharing* to ensure open access and identification of knowledge gaps *CoP* enables coordination of plans for and investments in critical infrastructures *Emergency plans and trainings:* regular practicing and coordination

Dimensions	Strategy	Examples of resilient and strategic port management
Unknown-Unknowns **(Knowledge absence)**	*Knowledge Exploitation* (Knowledge creation, explore new alternatives)	*Innovation and experimentation:* Participate in R&D, pilots and demos to prepare implementation of new knowledge, management, technology *Scenario planning:* to prepare and respond to future changes, events, and disasters *Control centres* may be considered to ensure collaboration and coordination of different actors

5.2 Is Theory a Significant Basis for Scenario Planning of Future Changes, Events, and Disasters?

The interviews underscore that knowledge is a key component in preparing for future changes, and that scenario thinking is vital for responding effectively to uncertainties. The theorical perspectives applied in this study take a proactive approach, emphasising the identification of potential futures alternatives. Past, present and anticipated knowledge is used in development of scenarios, foresight studies, and trend analysis. Dynamical planning enables the systematic collection, analysis, and dissemination of knowledge.

Furthermore, the two perspectives complement each other and together provide a comprehensive framework. They support the identification of potential future scenarios and the development of strategies to address them. While resilience perspectives are typically multi-disciplinary, strategic management theory offers more detailed guidance on specific measures related to leadership and decision-making. The four knowledge strategies offer a structured way to categorize relevant tools measures and procedures. In complex cases, the framework helps clarify which types of management strategies are appropriate for different challenges, events and scenarios (depending on the degree of insight available. Resilience theory supports scenario planning by emphasizing the importance of flexibility, redundancy, and adaptive capacity. It encourages the development of contingency plans and the ability to pivot quickly in response to foreseen and unforeseen events.

Innovation is described by Bratianu (2022) as a complex, nonlinear, and interactive process with many unknowns and unexpected outcomes. He argues that innovation is a dynamic design and decision-making process involving a series of risks and actors, and that it requires a new managerial philosophy - one that embraces open innovation, knowledge co-creation, strategic learning, and scenario thinking. The findings of this study support this view, indicating that innovation is essential for preparing future operations and managing transformation processes. Innovations may stem from known trends (as digital transformation), or more unknown challenges like natural hazards or geopolitical instability. In all cases, innovation may involve the development of new or changed processes, standards and digital platforms for communication and date sharing.

6. Conclusions

This study suggests that the perspectives of resilience and knowledge management can significantly support port development and the management of global trends and future challenges. Knowledge strategies may assist ports managers in strengthening preparedness and responsiveness to future changes, events, and disasters. The four knowledge strategies provide a useful framework for categorising, analysing and identifying knowledge needs in both in current context and in relation to future scenarios.

The findings also highlight a need for increased coordination between actors, integrated planning emerges as a key area that should be emphasized and further exploited in future research and innovation efforts. Today, traffic and transport management operate in silos within each mode (sea, road, rail, air), which limits the potential for holistic and resilient solutions.

Acknowledgements

The authors acknowledge the Norwegian Research Council projects MARMAN (324726 - FORSKER21).

Ethics and AI declaration: Ethical clearance for the research referred to in this paper was not needed. However, the informants are anonymized. No relevant AI tools are used to develop this paper.

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Innovation Management of Centres for Research-Based Innovation

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Abstract: Although perspectives on innovation management have changed significantly since 1900, the capability to innovate is the most important factor in value creation (Miller, 2015). This paper focus on the innovation management of one long term R&DI project – SWIPA – of eight years. The Research Council of Norwegian (RCN) established Centres for Research-based Innovation (SFI) projects in 2005 to strengthen technology transfer, internationalisation and researcher training. Close cooperation between R&D-active companies and prominent research groups is intended to develop expertise that is important for innovation and value creation. Among the defined success criteria for centres' innovation and value creation is to develop a framework for encouraging innovation and defining, mapping and following up research results that have innovation potential. Based on Damvad Analytics (2018) evaluation of long-lasting projects, RCN currently requires that proposals clarify innovation management regarding competence, integration in the centre strategy, and collaboration. The effect of the centres' contribution to innovation can be challenging to measure and make visible. One reason is that the realisation of the innovation potential from an SFI mainly takes place by user partners and in many cases in separate projects that run in parallel with or after the SFI's lifetime. This paper uses the SWIPA centre (2021 – 2028) to illustrate innovation management activities and challenges. This paper presents established management practices and actions and use theories on knowledge management to reflect on these, e.g. a dedicated work package for innovation and technology development, roles and responsibilities related to the Centre Director and the Innovation Advisory Committee (EIAC), collaboration between work packages, involvement of partners, and creation of Key Performance Indicators.

Keywords: Innovation management, Knowledge management, Key performance indicators, Inter-organizational coordination

1. Introduction

Although perspectives on innovation management have changes significantly the last century, the capability to innovate is today the most important factor in value creation (Miller, 2015). This paper focus on the innovation management of an eight-year R&D project – SWIPA – financed by The Research Council of Norway (RCN). Such long-term centres are labelled Centres for Research-based Innovation (SFI). RCN established SFI organized projects in 2005 to strengthen technology transfer, internationalisation and researcher education. Close cooperation between R&D-active companies and prominent research groups is intended to develop expertise that is important for innovation and value creation.

Based on a literature review, Leonidou et al (2020) have studied stakeholder engagement in innovation management and entrepreneurship development. A *stakeholder* is defined as any individual or group who can affect or is affected by the accomplishment of the company's objectives. Of the fourteen stakeholder categories, the most studied category is academia, followed by government and community. Academic studies emphasize that innovation management education may prepare students to engage in innovation and entrepreneurship development. (1) *Academic scientists* contribute both to social and human capital. In developing scientific strategy, human capital may contribute with a variety of scientific expertise and knowledge of laboratory techniques. Social capital of scientists may contribute to innovation management and knowledge transformation into two scientific networks: local laboratory networks and cosmopolitan networks constituting scientific peers and expertise. (2) *Government* may enhance innovation by e.g. engagement in developing an open data policy, or policies as regards to labour and business operations. (3) The *community* stakeholders cover two sub-categories: Physical community and User community.

The SWIPA centre is heterogenous, constituting stakeholders from academia, university, government, industry, suppliers, and business. Further, Leonidou et al (2020) argue that there is a lack of research on the interrelationships between the various stakeholders and their collective impact on innovation management for entrepreneurship development.

2. Theory

The literature on innovation is extensive, complex, and based on different perspectives and approaches. Furthermore, perspectives vary depending on the management level involved, the type of innovation involved, the degree of innovation/change and desired value creation.

2.1 Definition of Innovation

Several definitions of the innovation concept exist. Later classifications of innovations are influenced by Schumpeter's work from 1939 proposing a list of five main innovation types (Rocchetta, 2024): (1) Introduction of new products; (2) Introduction of new methods for production; (3) Opening of new markets; (4) Development of new sources of supply for raw materials or other inputs; (5) Creation of new market structure in an industry.

What characterize innovations in the private and the public sector deviates. Most research on innovations is based on the Oslo Manual (OECD/ Eurostat, 2005/2018), which giving guidelines for evaluation and criteria for measurement of innovation in the business sector. Four types of **innovation results** are specified: the implementation of a new or significantly improved *product* (good or service) or *process*, a new *marketing method*, or a new *organisational method* in business practices, workplace organisation or external relations. The Oslo Manual is concerning the private sector.

However, how can innovation management facilitate achievement of results? The **innovation process** is highly variable according to industrial sector and the level of abstraction of the innovation itself (Robertson, 1974). The complexity of the new product and its technological level will determine how the innovating organisation handles the innovation. The degree of change or novelty are often used to classify three **innovation categories**: (1) *Disruptive* (ground-breaking change, brand new), (2) *Radical* (significant change) and (3) *Incremental* (gradual change).

The innovation definition used as the basis for describing the management and facilitation of innovation within Norwegian ministries are (Defi, 2018): "*New or significant changes in the organisation to improve activities and results*". Innovation results can be new or significantly changed services, products, processes or ways of organizing work, or ways to communicate with the outside world, such as service recipients, citizens and businesses. Our study is based on RCN's **definition of innovation**, which specifies potential innovation results:

> *Innovations are new or significantly improved goods, services, processes, organisational and governing forms or concepts that are implemented to promote value creation and/or yield benefits to society.*

2.2 Innovation Management

The capability to innovate is the most important factor in value creation of an individual, an organization, a community, a region, an industry, a society and an economy (Miller, 2015). Miller argues that innovation management perspectives may be described by *four generations* with significant changes, i.e. perspectives on best practice to enable radical innovations. In the first generation (1900 – 1940) basic functional business disciplines (as marketing, finance, operations) and hierarchical business units were created. The second generation (1940 – 1975) added e.g. project management, teams, linear stage gate product development processes, and HR performance management. New information technologies (as ITC and TV) created new possibilities and enabled new management tools. In the third generation (1975 – 2000) radical innovations was thought to be radically new products, services or processes. Strategic planning developed as a new approach including e.g. scenarios, competitive strategy, technology roadmaps, lean, knowledge management, and globalization. The fourth generation (2000 -) adds more to radical innovations than prior generations, and where characteristics that transform industries and markets are new capabilities, business models and industry structures. Linear processes are replaced with nonlinear, iterative processes for creating radical innovation. While prior models presented rational and simple phases of product innovations, current theorists perceive innovation as a dynamic design and decision process, including irrational knowledge as intuition and emotional knowledge (Bratianu, 2022).

The field of innovation is multi-disciplined (economics, finance, organisational behaviour, etc.). Hence, numerous perspectives and research are related to innovation. Global trends like increased digitalization leads to increased complexity, interrelations, collaboration and communication. Innovation studies may benefit from knowledge management perspectives (Asimakou, 2009). Creation of innovations and processes that deal with coordination, dissemination, and specialization can be facilitated by socio-technical theoretical approaches (Lim, 2000). In a complex and interconnected world, it will be even more important in the future to study how networks of organisations and actors together may contribute to successful innovation processes (Stene, 2021). New business models for cooperation are developed in several innovation projects based on partnership.

Communities of Practice (CoP) are arenas for collaboration, experience sharing, learning and planning. Based on situated learning theory, CoPs emphasise that individuals learn through participating in social activities. They provide social contexts for learning and co-creating shared practices. Wenger (1998) defines CoPs as groups that

share practices, frequently communicate, and develop shared values and identities. Motivation may vary between members depending on values and sense of belonging. While CoPs traditionally met face-to-face, most interactions now occur online (Bratianu, 2022). He argues that CoPs are social practices aiming for cooperation, not competition, and where trust is the key concept of success.

Terry et al (2019) distinguish between three CoP types: (a) *Informal* groups seek to provide a forum for discussion among individuals who are interested in a topic. (b) *Supported* groups are sponsored by management and seek to build knowledge and skills for a given competency area. (c) *Structured* groups are developed and managed by an organisation to advance business strategies or goals.

2.3 Value Creation

The innovation objectives describe intended achievement or goals. A society in continuous change makes measurements challenging. For example, technological development may redefine the rules for value creation for both governance, business management, and citizens. Examples of value creation are:

- *Social impacts* – reduced poverty, security, equality, welfare distribution, increased health, etc.
- *Service* – through efficiency, quality, user satisfaction, increased usage, greater choice, etc.
- *Trust and legitimacy* – affect user satisfaction with service and the ability to achieve larger societal goals.

Value creation can be defined as successful at different levels based on goal achievement (Samset, 2003):

- *Strategically* – The total measure (actually, a package of measures) is socio-economically effective – contributes to a socially desired development over time.
- *Tactically* – The measure is purpose effective – gives rise to the greatest possible benefit for users and side effects are optimized.
- *Operationally* – The delivery is as agreed and produced in the most cost-effective way.

3. Methodology

RCN centres are dedicated, long-term initiatives designed to strengthen excellent, creative research and innovation groups or to build research groups in strategically important areas. Document analyses are used to present SWIPA structure, management and objectives, including the project description, Collaboration Agreement, work plans, MOMs, in addition to internal and external evaluations. In addition, observations and active participation in the centre have been an important basis.

The innovation measures and evaluations are developed in collaboration with centre partners and other SFIs and are based on RCN evaluations of long-term projects.

4. The SWIPA centre

SWIPA (Subsurface Well Integrity, Plugging and Abandonment) is a centre for research-based innovation (SFI) financed by The Research Council of Norway (RCN) for 2021-2028.

4.1 Objectives

The *overall objective* is to obtain a scientific understanding of permanent well barriers and allocate for improved well barrier design methodologies. The *primary objectives* are to:

- Reduce plugging and abandonment (P&A) costs by facilitating rapid deployment of well barrier establishment and P&A technologies and system solutions
- Increase value creation in the Norwegian O&G industry by implementing solutions for new P&A and sidetracks
- Create new solutions and products for storage of CO2 and nuclear storage, and reconversion of petroleum wells

4.2 Organisation

The 35 partners represent three research institutes, two universities and industrial end users (operating petroleum companies, service companies, authorises, and international academic partners).

The Board is responsible for the scientific quality, progress of work, overall plans, address conflict resolutions, and admits new partners. It is led by industry. In addition to R&D partners and RCN, the three operational companies are represented.

The Centre management team consists of the Centre Director (employed at SINTEF), four work package (WP) leaders and two university representants. The WP leaders work at research institutions (SINTEF, NORCE, IFE) and the universities are represented by the Norwegian universities UiS (University of Stavanger) and NTNU (Norwegian University of Science and Technology). The Centre Director is responsible for administrative, financial and legal tasks, and serves as main contact for WP leaders, educational program and SWIPA committees.

Scientific Advisory Committee shall safeguard the scientific quality and is represented by all academical partners. The committee is led by a financial industry partner.

Exploitation and Innovation Advisory Committee (EIAC) shall advise the Board on new research directions, evaluate commercial potential and identify spin-off projects. EIAC constitutes all SWIPA partners and is led by a financial industry partner. Administrative support is given by work package 4 (see Figure 1).

Technical Advisory Committees are established for and managed by each WP. The purpose is to present specific R&D topics to ensure knowledge transfer between partners and to get feedback on partner priorities. Technical Review meetings are held twice a year.

4.3 Innovation Management

A work package (WP4 "Innovations and technology management") is dedicated to innovation management. *WP4 objectives* are to:

- Review and prioritize results and innovations toward further technology qualification, in addition to identify potential test campaigns at high technology reediness level (TRL)
- Evaluate how a potential risk-based approach to technical barriers affects the holistic risk picture including non-technical aspects such as organizational barriers
- Have close communication with national authorities as HAVTIL (Norwegian Ocean Industry Authority) and international consortiums such as Net Zero in UK
- Perform business case studies

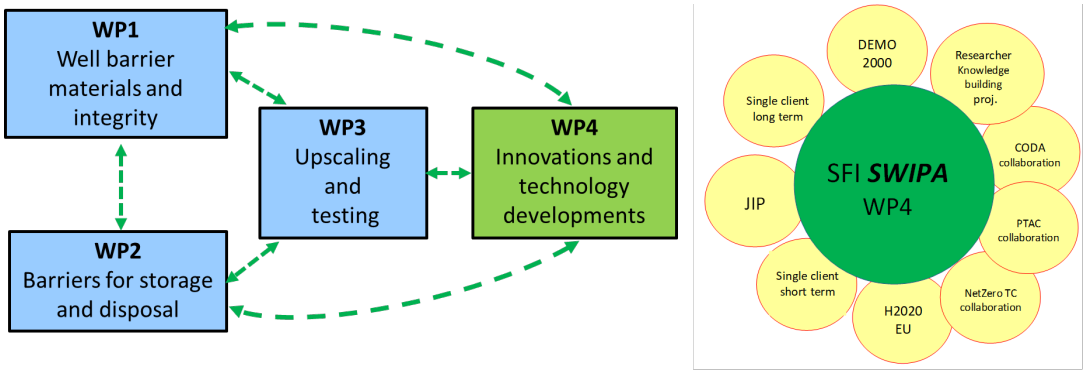


Figure 1: Collaboration between SWIPA work packages to create spin-offs

Figure 1 illustrates the collaboration between the four work packages. All contribute to create spin-offs as demos, pilots, national/international research projects or knowledge building programs.

WP4 collaborates with the innovation committee (i.e. EIAC) to review and prioritize results and innovations towards further technology qualification. WP4 acts as a secretary for the EIAC, which is led by a financial industry partner.

5. Framework Encouraging Innovation

5.1 Innovation Strategy

The first year of the centre, developing an innovation strategy was emphasized. The WP4 manager contacted another newly started long-time centre. The innovation manager of SFI Autoship had experience from prior projects, and invited innovation managers of three other centres hosted by SINTEF and NTNU. Together the five

centres created a general document "Best practice innovation strategy for a research centre". Based on this each of the centres modified it to needs and demands of each specific centre.

The SWIPA Innovation strategy is based on the contract, project description and consortium agreement. The strategy document is dynamic, i.e. is regularly updated. The content includes definitions of key concepts, SWIPA goals and objectives, innovation management structure and processes, utilization of results, IP management and technology transfer, tools and procedures, in addition to competence building and innovation culture. Appendixes are added if necessary and includes templates for Key Performance Areas (KPA), innovation potentials of deliveries and results, and Maturity scales.

5.2 Collaboration Arenas

Some innovation management arenas include internal, academical partners collaboration, while other arena also incorporate end users. Further, most arenas are digital web meetings, and some are physical face-to-face meetings.

R&D collaboration – The Centre management team has short administrative *on-line* web meetings each month. The Centre Director defines the schedule at monthly meetings for academical partner, including WP managers and university PhD/ Postdoc supervisors.

However, *face-to-face WP4 workshops* are the most significant arena for experience transfer and reflections on value creation and potential improvements. These two-day physical internal workshops are held twice a year and involve all academical partners. Dialogue and reflections are related to specified topics. In addition, laboratories visits are arranged to get insight in research settings, artefacts, methods and results.

Collaboration with external partners – Separate Technical Review meetings for each WP are arranged twice a year. Digital EIAC *(innovation committee) meetings* are synonym with WP4 Technical review meetings, held twice a year and last 1,5 – 2 hours. The WP4 scientific team administers these meetings.

Likewise, the *scientific advisory committee meetings* are arranged twice a year as digital events. In addition, annual conferences are arranged as physical 1,5-day events. The first half day is limited to SWIPA partners, followed by lunch-to-lunch open for external organisations. Board meetings have a schedule at twice a year as physical meeting.

5.3 Topics and Processes

EIAC (Exploitation and Innovation Advisory Committee) meeting topics are related to:

- Innovation potential of deliverables and results, i.e.:
- *Single-page evaluation sheets: Academical paper evaluation of innovation potentials: (a) commercial utilisation, (b) patentability, (c) spin-offs, and (d) academic impact*
- Evaluation of achievements
- *Status SWIPA objectives*
- *Progress indicators: KPA/KPI*
- *Verification of well barrier elements*
- *Qualification process of new technology*
- *Standards and regulation – Qualification using new technology and methods*
- Learning and experience transfer from relevant centres and projects
- *How can collaboration lead to successful innovation?*
- Exploitation of results
- *How to succeed in generating spin-off projects*

Physical WP4 workshops emphasize a combination of prepared presentations and documents by each WP, discussions and reflections, and agreements on further actions and strategies. Topics include:

- Innovation strategy
- Lab and facility visits
- Communication plan
- Involvement of partners
- Regulations and standards
- Evaluation of results and deliverables

Physical Annual conferences topics are e.g.:

- Status objectives and WPs
- Innovation strategy
- Standards, regulations and verification processes
- Future P&A operation practices
- Spin-offs
- International collaboration

The day before the conference, a *networking workshop for the students* is arranged. The students present status of work, get feedback and get insight in each other's subjects, methods, results and progress plans.

Webinars have been arranged related to specific topics, i.e.:

- PhD and Postdoctoral research
- Collaboration with international partners

5.4 Key Performance Areas

Defined success criteria for innovation and value creation include to develop a framework for encouraging innovation and defining, mapping and following up research results that have innovation potential. However, an evaluation in 2018 of long-lasting projects financed by the RCN argues that the effect of the centres' contribution to innovation can be challenging to measure and make visible. One reason is that the realisation of the innovation potential from an SFI mainly takes place by user partners and in many cases in separate projects that run in parallel with or after the SFI's lifetime.

5.4.1 Result assessment

One type of **result-KPIs** (Key Performance Indicator) is related to the objectives described in the project description, including e.g. number of PhD candidates, academical papers, spin-off projects and news articles. These are regularly measured and presented at arenas open for all partners.

In addition, **innovation potentials** are noticed for each academic paper presented by PhDs, Postdoc students or R&D partner. Innovation indicators include: (a) commercialization utilization, (b) patentability, (c) spin-off projects, and (d) academic impact. The one-page template is created by the Centre Director and shall be commented on by the involved WP manager, and assessments are made available to all partners at the SharePoint site. This gives the partners an update of results, opportunity to consider what may be relevant, and a basis for utilizing the results further in new projects, demos or pilots. This may also encourage to take contact with the involved R&D partners, to utilize lab facilities, or to create new activities and projects together with some of the other industrial partners.

5.4.2 Process assessment

A project initiated by RCN challenged eight of the SFI Centre Directors to share experiences and best practices to increase the potential regarding innovation and value creation based on the R&D activities. A report from the working group were delivered in 2023, presenting recommendations on five Key Performance Areas (KPA):

1. Innovation
2. Involvement
3. Internationalisation
4. Communication
5. IP management

Based on these recommendations, the WP4 management team in 2024 created **process-KPIs** for each KPA to map the progress towards centre goals and to reflect on how to achieve intended results. KPIs are specified by reference to SWIPA documents as the project proposal and Consortium Agreement. The purpose of the KPI descriptions is to have a basis for reflections and discussions both in the management team and with all partners. In addition, the SWIPA partners should have knowledge of best practice for innovation and value creation.

Column three in Table 1 gives examples of KPI descriptions included in the five KPAs. Autumn 2024, the WP4 management team, Centre Director and EIAC leader reflected on the status. Column two presents the status marked with green, yellow or red. Green means that "Activity status is satisfying", yellow indicates "Improvement potential", and red informs about "No activity". Column four are comments on how the status

may be followed up for user partners. The results were presented at autumn 2024 at WP4 Technical Review Meeting.

Table 1: Process-KPA/KPIs status autumn 2024.

KPA (1) Innovation			
KPI	**Status**	**Description**	**Folow up for user partners**
Objectives and concept		Innovation Strategy established and is regularly updated	Understand partner's innovation expectations
Resources		WP4 responsible for innovation management	Involvement in R&D activities and initiatives
Culture and trust		Innovation on the agenda (all relevant joint meetings) Centre result report – Include innovation contributions	Challenge the partners to clarify their contributions to innovation and utilization of results.
KPA (2) Involvement			
KPI		**Description**	**Status**
Involvement strategy		Establish partner arenas for sharing expectations and experience Establish a reference group for each WP (include partners)	Several areas as technical review meetings, conferences, webinars. SharePoint for sharing information and documents.
Collaboration		Create partner ownership and relevance to R&D Facilitate joint publication	Contribution with materials and recommendations in projects.
KPA (3) Internationalization			
KPI		**Description**	**Status**
Internationalizatio n strategy		Clarify internalisation expectations Estimate market and export potential Consider R&D mobility and stay abroad	Scientific committee
Documentation		Document centre activities (EU proposals, co-publication, requitement, market and export possibilities)	Dissemination of results at international conferences. Opportunities presented in related EU projects.
KPA (4) Communication			
KPI		**Description**	**Status**
Communication strategy		Define goals for communication Adjust communication plan if needed	Plan established.
Involvement		Involve partners and students	SharePoint, social media etc.
Resources		Establish dedicated personnel	OK
KPA (5) IP management			
KPI		**Description**	**Status**
IP principles		Legal settings of research results – Clarify ownership and right of use Effective and transparent IP management	See Collaboration Agreement.
Utilization plan		Establish a plan for utilization of research results	Template for registration of commercial potential. RCN emphasizes the importance of bringing results to commercial innovations.

6. Discussion

6.1 How to Support Innovation Processes?

An innovation strategy, collaboration arenas, innovation-focused processes and topics, as well as a framework for assessing both result and process KPIs, are key components of an effective innovation management system. The established system supports innovation processes in various ways by continuously monitoring and maintaining a strong focus on innovation within SWIPA.

In addition, a dedicated work package (WP4) focuses specifically on innovation and technology management. Its purpose is to follow up on the innovation strategy, evaluate outcomes and potential innovations, and identify relevant test campaigns. WP4 plays a crucial role in the research centre, as it addresses the need for expertise in innovation management and ensures that resources are allocated to maintain and develop the innovation management system. For most partners and researchers in the centre, this represents complementary expertise that enhances their scientific and technological competencies.

Coordination and collaboration are key functions in SWIPA's innovation management. From a knowledge management perspective, dialogue is essential for learning, and several arenas have been established to support this. The centre can be seen as a structured group or Community of Practice (CoP) aimed at advancing strategic goals. It is led by the Centre Director at SINTEF, in collaboration with three research institutes and two universities.

The Innovation Advisory Committee meets online twice a year. A challenge is that communication tends to be formal and one-directional, with most participants keeping their cameras off. This makes it difficult to observe reactions, gauge engagement, or invite spontaneous feedback. As a result, open reflection and discussion are hard to foster. In contrast, physical workshops enable richer communication and shared reflections on innovation opportunities and management.

The relevance of the KPI framework depends on how it is applied for assessment and continuous learning. In SWIPA, both KPIs and evaluation sheets can support innovation processes, though engaging all stakeholders remains a challenge.

6.2 Drivers and Barriers for Innovation Practice

After four years, SWIPA has been evaluated by RCN and external experts based on documents, interviews, and a partner survey. The midway evaluation highlights that success in innovation and value creation largely depends on add-on projects and partnerships. A solid framework and tools to promote innovation and track research outcomes are essential. Key measures include the dedicated innovation work package, the External Innovation Advisory Committee (EIAC), technical review meetings, conferences, and PhD development. Digital platforms like social media, webinars, and podcasts also support innovation. Additionally, risk-based R&A solutions developed in collaboration with HAVTIL may help improve regulatory frameworks. For SWIPA this means that the centre management must continue building on the established innovation management system, which supports structured work with research- based innovations.

A key challenge is that the motivation among members may vary, depending on factors such as values and sense of belonging. The centre consists of a network of heterogenous organisations, including stakeholders from academia, industry, government and suppliers, each with different goals and reasons for participating. One barrier to collaboration is competition among in-kind partners, particularly those delivering specific service or technology to the three operating oil and gas partners. These partners may, to some extent, compete for similar contracts, which can limit collaboration.

Trust between partners is a key driver for collaboration and Mora et.al (2023) emphasise the importance of building partnership through knowledge sharing networks. Based on the arguments presented above, trust may also represent a significant barrier to collaboration. They further highlight the value of digital platforms – for example involving partners and using dashboards and visualizations to support decision making. However, it is essential that front-end interfaces are user-friendly and allow for easy interaction with the system. Drawing on experiences from SWIPA, we argue that digital platforms cannot replace physical interaction and communication, but they serve as valuable tools for dissemination and information sharing.

Furthermore, we see potential in leveraging regulations to establish clear strategic plans and vision statements that align project goals with available resources. In this context, the collaboration with HAVTIL within SWIPA

represents a valuable opportunity to stimulate innovation processes, and function as a driving force for the implementation and commercialization of new solutions in the oil and gas industry.

6.3 Evolution of Innovation Management Perspectives

Value creation by implementing solutions is one of the primary objectives of SWIPA. The focus is mainly on technological aspects of new materials and verification methods of plugging and abandonment (P&A) of subsea offshore wells. Likewise, Mora et al (2023) argue that innovation approaches solely have focused on technological aspects and linear models. Barbieri and Álvares (2016) describe the evolution of innovation management generations, where the two first models are characterised by technology-push and market demand pull. Later generations have moved to nonlinear models, characterized by dynamic interactions and feedback between R&D and market. The authors argue that the models cover management of radical innovations but should also include incremental innovations and small improvements. Further, the sixth-generation emphases network interaction and the innovative milieu, where important features are ease of contact and trust between partners and social, cultural and natural conditions. The last SWIPA period must face challenges related to identifying potential spin-offs and test campaigns between the many partners with deviant motivation, business models and opportunity to gain directly utility of centre results.

Acknowledgement

The authors acknowledge the Research Counsil of Norway (RCN) for financing SWIPA centre for Subsurface Well Integrity, Plugging and Abandonment, RCN project number 309646.

Ethics and AI declaration: The centre management team is informed about the publication of this paper. No relevant AI tools are used to develop this paper.

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Knowledge Matters: Insights from the COVID-19 Experience in the Tourism Industry in Poland

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Abstract: Purpose: Tourism organisations are responsible for destination management and marketing. Given that they operate within a membership structure, serving as sectoral organisations and communication hubs, their role during crisis situations becomes particularly significant. The purpose of this study is to examine the types of knowledge and the sources from which this knowledge was derived during the COVID-19 crisis from the perspective of tourism organisations (i.e., Destination Management Organisations). Methodology: This study is based on a qualitative in-depth analysis conducted through semi-structured interviews with 12 representatives of 6 tourism organisations in Poland. The informants were selected to represent a range of organisational levels, including managerial and operational roles. Findings: The empirical evidence indicates that knowledge at three levels was crucial during the pandemic crisis, particularly at the organisational, governmental and industry level. At the organisational level key knowledge areas included safety, both personal and of the institution, from a sanitary-epidemiological perspective. The quantitative data concerning tourist traffic held particular importance for governmental level. For the industry, the following knowledge types were crucial: law-related knowledge, aid-related knowledge, and education-related knowledge. The findings highlighted that the primary knowledge sources during the crisis were central and local authorities, collaborating partners, counterpart tourism organisations, and internal monitoring teams. Research limitations: Due to the qualitative nature of this study and its small sample size, the generalisability of the findings to a wider context or population is limited. Furthermore, this study was conducted on a group of tourism organisations in one country, thus it does not provide a comprehensive industry overview and international applicability. Practical implications: This research provides guidance for managers of tourism organisations regarding the navigation of knowledge during sudden crises. The findings can be used by decision-makers to develop crisis procedures at the KM level to build organisational resilience. Originality/value: This study provides valuable insights concerning the dynamics of knowledge during hazardous events impacting tourism organisations. The findings may trigger researchers investigating the area of crisis knowledge management to engage in further explanatory studies.

Keywords: Knowledge, Knowledge management, Tourism, COVID-19, Destination management organisations

1. Introduction

The COVID-19 pandemic has had an unprecedented impact on the global tourism industry, influencing mobility and economic activity on a scale never before witnessed in the modern times (Gössling, Scott & Hall, 2021). Due to the limitations in travelling and gathering, tourism organisations were forced to deal with a crisis characterised by high uncertainty, rapidly changing regulations, and severe financial limitations. In such a complex and unstable environment, access to relevant, up-to-date and crucial knowledge became a critical element for building resilience and decision-making (Sigala, 2020). While facing this crisis situation, tourism organisations had to rely on a wide spectrum of knowledge sources, such as government authorities, industry partners, internal monitoring units, or digital information channels (Zenker & Kock, 2020). This paper explores different types of knowledge and knowledge sources used by tourism organisations in Poland and how they helped them in organisational responses within the tourism sector during the COVID-19 pandemic. In such turbulent times, the effectiveness of crisis response was related not only to the availability of knowledge, but also to the organisational capacity to interpret and act upon it. Understanding what type of knowledge was acquired, shared, and applied during the pandemic, as well as from which sources, can offer valuable lessons for creating a crisis-resilient tourism industry in the future.

This paper develops as follows. First, knowledge in the crisis in tourism is described. Second, the methodology of the study is presented and third, the findings and discussion are described. The paper ends with the conclusion section and future research avenues.

2. Knowledge in Tourism During the COVID-19 Pandemic

Tourism industry is particularly vulnerable to various crises. Hazardous events can threaten the normal operations of the entire sector as they very often result in temporary stopping of business activity, travelling impediments, and decline in inbound tourism related to safety reasons (Hopkins, 2021). Undoubtedly, the crisis stemming from the COVID-19 pandemic is considered a disruptive event of substantially greater magnitude

compared to any past crisis (Higgins-Desbiolles, 2020). This crisis engendered numerous challenges within various dimensions of the organisational activity, including aspects of knowledge management (Cegarra-Navarro et al, 2021; Bratianu and Bejinaru, 2021). Acknowledging after Tomé et al. (2021) that the pandemic crisis was a crisis about knowledge (Tomé et al., 2021) and considering the information-intensive character of this event, effective management of knowledge becomes vital in handling such turbulent situations.

The demand for knowledge during disasters is evident across the whole crisis lifecycle, in the preparatory phase, during the crisis and in the recovery stage (Mistilis and Sheldon, 2006). Ng et al. (2022) affirm that knowledge may facilitate the organisations to handle negative consequences of hazardous events when the very first crisis-related challenges appear, but also it may support the new knowledge development and implementation of lessons learnt (Ng et al, 2022). Moreover, while facing the crisis, knowledge may intensify the defence strategies of the organisations (Kir Kuščer et al, 2021) and assist in preserving the safety of employees and their workplaces (Schiuma et al, 2021).

Within the academic literature, an overview of diverse typologies of knowledge is presented. One of the most popular classifications is the one proposed by Nonaka (1994), based on the knowledge division delivered by Polanyi (1962). Nonaka (1994) presents a framework for managing the dimensions of knowledge-creating processes within organisations and divides knowledge into tacit (residing in minds) and explicit (codified). Tacit knowledge, as being personal and derived from experience, cannot be easily transferred, and it reveals itself through the actions (Nonaka, 1994). Whereas, explicit knowledge, which can be easily articulated and shared, can be identified and employed in the organisational context without restraints (Alavi and Leidner, 2001). Another typology is the one provided by Lundvall and Johnson (1994) is built on four types of knowledge: know-what, know-why, know-who, know-how. However, it is important to note that the discussed classifications relate to organisations operating under standard conditions, rather than in a crisis mode.

Crisis situations, including the pandemic, often present new opportunities. According to Sigala (2020), the COVID-19 period can be perceived as a catalyst for significant transformation, wherein knowledge itself played a key role in facilitating the revision of existing strategies and exploration of novel paradigms (Sigala, 2020). Moreover, knowledge contributes to recovery efforts by fostering organisational resilience (Reddy et al., 2020). Knowledge based on the retrospective reflection and after-action review can constitute an important component for strategies so that they mitigate the effects of new potential crisis situations.

All in all, as it can be seen on the basis of the literature analysis presented above, knowledge is a valuable resource also during the crisis. There are some studies indicating knowledge importance during a crisis, however, little is known about the types of knowledge and knowledge sources that are crucial for tourism organisations during a crisis. This paper aims to fill this knowledge gap on the basis of a qualitative study conducted in Poland.

3. Methodology

The aim of this study is to investigate in-depth the knowledge dynamics in the context of the pandemic crisis from the perspective of tourism organisations operating in Poland. Tourism organisations serve as sectoral institutions and operate within a Destination Management Organisations (DMOs) framework. These institutions are in charge of managing and marketing tourism destinations (incl. attractions, cities, regions, etc.) and play a leading role in coordinating a network of various stakeholders within the tourism industry (UNWTO, 2007). Being "in the middle" of the tourism ecosystem and acting as a communication hub, result in the role of such organisations as particularly significant during crisis situations.

In order to address the purpose of the study, this paper states the following research questions:

RQ 1: What types of knowledge supported tourism organisations during COVID-19 crisis?

RQ 2: Which knowledge sources were crucial for tourism organisations while facing pandemic crisis?

The process of data collection took place between November 2023 and January 2024 via semi-structured interviews. The representatives of local and regional tourism organisations in Poland at two organisational positions, namely decision-makers and operational employees, were chosen to take part in the interviews (the profile of respondents is presented in Table 1). The informants were selected on the basis of the inclusion criteria, including both the organisational role and the professional tenure length (at least since 2020). Altogether, 12 interviews, conducted in 6 tourism organisations, have been analysed within this research. All of the interviews were recorded, subsequently the Polish versions were transcribed *verbatim* (Poland, 1995) and the transcriptions were translated to English. MAXQDA software was used for coding the data. The analytical

approach used within the study followed the procedure of thematic analysis (TA) proposed by Braun and Clarke (2012) and was based on the six-step framework for doing TA.

Table 1: Profile of sample

Organisation	Position
Local tourism organisation 1	CEO
	Product Specialist
Local tourism organisation 2	CEO
	Tourist Office Employee
Regional tourism organisation 3	Director
	Tourism Specialist
Regional tourism organisation 4	Vice-Director
	Tourist Office Employee
Local tourism organisation 5	CEO
	Tourism Specialist
Local tourism organisation 6	CEO
	Tourist Office Employee

Source: Own elaboration

4. Findings and Discussion

On the basis of the results, it can be stated that Destination Management Organisations (DMOs) played a vital role during the crisis. They became information brokers in the first months, as they had the possibility of gaining information first-hand from various levels of public administration (namely, from the government level, from the municipal level) and pass it on to the industry. What is important is that this knowledge flow was not only one-directional, it was reciprocated back to those various levels of public administration. The CEO representing tourism organisation 5 highlighted the meaning of information and knowledge at the beginning of the crisis in the following way: "I believe that at the very beginning of the crisis, information management is the most important, because many rumors appeared, many problems that needed to be immediately addressed and then solved." It was not only the issue of problems or rumours where information management appeared useful, but also the matter of aids that were offered to various organisation, which was mentioned by CEO from tourism organisation 1: "They (i.e. the aids) were indeed very dynamic in this initial phase - several laws were changing, conditions were changing." Therefore, it was necessary to manage knowledge and information well, to be up-to-date with all the new issues and regulations in order to follow the law and also support organisations with administrative support.

4.1 Types of Knowledge During Crisis

As far as the RQ1 is concerned on the types of knowledge that supported tourism organisations during COVID-19, the empirical evidence indicates that knowledge at three levels was crucial, namely knowledge at the organisational, governmental and industry level, as summarised in Figure 1.



Figure 1: Types of knowledge during crisis

At the organisational level, key knowledge areas included safety, both personal and of the institution, from a sanitary-epidemiological point of view.

> *"Looking at that perspective, in the first phase, it was information concerning safety, both personal and of the organization - from a strictly sanitary-epidemiological point of view." (CEO from tourism organisation 1)*

> *"I mean, especially at the level of tourist information, we focused on what it really looks like? How to protect ourselves? What can we do?" (Tourist Office Employee in tourism organisation 6)*

The quantitative data concerning tourist traffic, revealing its significant reduction, held particular importance at governmental level.

> *"On the other hand, for the municipal and governmental level, quantitative data from tourist traffic was very important to know what information we can obtain, how much the traffic has decreased, and to have reliable data." (CEO from tourism organisation 5)*

This was important for the government and municipalities to undertake the right measures and actions to support tourism organisations in those turbulent times. Tourism was one of the most severely affected sectors during a COVID-19 crisis. For example, the UN World Tourism Organization (UNWTO) reported that international tourist arrivals declined by 72% in 2020 and 71% in 2021 compared to 2019, resulting in a loss of 2.1 billion international arrivals over the two years (UNWTO, 2022). For the industry, three main knowledge types were crucial. First of all, law-related knowledge (incl. changing laws, proposed changes, new regulations and restrictions) was mentioned by the respondents:

> *"Changing regulations regarding, for example, what is allowed, what is not, how quarantine looks, what lockdown rules are, etc... This could change from minute to minute" (Product Specialist from tourism organisation 1)*

> *"key knowledge was about restrictions - what could and couldn't be done, whether museums were open or closed, whether something would be available or not - because that changed a lot. At times, it was literally changing day by day, and those were also very difficult decisions that had to be made about cancelling large events, whether to plan something for a certain date or not, and even if planning was possible, how many people could attend, under what sanitary regime" (Tourism Specialist from tourism organisation 5)*

> *"Certainly, knowledge about those restrictions, those regulations, was crucial - and we also tried to simply know it because we were often asked about it - someone would contact us because they were organizing something and sometimes we had this knowledge, even somewhat unofficially." (Tourism Specialist from tourism organisation 5)*

During the COVID-19 crisis, tourism organisations had to constantly monitor rapidly changing laws and public health regulations, for example travel bans, quarantine requirements, and gathering restrictions (e.g. limits for events, groups in one place, etc.), which directly influenced their ability to organise and conduct events, tours, and services. The introduction of new safety protocols, such as vaccine requirements and capacity limits, required tourism businesses to adapt their activities to avoid penalties and provide the health and safety of both staff and guests. Understanding proposed legal changes and policies became crucial for tourism organisations to plan ahead, manage cancellations or refunds, and keep trust with clients in a highly uncertain and legally dynamic environment, changing not only every day, but sometimes also during one day.

The second type of knowledge indicated by the respondents was aid-related knowledge (incl. financial aid measures, support programs for entrepreneurs, compensations). It was mentioned by several respondents, also in the context of legal knowledge that was crucial.

> *"About funding, about various kinds of shields related to it, online training, but mainly about possibilities of assistance for entrepreneurs who could not operate normally." (Tourism Specialist from tourism organisation 3)*

> *"For the industry, for example, information related to legislation, proposed changes, support for entrepreneurs, what we can count on, and where they can submit their issues was crucial." (CEO from tourism organisation 5)*

> *"information about changing laws, the formal-legal issue, financial, aid-related issues - and somewhat a bit of prediction, seeking, how long this might last and how to really plan this business, right?" (CEO from tourism organisation 1)*

> *"We gathered the freshest information possible regarding restrictions - which changed rapidly - and information about possible aid measures, support programs, various support lines, and places where entrepreneurs from the tourism industry, as well as entities, could receive such support." (Tourism Specialist from tourism organisation 5)*

During the COVID-19 crisis, tourism organisations relied to a high extent on aid-related knowledge, namely financial aid measures, compensation schemes, and government-backed support programs. They needed this kind of knowledge due to the sudden stop of their operations and problems with cash flow caused by travel restrictions and event cancellations (OECD, 2020). This type of knowledge became crucial for organisational survival, as many tourism businesses, especially from the SMEs sector, lacked the financial reserves to survive prolonged periods of business inactivity (UNWTO, 2020). Research also shows that access to and understanding of support mechanisms significantly influenced the resilience and recovery capacity in the tourism sector during the pandemic (Baum et al., 2020). This is confirmed in the conducted study, where respondents indicated this kind of knowledge as one of the most important.

The last type of knowledge mentioned by respondents was education-related knowledge (including training). This shows that respondents were aware of the existing knowledge gap and the necessity to fill it with new, up-to-date knowledge to handle the crisis in a more resilient and efficient way.

> *"We had information about training, funding from various sources, and we passed it on to our members " (Tourism Specialist from tourism organisation 3).*

4.2 Sources of Knowledge During Crisis

In regard to RQ2, concerning the knowledge sources which were crucial for tourism organisations while facing pandemic crisis, results highlighted that the primary knowledge sources during the pandemic crisis were: central and local authorities, collaborating partners, counterpart tourism organisations, and internal monitoring teams.

> *"Plus, of course, at that time we had one or even two people who did nothing but research tools and support for the industry. So it was absolutely key then. That access to reliable information." (CEO from tourism organisation 2)*

> *"[...] in the Program Council at that stage, we also had representatives of entrepreneurs and city representatives. So by force, at the level of the Program Council and discussion groups, in this group, a lot of information, also how we could locally support entrepreneurs here at the level of the [name] local government. Also due to the fact that a member of this group was [name and surname], who was a member of [name], i.e., this event platform, so a lot of information also came from there and [name] was a very engaged person. Another person was [name], who is the head of [name of organization] here in [city], and at the same time the head of the Consortium [name of organization]. So we managed to create such an information exchange platform within these statutory bodies of the organization. And indeed it worked. We were like a catalyst, a tank, into which many stakeholders from various sources threw information, and we then pushed it further." (CEO from tourism organisation 2)*

> *"We also used knowledge transfers from other regional tourism organizations, which organized some online event and allowed representatives of the industry from other regions to participate in these meetings, not limiting it to their region only." (Tourism Specialist from tourism organisation 3)*

> *"On one hand, from our various partners or entities we collaborate with, e.g., at the governmental level or the Polish Tourism Organisation, and on the other hand, simply, in today's times, it's a matter of reviewing various online sources - services of the Ministry of Health, the Ministry of Sport and Tourism, etc. Of course, we also shared information among each other, different organizations also looked because we weren't the only ones doing such things. I remember the [Name] Tourism Organisation also published such information on their site. And a bit on the principle of "one lady told another" - each of us reads the press, watches TV, follows online services, so we also exchanged knowledge within the team." (Tourism Specialist from tourism organisation 5)*

The respondents highlighted that the primary knowledge sources during the pandemic crisis were central and local authorities, collaborating partners, counterpart tourism organisations, and internal monitoring teams. This reliance reflects findings from the OECD (2020), which emphasized the crucial role of government institutions and public health authorities in disseminating up-to-date guidelines and support measures to tourism stakeholders. Additionally, studies such as UNWTO (2020) and Sigala (2020) indicate that inter-organisational collaboration and internal crisis response units played a key role in navigating uncertainties, enabling organisations to quickly adapt their operations and decision-making. Internal knowledge monitoring helped many organisations assess real-time changes and risks and make quick adjustments to services, staffing, and customer communication (Gössling et al., 2021). This was necessary in times of constant changes, new regulations, facts related to the illness and its spreading, etc., and it has been confirmed in the conducted study.

Also, some respondents indicated their role in facilitating and supporting partners.

> *"That is, the subpage of our tourism portal, where we gathered information, and here we didn't find it appropriate to divide it into categories, etc. - it was about collecting knowledge that, from our perspective, was useful for our partners, for entities that cooperated with us." (Tourism Specialist from tourism organisation 5)*

Collaboration across various tourism entities was important as it supported sectoral resilience and knowledge exchange, which proved essential for sector-wide adaptation to this new, crisis situation (Zenker & Kock, 2020). To sum up, the results indicate that tourism organisations during the COVID-19 crisis relied to a high extent on multiple sources of knowledge to deal with the quickly evolving situation.

5. Conclusion and Future Research Avenues

This paper presents the results of a qualitative study related to tourism organisations in Poland and their operations during the COVID-19 pandemic, with an emphasis on knowledge and its sources that are used during a crisis. The empirical evidence indicates that knowledge at three levels was crucial during the pandemic crisis, particularly at the organisational, governmental and industry level. At the organisational level key knowledge areas included safety, both personal and of the institution, from a sanitary-epidemiological perspective. The quantitative data concerning tourist traffic held particular importance for governmental level. For the industry, the following knowledge types were crucial: law-related knowledge, aid-related knowledge, and education-related knowledge.

Tourism organisations searched for this knowledge among various entities. Central and local authorities provided critical legal, health, and financial guidance, while collaboration with partners and other tourism entities facilitated knowledge exchange and sectoral adaptation. Internal monitoring teams played a crucial role in following current developments, to help organisations in making informed, agile decisions. Following Nonaka (1994), it can be concluded that generation of organisational knowledge during a pandemic crisis was facilitated by an ongoing interplay between implicit (tacit) and articulated (explicit) knowledge. Altogether, access to accurate, timely, and diverse sources of knowledge significantly supported sectoral resilience and crisis response capacity of individual tourism organisations.

This paper is useful both from the theoretical and practical perspectives. First of all, it provides an overview of knowledge types that are important for tourism organisations in times of a crisis like COVID-19. Second, it offers the typology of those knowledge types that could be applied not only by tourism organisations themselves to search for the key information, but also by governmental bodies supporting these organisations in a crisis situation. This typology could be used as a source for classification of news that are addressed at tourism organisations in media or on governmental and municipal websites. Third, it could also be used by researchers to examine this topic in the future, also in cases of other types of crises.

This paper is not free from its limitations. As this study is based on a case study approach, it is subject to the methodology-related limitations. Research output is limited to the analysis of several organisations and therefore, it does not offer a comprehensive overview of the whole sector or other sectors. The analysed case studies are from a single country (Poland) and it also limits the applicability of the results to tourism organisations from other countries.

Future research areas may concentrate on exploring other industries, also affected by the COVID-19 pandemic or another type of a crisis. Furthermore, quantitative studies could be conducted to evaluate the importance of particular types of knowledge in more detail. Additionally, tourism organisations from other countries could be examined, especially the ones facing COVID-19 or other pandemic. By examining tourism organisations from other countries and comparing the results, the cultural aspects of dealing with the crisis with appropriate knowledge and its sources could be detected.

Acknowledgements

The authors greatly acknowledge the financial support from the National Science Centre, Poland, within the grant no. UMO-2022/45/B/HS4/02631, entitled “Knowledge management in tourism organisations in crisis.”.

Ethics declaration: The authors report there are no competing interests to declare, and ethical clearance was not required for the research.

AI declaration: The authors report that AI tools assisted in the development of this paper with respect to linguistic matters, i.e. translation.

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From Tacit to Explicit: Using Live Documentation and Feedback Loops to Facilitate Knowledge Transfer

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Abstract: The preservation and structured use of tacit knowledge (TK) is a critical challenge in industrial environments contending with increasing automation and a skilled labor shortage. The loss of undocumented expertise, especially in circular economy applications such as disassembly processes, threatens process efficiency, adaptability and quality. This paper presents a knowledge management approach that combines industrial engineering methods with Industry 4.0 technologies to capture and integrate TK into semiautomated disassembly systems digitally. Taking Fraunhofer IFF's iDeaR project as a case study, a demonstrator is developed to document and convert experts' actions during PC disassembly into machine-readable formats. The approach integrates live documentation, feedback loops and digital twins to systematically capture contextual problem-solving strategies, enabling their reuse and continuous learning in technical systems. Tacit knowledge is structured using a dedicated Asset Administration Shell (AAS) submodel, comprising situational context, problem description, solution, guidance and benefit. This facilitates contextual reuse across diverse scenarios. The demonstrator architecture links captured knowledge with product, process and resource twins and provides context-sensitive support through modular software applications. Expert-reviewed feedback loops transform raw data into validated disassembly instructions, checklists and training content. A user-friendly interface facilitates intuitive data entry and practical applicability in industrial settings. Results from a workshop-based analysis of disassembly steps confirm that both implicit and explicit knowledge can be meaningfully structured and evaluated for automation capability. The approach preserves expertise, enhances organizational learning and contributes to more adaptive, error-resistant processes. Future developments include AI-assisted storytelling and enhanced sensor integration to further improve feedback quality and reduce editing. This paper thus contributes to the design of intelligent knowledge systems for (semi)automated environments and highlights the value of digital knowledge models in industrial transformation.

Keywords: Knowledge transfer, Knowledge preservation, Tacit knowledge, Industry 4.0 technologies, Circular economy, Automated disassembly, Live documentation, Feedback loops

1. Introduction

The preservation and transfer of tacit knowledge (TK) are vital for companies to ensure long-term efficiency, quality and innovation. Industrial settings in which complex machinery and processes require extensive expertise particularly raise the question of how to document and utilize such valuable knowledge sustainably. The growing skilled labor shortage and demographic change are further increasing this challenge: Experienced employees leave companies and qualified replacements are often scarce, creating a risk that knowledge accumulated over years may be lost (Ottersböck et al, 2024).

One particularly complex issue is the transition from implicit to explicit knowledge. Systematic methods must be used to transfer implicit knowledge and structured accessibility to semiautomated processes must be ensured. This is especially true of disassembly processes, which are growing increasingly important in the circular economy (Saenz et al, 2024). Product reuse and recycling require efficient disassembly strategies based on experts' TK. Failure to preserve specific knowledge entails the risk of losing specific operational knowledge and problem-solving strategies and consequently not integrating them into future process chains (Polany, 1985).

Ongoing technological advances are necessitating targeted actions that impart hitherto elusive TK of disassembly processes to new employees while simultaneously preserving departing experts' knowledge. The combination of industrial engineering methods and advanced Industry 4.0 technologies offers novel opportunities to capture, document and leverage knowledge in real time.

Taking Fraunhofer IFF's intelligent Disassembly for Remanufacturing and Recycling (iDeaR) project as an example (Fraunhofer IFF b, 2025), this paper shows how expert knowledge from disassembly processes can be systematically captured and digitally formatted. A key element of this approach is the use of digital twins—virtual models that mirror real disassembly workflows and serve as structured knowledge agents. Digital twins can continuously incorporate practical experience and human actions, making them usable for future applications. This makes tacit knowledge part of a shared, data-based knowledge base that enhances process efficiency and facilitates learning in automated environments.

2. Research Background and Theoretical Framework

This section establishes the thematic and project-specific framework to highlight the study's relevance and objectives. Key concepts of and developments in knowledge management are subsequently explored in the context of automated work environments, focusing on live documentation approaches and feedback loops for organizational learning and the use of digital twins.

2.1 Thematic Framework

Numerous industries use automation in parts of the disassembly process, but such automated systems are often limited to specific product types and lack flexibility (Saenz et al, 2024). The iDeaR project is addressing this issue by enabling adaptative disassembly of diverse items such as electronic waste. To do so, it is drawing on Industry 4.0 technologies, such as digital twins and real-time data systems, to facilitate knowledge-driven automation.

Key challenges, aside from wide product variety, that make great demands on flexibility include automated product evaluation and adjustment of disassembly depth, the integration of tacit knowledge, the incorporation of experiential knowledge, the establishment of a knowledge base and the transferability of the methods developed to other use cases. The evaluation process determines if and to what extent a particular product is disassembled. Market demand for reusable components, raw materials, plant costs and availability and the carbon footprint of disassembly are consequently included in the evaluation. Disassembly steps are automatically adapted and performed based on this evaluation.

Tacit knowledge is essential for adapting disassembly processes, managing manual actions and solving problems whenever automated systems experience errors. A key element of this is the *disassembly sequence*—a step-by-step procedure that defines how a product is taken apart. Such sequences often rely on practical experience and are refined by hands-on problem-solving. To preserve and reuse such knowledge, information on items, processes, resources and expert actions must be collected in a structured knowledge base. Digital tools such as interconnected disassembly twins and appropriate software systems are needed to ensure data consistency.

2.2 Tacit Knowledge and Its Role in Automation

Even though is it difficult to formalize, tacit (or implicit) knowledge acquired through experience and embedded in practical routines is essential for automated work environments. This section defines tacit knowledge and explains why its integration into technical systems requires specific strategies beyond conventional documentation. The goal is to preserve valuable knowledge and structure it for machine accessibility and readability.

Explicit knowledge provides the formal basis for work processes (e.g., instructions or documented information), whereas implicit knowledge acquired through years of practical experience is often intuitively applied without explicit documentation. Explicit knowledge sourced from manuals or training programs is more accessible and easily transferable. Implicit knowledge's deep integration in specific machines, processes and corporate cultures make it indispensable to automated work environments (Polany, 1985).

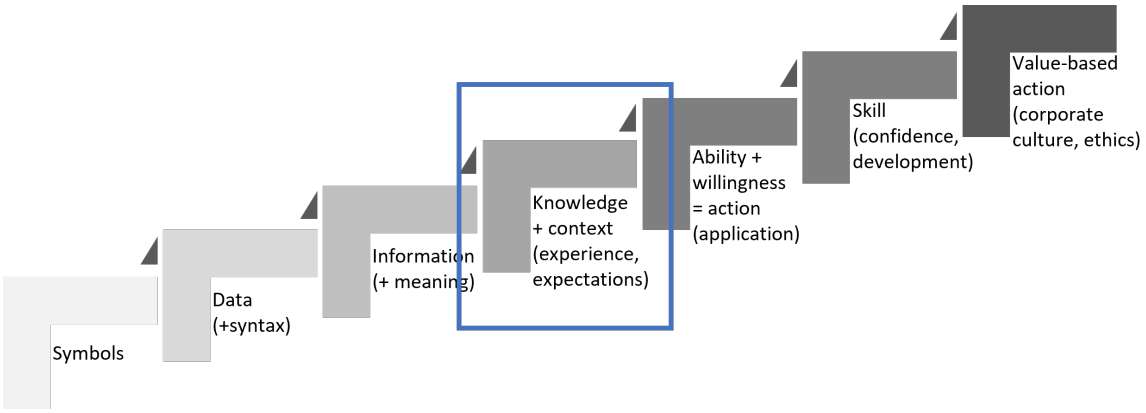


Figure 1: Stepped information processing model (Reisach et al, 2025)

Human expertise and everyday work practices are far more challenging to capture than machine data that are automatically recorded in structured formats such as sensor data logs (BIDT, 2021). Tacit knowledge, on the other hand, is often concealed in routines and difficult to articulate. All the same, making this kind of knowledge usable in automated environments is becoming increasingly important (Reisach et al, 2025). Narrative methods

such as storytelling or triadic conversations, a specific form of guided conversations, offer promising ways to transfer TK by conveying not only facts but also the reasoning and decision-making behind them.

Research stresses the irreplaceability of humans as knowledge agents, even in an increasingly digital world, and the need for technological support. Designing user-friendly human-machine interfaces is crucial: They must facilitate learning, be intuitive to understand and facilitate decision-making in complex situations, particularly when human TK is integrated into digital processes (BIDT, 2021).

2.3 Live-Documentation as a Capture Strategy

Live documentation techniques make it possible to capture tacit knowledge, even though it is often unstructured. This section presents technological approaches and practical implementations of live documentation, emphasizing their role in preserving expert knowledge during disassembly processes.

Practical methods of live documentation include technologies such as IoT sensors, internet-connected devices that collect and transmit real-time data continuously, and automated image analysis and data capture systems. In logistics, for instance, employees can use mobile devices to send live images of damaged goods to central systems, improving both the speed and accuracy of tracking (Flicono, 2025). In manufacturing, embedded real-time systems help monitor and prioritize processes, reducing disruptions and keeping product quality consistent (Intel 2025).

Live documentation is particularly valuable in the circular economy, where the goal is to keep products and materials in use for as long as possible through reuse, remanufacturing or recycling. In disassembly processes, it enables the continuous capture of data on the condition of parts, helping recover valuable components and avoiding unnecessary waste (Fraunhofer IFF, 2025; Solarify, 2025). Research projects such as Fraunhofer IFF's iDeaR project demonstrate how sensors and camera systems can supply data to digital twins. Such digital twins serve as structured knowledge agents, enabling robot systems to react to changes flexibly while also preserving employees' knowledge for future tasks.

Clausthal University of Technology (TU Clausthal) is using automated disassembly cells to guide robots based on real-time tracking of components' location and condition (WissenhochN, 2024; TU Clausthal, 2024). Similarly, recycling facilities use live data, collected by various technologies, to manage material flows and recover resources more efficiently (Brother, 2020).

Overall, live documentation improves transparency, adaptability and long-term knowledge retention. Technical and organizational challenges remain, though, especially in terms of data quality, system compatibility and the training of employees to work effectively with such tools (Fraunhofer IFF, 2025; WissenhochN, 2024; Solarify, 2025).

2.4 Feedback Loops for Organizational Learning

Feedback loops make captured knowledge actionable by systematically integrating practical knowledge into organizational processes. According to Willke (2001), organizational learning results when individual experiences are structured and embedded into routines. In keeping with this, feedback mechanisms enable continuous improvement and facilitate the integration of tacit knowledge into adaptive, semiautomated systems. A feedback loop is a cyclical mechanism that reintegrates operational knowledge (e.g., disruptions, effective solutions, manual adjustments) into system development or process design. Such feedback processes enable continuous adjustments consonant with single-loop learning in which routines are optimized to prevent recurring problems. Conversely, double-loop learning aims for more far-reaching structural changes. Underlying assumptions and strategies, such as those that guide automated approaches, are examined critically and revised (Argyris and Schön, 1978). Digital technologies, including IoT sensors, digital twins and AI-based analyses, significantly enhance this learning process, boosting organizational adaptability and resilience. Challenges include data quality and user acceptance of feedback systems.

Feedback loops are instrumental to the development of adaptive, learning-capable systems, strengthening organizational resilience by systematically integrating TK into technical systems.

2.5 Digital Twins as Knowledge Integration Platforms

Tacit knowledge must be embedded in structured digital representations to make it accessible for automated applications. Digital twins—virtual replicas of physical objects, products or processes—serve as dynamic knowledge agents that enable real-time monitoring, analysis and contextual reuse of data and knowledge (FirstIgnite, 2025; Fraunhofer IFF a, 2025). They are already widespread in industrial practice as interfaces

between physical and digital realms and play a key role in both process optimization and knowledge preservation. This section explores how digital twins can be used as integration platforms for TK, focusing on their role in facilitating interoperability and standardization in knowledge-based disassembly processes. Digital twins integrate various digital tools and standards. The Asset Administration Shell (AAS), as defined in IEC 63278-1:2022-07, is on such standard for a unified information model. It enables consistent data storage and easy integration into existing IT systems (Fraunhofer IFF a, 2025). Industrial Digital Twin Association (IDTA) standards enhance specific submodels' interoperability and data exchange (Newroom Connect, 2024; Kem, 2023).

Practical benefits of digital twin technologies include enhanced interoperability and streamlined integration through standard data models, enabling consistent data management and facilitating knowledge sharing, such as recording disassembly instructions and optimizing processes using real-time data (Gabor et al, 2020). Significant challenges remain, though, particularly in terms of data quality, system integration complexity and the work required for initial implementation (BMDV, 2024). Strategies, such as phased implementation and modular platform architectures, help companies overcome these hurdles (BVMW, 2025).

3. Methodological Development of the Demonstrator

The following section outlines the implementation of a demonstrator that operationalizes live documentation, feedback loops and digital twin models based on the theoretical concepts presented in section 2. This technology demonstrator focuses on knowledge digitization and preservation, demonstrating how tacit knowledge can be captured digitally and embedded into a network of digital twins for utilization in an Industry 4.0 environment.

3.1 Concept

Wide product variety will inevitably result cases in which a product differs to such an extent that certain disassembly steps are not yet automatable. Such instances cause an error occurs in the disassembly system that requires manual action be taken by staff.

The first objective is to clear the blockage in the disassembly system. Staff sees whether the problem can be resolved on-site so that the system can resume operation right away or the component must be taken out and disassembled manually. The second objective is to document the manual action to automate it in the future or to plan and expedite the manual disassembly step with the aid of the knowledge base. Digital twins based on interconnected AASs for products (PC), processes (disassembly), resources (e.g., robots) and TK make contextual knowledge transfer and capture modules possible (Figure 2).

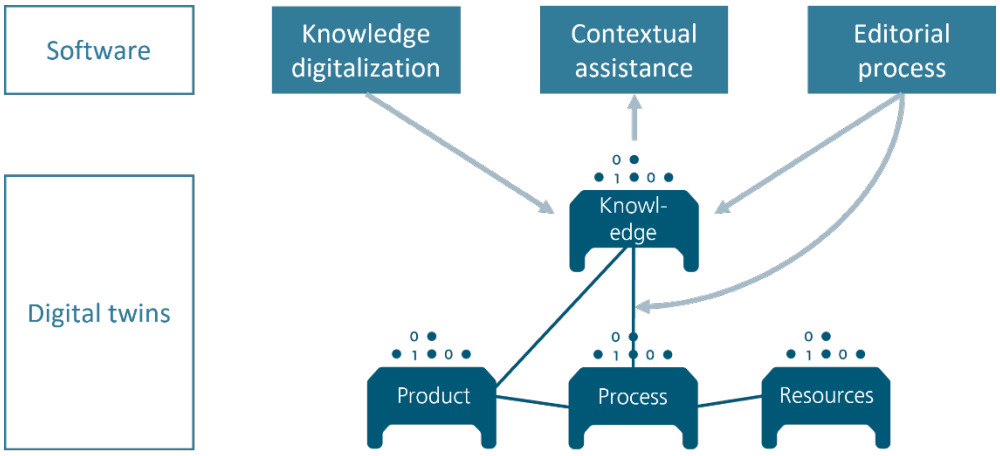


Figure 2: Software components and digital twins of the demonstrator (created by the author)

3.2 Scenario Process Description

On-site problem resolution is employed when a quick solution will enable the system to resume operation. Two cases are considered: In the first case, the system requires an adjustment to resume operation (because of incorrect disassembly tooling). A worker selects the correct tool, enabling the system to resume operation. In the second case, the system cannot perform a specific disassembly step automatically (because of tool unavailability or limited robot capabilities). A worker performs the required manual action on the product, enabling the system to resume operation.

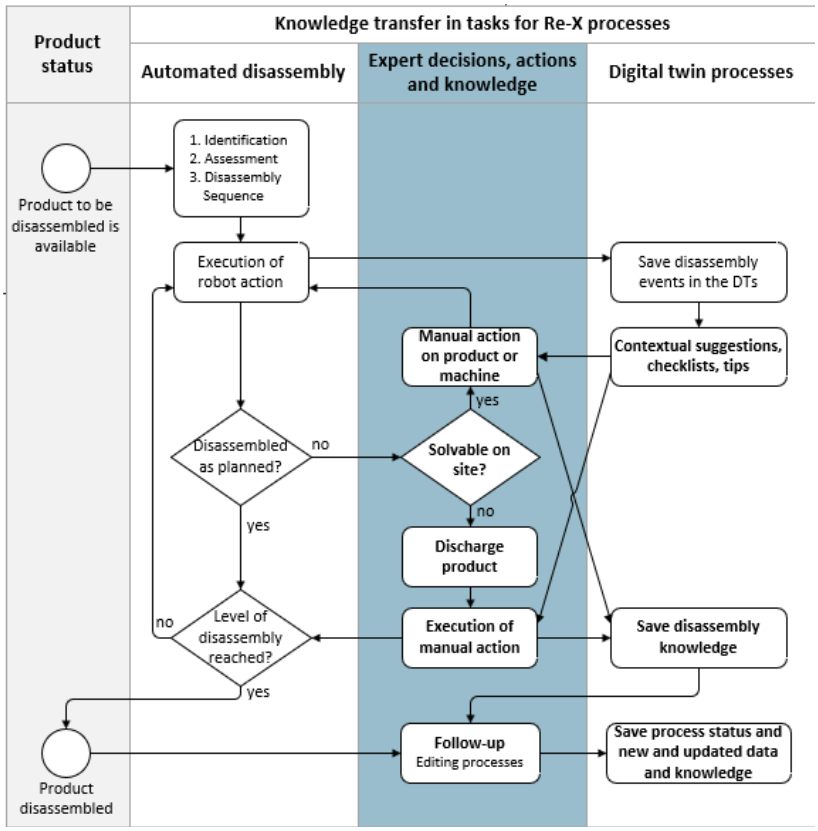


Figure 3: Swimlane flowchart of knowledge transfer in disassembly processes, based on Saenz et al, 2024 with boldface additions by the author. The automated disassembly process has been condensed

Components are removed from the automated process whenever on-site diagnostics require shutting down the system for an extended period. In such a case, staff perform the necessary manual disassembly steps at a separate work cell. Once they have finished, the PC is either returned to the automated disassembly system or the disassembly process ends at that point.

In both cases, an expert makes decisions based on their own tacit knowledge and the system's contextual suggestions and checklists (Figure 3). The expert performs manual disassembly steps and records new knowledge. This new knowledge is stored as raw data and is immediately available for future disassembly tasks (live documentation). An editing process follows to enhance the knowledge's value and ensure its quality. Experts edit the content and compile adapted disassembly sequences, checklists and notes (feedback loops), which are then integrated into the proper digital twins.

4. Technological Implementation

This section outlines the planned technological implementation of the demonstrator described in section 3. The following sections present the central elements of the implementation plan, beginning with the determination of an appropriate disassembly depth, continuing through the integration of TK into digital submodels and concluding with the planned implementation of the complete system with software support.

4.1 Determining the Depth of Automated PC Disassembly

An interdisciplinary workshop was conducted in the iDeaR project to determine the depth of automated disassembly of a DELL i5 OptiPlex 3010 PC as a case study. The objective was to capture explicit and implicit knowledge systematically and to assess the automation capability of individual disassembly steps.

The workshop centered on the structured documentation of each disassembly task, such as rear cover removal, graphics card extraction and cable detachment, factoring in time requirements, component weights and manipulation techniques. The analysis combined domain expertise with practical knowledge. Particular emphasis was placed on component accessibility and fasteners. Plug-in, screw and tool-free fasteners were determined to be well-suited for robotic systems, whereas glued or highly stressed parts require manual action. Only four screws secure the SSD, for instance, making it an ideal candidate for automation. Conversely, cable

removal remains a largely manual activity because it is difficult for robotic manipulation but trivial for human workers.

Altogether five out of ten standardizable disassembly substeps were classified as highly automatable. These results were included in a criteria package intended to serve as the basis for the evaluation of future disassembly processes. Explicit knowledge assets, such as CAD models and digital process models, were incorporated as well. The workshop additionally targeted unskilled operators: The documented tasks were worded to be easily understood and safe to perform with the aid of digital assistance systems.

Table 1: Core workshop results

Core Result	Description
Documentation of individual disassembly steps	All disassembly substeps were documented using explicit and implicit knowledge
Assessment of individual disassembly steps' automation capability	Automatable disassembly steps were identified based on manipulation, variability and fasteners
Consideration of target user group	Disassembly steps were worded to be easily performed by unskilled operators

The workshop results are the basis for model-based implementation in the digital twin (section 4.2) and provide essential information for the software architecture (section 4.3).

4.2 Digital Twin Submodels

As explained in section 3.1, one goal is to transfer tacit knowledge to an Asset Administration Shell. A specific submodel for TK must be developed to do this. Our approach for the submodel is based on a structure proposed by Mittelmann et al (2023), comprising context, task description, solution approach, conflicts, pitfalls and references. These elements are present in the submodel as follows:

- Situation: Description of the situational context in which the problem occurred (e.g., product configuration, process status, resource status)
- Background: Contextual information such as technical dependencies or previous experiential data
- Problem: Description of the disruption or problem encountered in the process
- Solution: Documentation of the measure taken to resolve the problem
- Guidance: Step-by-step instructions for implementing the solution
- Benefit: Indication of the value added by the solution (e.g., time savings, error prevention)

Digital twins that utilize this submodel are linked with other digital twins in the system, such as those for products, processes, or resources (Figure 2). This enables targeted contextualization and reuse of TK across different application scenarios, covering access and disassembly sequences, status and process data, notes, checklists and training content.

4.3 Software

To actually transfer knowledge, an employee interacts with software that uses the structures and data of the Asset Administration Shell in the background. The modular software architecture comprises multiple applications customized for specific workflow steps and user groups. Established software platforms, such as Eclipse BaSyx (BaSyx, 2025) and KIWAI's Artificial Intelligence Framework (KIWAI, 2022) are employed to enable seamless integration of the AAS. These applications facilitate end-to-end linkage of tacit knowledge with components' digital twins, ensuring targeted delivery of information in the appropriate context. The underlying architecture is built around three functional areas, presented in Figure 2:

- Knowledge digitization: This module systematically captures TK. Data is entered in user- and context-specific forms, such as standardized input fields for problem statements, solution approaches, action steps and benefit evaluations. Unique assignment of these data to components, process steps or resources is essential for subsequent reuse in the complete system.
- Contextual assistance: This module provides specific guidance and recommendations. A user-friendly interface automatically displays content based on documented TK contextually. Automatic linking of these instructions to the proper digital twins (product, process, resource) directly supports practical implementation.

- Editing process: This module is used to edit and release captured knowledge. An expert validates, contextualizes and approves content on disassembly. The goal is to use AI methods to automate validation and contextualization further, thus reducing manual editing.

The prototype software is currently focused on efficiently representing, structuring and transferring knowledge to digital twins. The user-friendliness of the input interfaces is critical to acceptance and sustained use of the solution. Emphasis is additionally being placed on smooth integration of the modules into existing IT architectures to ensure practical utility and industrial applicability.

5. Conclusion and Outlook

This paper outlined key features of a demonstrator that uses feedback loops and live documentation to digitize and leverage tacit knowledge in industrial settings. It described the role that digital twins play and provided an overview of a possible technical implementation. Studies demonstrate that a structured knowledge management approach employing digital twins can document TK and make it available for future processes in the form of operational guidance, tips and tricks. Continually upgrading the digital twins during use optimizes the automation process in the long term and gradually reduces manual actions. Editing preserves and makes existing TK accessible. The prototype demonstrator designed has already yielded valuable insights into the automation capability of disassembly steps.

Refinement of the prototype for AI-assisted storytelling and the integration of related methods into a software solution such as EverAssist (Keller et al, 2022) are promising next steps AI-assisted storytelling would take interaction with a system that digitizes TK to a new, more intuitive level. Moreover, AI methods could be used to generate proposed instructions and actions automatically during editing. Further of sensing technology and intelligent systems to record live data more accurately and further enhance the quality of feedback loops is also conceivable.

The approach presented allows directly linking tacit knowledge with the proper digital twins, facilitating the creation and refinement of disassembly sequences (Poenicke et al, 2025). Experiences from disassembly enter directly into the adaptation and refinement of disassembly sequences.

These developments are intended to contribute in the next steps of the iDeaR and other Fraunhofer IFF projects to making the entire process of capturing, linking and applying knowledge possible in automated systems, based on standards such as the Asset Administration Shell. In the long term, this will reduce both workers' error rates and manual labor.

Ethics declaration: No ethical clearance was required for the research presented in this paper. Since the study did not involve human or animal subjects or the collection of sensitive or personal data, approval from an ethics committee was needed.

AI declaration: An AI tool (Fraunhofer Gesellschaft's FhGenie) was used during the development of this paper for minor tasks related to structure and translation. Specifically, the tool helped the author rephrase and organize certain sections more clearly and translate select passages from German to English. All content generated or revised with the help of the AI was carefully reviewed and edited by the author to ensure accuracy, coherence and academic integrity.

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Exploring the Role of KM in Integrating ESG Practices into Organizational Strategies

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Abstract: Knowledge Management ("KM") has a key evolving role in supporting businesses to better face the challenges related to the continuous economic and social long-run competitive development under the auspices of the new technologies and to the new advances of the digitization processes that seem to replace the human "*touch.*" This paper investigates the KM integration into corporate strategies as a driver of sustainable practices within the financial sector. It examines, through a bibliometric analysis, how banks can take advantage of KM systems to efficiently capture process-critical relevant information by promoting collaboration and enabling competent decision-making to adopt and develop competitive business models regarding *Environmental, Social, and Governance (ESG) factors*. By examining the impact of KM on sustainability, the paper highlights its potential as a catalyst for driving sustainable development within the financial sector. Considering these issues, our main goal is to identify the most relevant enabling tools of KM, such as to better boost the development of organizational strategies that encourage the development of ESG practices. The paper focuses on companies from the banking sector. The general results highlight the main enablers, also illustrating a series of challenges and presenting correspondingly a set of practical ways to face them, according to our team's vision. Based on these results, our team recommends a holistic vision of KM that has to be integrated into business models to ensure and keep a long-term competitive advantage. The paper is addressed mostly to practitioners and researchers manifesting a special interest in the financial sector. Our paper also has certain research limits, mostly in terms of the number of references identified and analyzed. For further research, we will continue to improve this perspective and enlarge our research.

Keywords: Knowledge management (KM), Sustainability, ESG, Corporate strategy, Banks, Gender diversity

1. Introduction

Integrating environmental, social, and governance (ESG) disclosure requirements into organizations' objectives and strategies is considered as one important and highly relevant topic, emphasizing the importance of long-term sustainable and resilient development. Companies' prospects depend on their level of ESG development, as in addition to regulations that impose ESG compliance requirements, investors place great emphasis on their ESG indicators and on the ratings established by major rating agencies (which also include companies' ESG results in their calculations).

Given these issues, we consider it is important to identify the main organizational factors that might contribute in order to boost ESG performance.

We strongly believe that one of these main key factors is the companies' knowledge management (KM). Effective KM, through knowledge generation (research) and sharing (transparent know-how), might have a better capacity to support both the competitiveness and the sustainability goals of the business.

Thus, our main objective is to analyze which are considered, at the academic level, the most representative enabling tools of KM that highly contribute to stimulating the development of the banks following ESG requirements.

The paper is organized as follows: in Section 2, we highlight some of the most relevant research results in this field based on literature review; in Section 3 we described the research methodology and the main data used; in Section 4, we present our results. The paper ends with conclusions.

2. Literature Review

The literature examining the relationship between knowledge management and ESG performance is growing, with more and more relevant research studies demonstrating a generally positive influence. These studies include among others those by Xia (2022), Saviano et al. (2024), and Alfiero et al. (2025).

Two views remain pervasive in the academic review and the discussion on the merits of governing a knowledge management environment: one envisages the idea of looking at KM as an object, an inert concept, and the other refers to the practice-based perspective (Xia, 2022).

Exploring further the knowledge management theoretical framework, we come across to identify some various approaches of knowledge management. We consider as mostly relevant issues in line with our paper vision the type of strategies that organizations pursue considering also the typology and structure of the organizations.

Consequently, depending on the organizational size and structure, we consider that knowledge management practices might be subject to some deliberate strategies (Cerdan et al., 2007), while other much simpler structures are proper to emergent-type strategies (Bolisani and Scarso, 2005).

When we discuss a company's strategy, there is a need to consider the type of strategy adopted. Minkov and Hofstede (2013) highlight that KM practices have to be significantly anchored into the overall strategies and context. If, for example, the organization is focused on standardized services, we consider that a codification KM framework is more appropriate, while if the organization is operating in an innovative industry, a personalization framework would be more appropriate.

We argue that the initial stages of using KM in integrating ESG practices into the overall organization's strategy cannot rely on one single definitive approach and that a combination of approaches should be put to work such as to better integrate a proper ESG strategy within the financial institution's overall strategies and policies.

As far as we manage to identify within the specialized literature there are not too many research studies performed in order to highlight the role that knowledge management and knowledge management systems may play for better integrating ESG into the overall organizational strategies and policies specific to the financial institutions.

At the European level, there are specific regulations that require banks to incorporate ESG factors into their business strategies. One of the important strategy in line with this approach is based mostly on the board's knowledge related to sustainability. For instance, the Basel Committee on Banking Supervision published in June 2022 the "Principles for the effective management and supervision of climate-related financial risks" (BCCS, 2022).

At the same time, the European Union, through Regulation 2019/2088 on Sustainable Finance Disclosure Regulation (SFDR), aims to increase transparency in the way financial market participants disclose information on how they integrate sustainability (ESG) aspects into their investment strategies so that investors have the most relevant and recent information when they have to decide how to establish their investments.

Reporting issues seems to be very important for all the stakeholders involved directly or indirectly within the ESG integration process. Thus, consequently, the strategy integration prioritizes compliance with regulatory aspects via reporting initiatives over a well-integrated ESG performance. As a result, KM becomes one of the vehicles that may highly contribute to the creation of outputs specific to reporting requirements.

External Stakeholders have to be part of the ESG approach. Building solid adherence to ESG practices should be one of the main objectives of the ESG strategy implementation agenda. For the financial institution, integrating ESG practices into the value chain is essential for a successful strategy.

Employees are the main internal stakeholders, the driving force behind making the ESG integration a successful tool. Leadership should aim at finding the right incentives to involve internal stakeholders in pursuing ESG integration at all levels of the organization.

Management's responsibility is primarily to provide operational input when it comes to integrating the ESG framework into the organizational strategy. Management and of course knowledge management is the binder between leadership and employees, facilitating the guiding activities to ensure proper ESG integration into the organization. Agnese et al. (2024) and Waterstraat et al. (2021) investigated the role of the knowledge endowment of directors on ESG performance within the banking sector (including banks in Europe), and their results highlighted that board knowledge is representative and relevant for ESG ratings.

When it comes to ESG performance, the Board of Directors (BOD) becomes the vehicle for driving a positive integration outcome.

Recent research (Zournatzidou, 2024) shows that encouraging a diversified board membership increases the likelihood of a successful ESG performance within organizations, including financial institutions. BOD diversity was found to lower agency costs (Wu and Chen, 2024) and thus improve the efficiency of ESG performance.

At the European banking sector level, Paolone et al. (2024) showed that board gender diversity and board cultural diversity, individually, have a positive effect on the development of ESG. Their results related to the importance of board gender diversity are confirmed by the study conducted by Galletta et al. (2022), based on a sample of banking sectors from 48 countries, showing that the presence of women in management positions in banks stimulates the E pillar, while Menicucci and Paolucci (2024) demonstrate a similar result on the social dimension, and Luh et al. (2024) confirm the results including for the G dimension.

Bhat et al. (2024) and Pu et al. (2023) also found that board qualification is an important element that positively influences ESG results. Agnese, Arduino, and Taddeo (2024) state that companies that have created a Corporate Social Responsibility (CSR) sustainability committee manage to obtain better corporate social performance.

Another important driver of ESG development is revealed by Wang et al. (2023), who, based on an analysis of Chinese A-share listed companies, highlighted that executive overconfidence plays an important role in the sustainable development process of companies. Lin et al. (2022) highlighted the importance of Research-Development-Innovation (R&D&I) in supporting the link between female management and green innovation.

De Silva, Gunarathne, and Kumar (2024) showed that another factor that contributes significantly to improving companies' ESG reporting is digital knowledge.

On the other hand, Martinez-Meyers et al. (2024) studied the impact of SFDR on the ESG of sustainable funds. The results indicate both an improvement in ESG values and a reduction in sustainability risk as a result of the implementation of this regulation. Further referring to the investment sector, Marszk and Lechman (2024) found, among other things, that tertiary education has a positive influence on ESG exchange-traded funds.

3. Methodology and Data

The main research methodology used in this paper is based on a bibliometric analysis. The data were collected from the Web of Science – Clarivate (“WoS”) database and referred to papers published between 2009 – 2025. The research was further extended to include the Scopus database.

The initial keywords used for the WoS research were: ‘knowledge management’, ‘knowledge sharing’, “sustainab*”, “bank*”, and ‘ESG’. The keywords were searched in the articles' titles, keyword plus, author keywords, and abstracts using the following categories: ‘knowledge management and ESG’, ‘knowledge management and sustainab* and bank*’, and ‘knowledge sharing and sustainab* and bank*’.

In order to improve the data used, we have divided our research into primary factors that might impact ESG integration into organizational strategies. The main identified factors are: technology, people, and governance (reporting).

Secondly, we have completed and updated our database using documents obtained by searching the following keywords as criteria: ‘technology’, ‘people’, ‘governance’, ‘esg*’, and ‘bank*’, grouped into three categories: ‘technology and esg* and bank*’, ‘people and esg* and bank*’, and ‘governance and esg* and bank*’.

There were taken into account papers that include the following four categories: *article, review article, proceedings paper, and early access.*

After the screening analysis of the articles generated in WoS, these were filtered such as to exclude those studies that did not exactly correspond to our research objective. The final database for the first computation includes 40 documents, while the updated database includes 89 documents. The data was processed using VOSviewer software, and the analysis we applied was co-occurrence - all keywords (for the number of occurrences of a keyword, we chose the value 3).

The initial keywords used in the Scopus database were “financial institution”, “knowledge management”, and “ESG strategy”. Based on the search, we have obtained a limited number of relevant academic papers, and consequently, the results lead us to further extend our research perimeter.

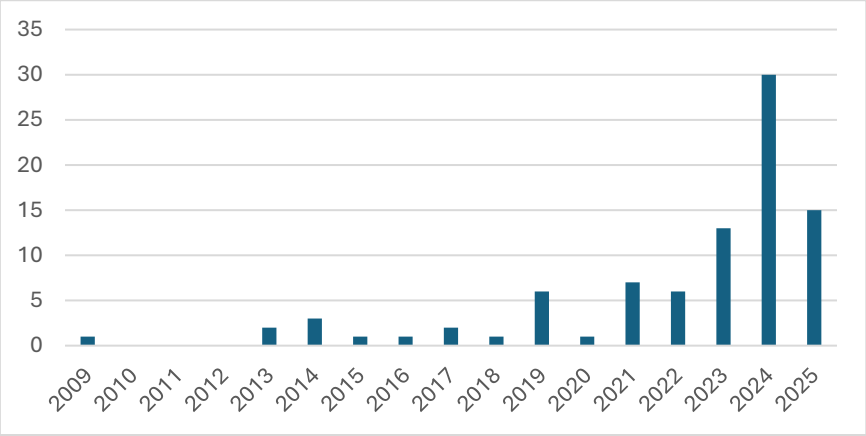
We have refined our research to include the following key terms: “best practices”, “sustainability”, “ESG strategy”, and “banking practices”.

We've identified 54 articles because of our refined search in the Scopus database. Given the importance of having a fresh-looking perspective on the envisaged topics, the Scopus search comprises a limited time interval between 2021 and 2025. The resulting academic papers can be categorized as: *articles, conference proceedings*, and *book summaries*.

Following the performed research, using VOS software, we have undertaken an analysis of the co-occurrence and of the bibliographic coupling functions.

4. Results and Discussions

The number of scientific studies, identified by us, that address the link between KM and ESG (or sustainability) for the banking sector is quite low (89 documents), but the data suggests that researchers' interest is currently growing (Figure 1).

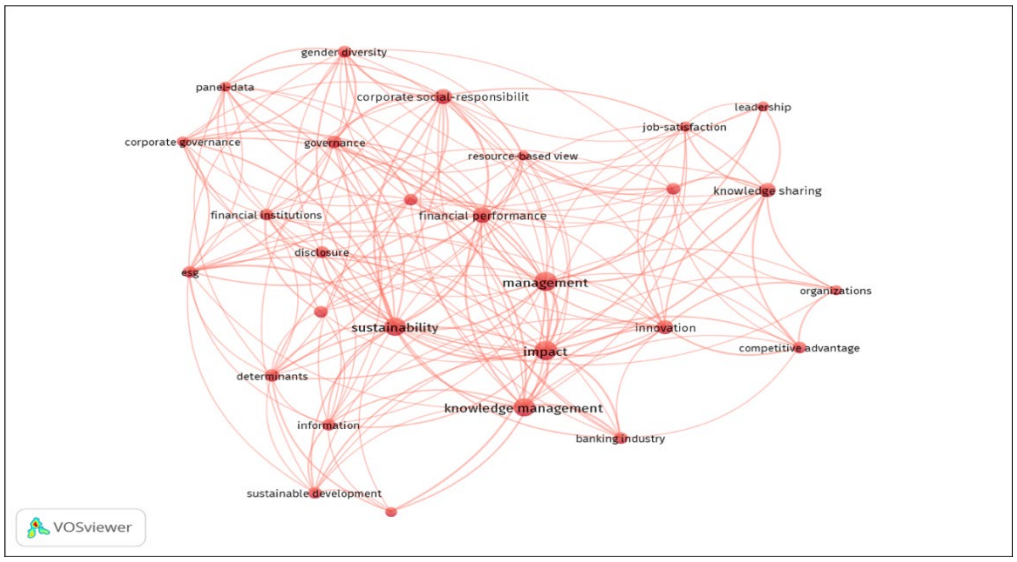


Source: Designed by the authors based on WoS data (available on April 02, 2025)

Figure 1: The number of scientific research studies dedicated to the KM & ESG/sustainability topic for the banking sector

Regarding the source of publication, most articles are published in the Sustainability journal (7 papers), followed by the Journal of Knowledge Management (5 papers).

Even though there is a small number of articles on this topic concerning the financial sector (banking, in particular), the results in Figure 2 show that, indeed, at the level of scientific literature, as far as we manage to identify emphasis is placed on the relationship between KM and ESG (or sustainability) for financial organizations (banks).

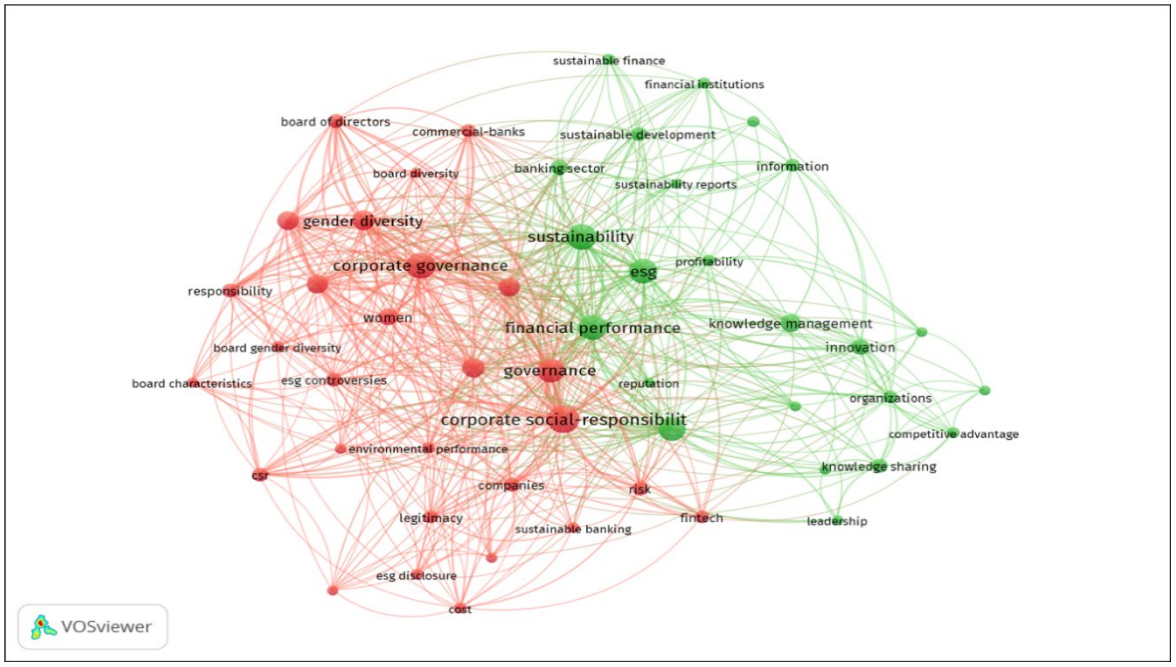


Source: Designed by authors based on WoS data (available on April 01, 2025)

Figure 2: Co-Occurrence Analysis of Key Terms based on the first search criteria (40 documents)

The basic factors that we had identified when analyzing the relationship between KM and sustainability are the company's board management, in general, and gender diversity in particular. These results reinforce the conclusions regarding the banking sector (presented in Section 2) obtained by Paolone et al. (2024), Galletta et al. (2022), Menicucci and Paolucci (2024), and Luh et al. (2024).

Further, after updating the database with the documents obtained based on the second search criteria, we noticed that, first of all, corporate governance appears in scientific research studies related to ESG (controversies and disclosure), and again, board characteristics (gender diversity) are a basic factor (Figure 3).



Source: Designed by authors based on WoS data (available on April 02, 2025)

Figure 3: Co-Occurrence Analysis of Key Terms based on the updated database (89 documents)

Given these results, we consider that it is important to highlight that a practical barrier that could hinder the KM-enabled ESG integration may be the lack of high skills and experience of the board members, considering that ESG requirements are quite recent for the banking practice.

We note that another term that appears in research on this topic is 'fintech'. Digital technologies such as AI play a critical role in filtering and analyzing relevant data. ESG performance involves massive data collection and logical selection. AI might help ensure a more efficient and more effective process.

We consider that by using advanced AI data analytics through Machine Learning (ML) and Natural Language Processing (NLP) might highly contribute to improving the decision-making process for the organization (Xu, 2024).

AI might contribute to mitigating risks for the financial institution, both in terms of identifying as well as preventing risk materialization and ensuring proper risk reporting.

We also believe that careful consideration should focus on the hardware architecture used in order to run AI applications. Thus, we consider that optimization of energy consumption has to be a top priority for the ESG strategy implementation team, as this initiative runs consistently in line with one of the primary ESG objectives (called as power consumption saving).

The implementation of technology, both for endogenous and exogenous purposes, has to take into account also the ethical issues as prerequisites that might ensure transparency, accountability, and fairness in all the relevant areas, including privacy, security, and fair treatment regarding data processing.

We consider that another barrier that could hinder the KM-enabled ESG integration is the large volume of data related to ESG, which requires, among other things, unbiased processing.

Another important key term in both Figure 2 and Figure 3 is 'leadership'. The role of the leadership stands out when it comes to enabling ESG integration into the financial institution's strategy. In particular, in cultures

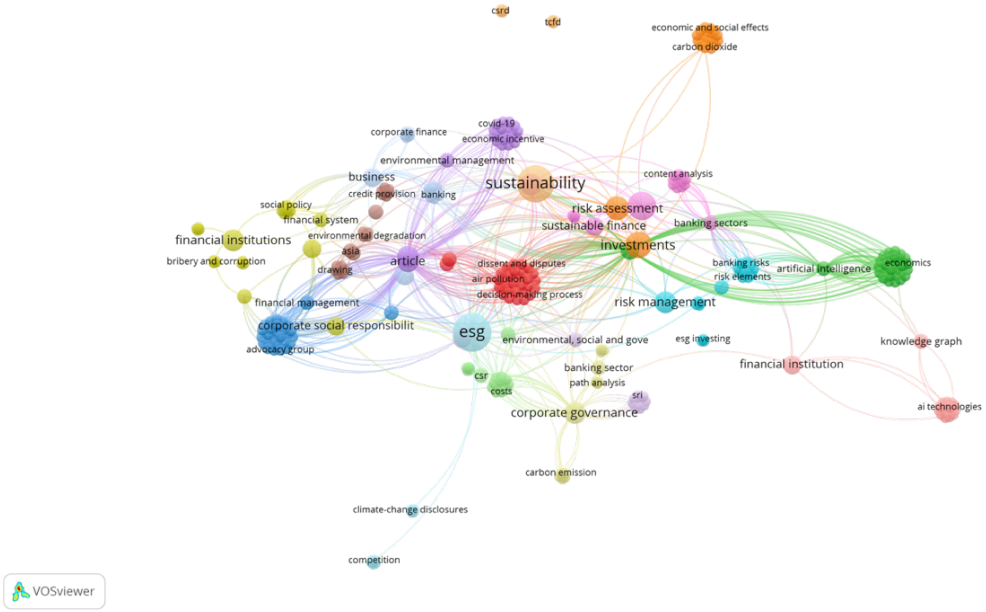
characterized by high power distance, leadership plays multiple roles: initiator, guide, command center (Minkov and Hofstede, 2013).

Leadership might also act sometimes as a detrimental factor for the success of ESG performance if agency theory is manifesting (Zournatzidou, 2024). Agency costs might become very high if leadership does not offer integral support for ESG strategy integration. The reversal is also true. Lower costs lead to higher efficiencies and, in turn, to a higher market capitalization.

We consider that leadership should embrace the idea of building ESG-related knowledge through external consultants and experts who would assist and support the creation and development of a proper framework for reshaping the business model.

Further, using the VOSviewer software on the Scopus database bibliometric analysis, we've focused on analyzing the frequency of keywords, using co-occurrence functions, the evolution of key terms in the academic literature, and the degree of citations.

The map illustrated in Figure 4 shows the intensity of the key terms identified during the literature review and the connection strength between those items.

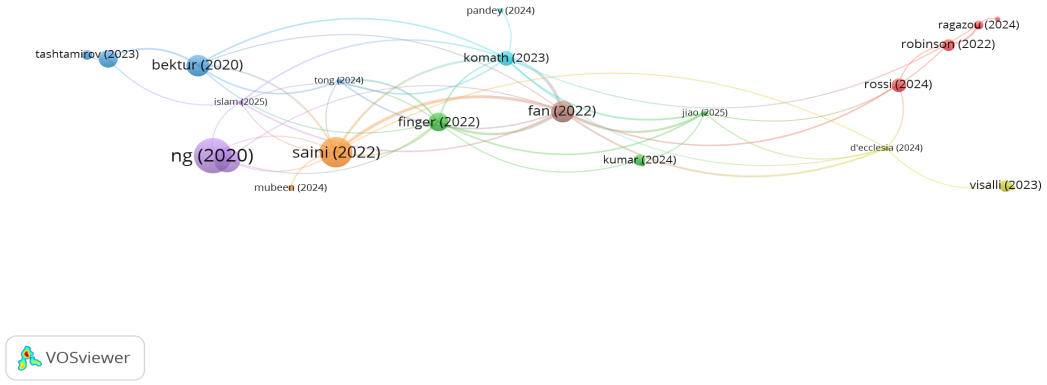


Source: Designed by authors based on Scopus data (available on February 2025)

Figure 4: Co-Occurrence Analysis of Key Terms based on Scopus search criteria (54 documents)

For the Scopus co-occurrence function, the most frequent terms were sustainability, ESG, and corporate social responsibility.

The co-occurrence diagram illustrated in Figure 4 shows a gradual transfer from the general, broad concepts such as sustainability, corporate responsibility, climate change, highlighted in the blue, red and yellow clusters to the more specific concepts such as ESG, corporate governance, risk management, and AI technologies, evidenced in shades of green, teal and pink. The diagram exemplifies the increase in specificity of ESG-related topics and the higher degree of their integration into the organizational functions.



Source: Designed by authors based on Scopus data (available on February 2025)

Figure 5: Bibliographic Coupling of Authors based on Scopus search criteria (54 documents)

The diagram illustrated in Figure 5 shows the focus of mostly cited authors, the degree of concentration of cited authors, as well as the level of connectivity and collaboration between the authors

The diagram highlights that authors focused on broader topics, such as sustainability, corporate responsibility, were more present in the academic literature up to the years 2020/2021, while authors who discuss topics such as ESG and ESG integration and best practices are less present and less cited and connected.

5. Conclusions

Our analysis demonstrates that the scientific literature indicates a link between KM and ESG/sustainability in the banking sector, even if such a conclusion can currently be obtained based on a relatively small number of studies dedicated to this topic. At the same time, we managed to identify one of the main contributors to stimulating this link, namely the management of the companies, with a special emphasis on gender diversity.

The bibliometric analysis performed and the research results show that AI has to be used as an important tool in enabling and even improving ESG performance.

Our research shows that leadership and, in particular, governance practices are enablers of ESG performance and thus it might support and assist the integration of these practices into the overall organizational strategy of financial institutions.

Furthermore, the research analysis shows that ESG compliance through the financial institutions' value chain is growing, providing more opportunities to be properly used also in the financial sector. We appreciate that the number of scientific studies dedicated to this topic will continue to grow exponentially in the coming years, given the importance of ESG/sustainability and the high demand of companies to adapt quickly to the new requirements.

Our paper is addressed to the researchers studying the link between KM and ESG but also to those involved in the development of the knowledge management process at the level of banking organizations.

We consider that the main limitation of this study is represented by the small number of articles and research studies dedicated to this topic. Thus, we highly believe that the research has to be developed and expanded in the future based on a bibliometric analysis carried out for a larger number of inputs, as well as by diversifying the search criteria (for example, the link between KM and each ESG pillar).

Ethics declaration: Ethical clearance was not required for the research.

AI declaration: No AI tools were used for this paper.

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Barriers to Knowledge Sharing During the Onboarding Process

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Abstract: Onboarding is understood as a process of the gradual integration of newcomers into two key dimensions: the professional role and the social dynamics of the organization. By definition, an onboarding process should be inclusive, aiming to provide the new employee with comprehensive organizational support to facilitate their swift and effective inclusion into both domains. This consists of the sharing of necessary procedural and explicit knowledge, as well as tacit and implicit knowledge. Ensuring an uninterrupted flow of knowledge sharing among all stakeholders—newcomers, experienced employees, and managers—is crucial for achieving successful onboarding, ultimately leading to full integration within the organization. However, various barriers may impede efficient knowledge sharing within the organizational context. The primary objective of this article is twofold: first, to identify and examine the barriers to effective knowledge sharing during onboarding, including the contextual factors influencing their emergence, with attention given to gender and positional perspectives; and second, to outline the most effective solutions to mitigate these barriers. The theoretical framework guiding this investigation is a narrative summary, serving as an initial step towards a more comprehensive systematic review. It is based on literature review specifically selected for its relevance to the onboarding process. The findings from this narrative summary aim to assist organizations in designing onboarding strategies and associated human resource practices that mitigate potential obstacles to knowledge sharing, thereby enhancing the onboarding experience.

Keywords: Onboarding, HRM, Knowledge sharing, Barriers to knowledge sharing

1. What is Onboarding?

Organisational onboarding can be defined as a deliberate, structured, and strategically designed process undertaken by an organization to facilitate the effective and systematic integration of newly hired employees into the multifaceted professional and social environment of the workplace (Szeluga-Romańska, 2024). In the professional dimension, this means meticulous familiarisation of the new employee with their duties, as well as with the workplace, necessary tools, devices and systems. In the social dimension, getting to know the organisation takes much more time as the new employee is thrown into multidimensional, previously formed social life – into interpersonal relations, overt and covert patterns of accepted behaviour, specific language (sometimes jargon or slang), coalitions and oppositions to specific people, groups, authorities and many other complex social phenomena that always appear in the organisation. The dominant function of onboarding process entails the fluent incorporation of employees with diverse competencies, physical or mental requirements, and socio-demographic backgrounds 'on board'. It is important to recognize that onboarding involves assimilating employees into a complex organizational system composed of both visible and intangible elements, like e.g. several types of organisational knowledge. Klein and Heuser (2008) claim that the onboarding process reveals immediate results that they refer specifically to developing new knowledge and better understanding or absorbing the substantive content of socialization processes. Additionally, according to Becker and Bish (2021), it also influences the employee's short-term and long-term behaviours and decisions. Each of the time perspectives carries certain specific psychological and social effects for the employee. If the onboarding process negatively impacts employees, it primarily results in a lack of commitment to their assigned tasks and, consequently, an increased likelihood of resignation. Ellis *et al.* (2017) observed that in cases where onboarding is inadequately conducted, up to 17% of newly hired employees leave the organization within the first three months. This outcome is detrimental both for employees who must seek alternative employment and undergo new recruitment, selection, and adaptation processes, and for the organization, which risks losing valuable talents and must allocate both material and non-material resources to recruit a new employee again. Conversely, when onboarding is effectively implemented, it contributes to greater job satisfaction, enhanced organizational commitment, reduced turnover, improved performance levels, increased career effectiveness, and lower stress levels (Bauer, 2012).

2. Knowledge Sharing During Onboarding and why it is Important

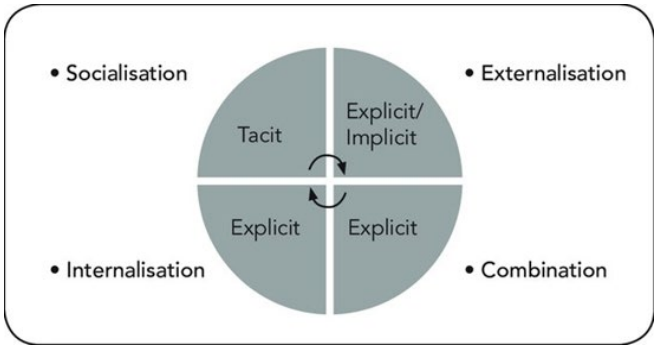
The process of sharing knowledge is based on mutual exchange of knowledge between people and should lead to synergistic co-creation of the new one (van den Hooff and de Ridder, 2004). Onboarding, to be efficient at emerging newly hired into professional and social dimensions of the organisation, requires particularly intensive knowledge sharing (Van Maanen and Schein, 1979; Haave *et al*., 2020). Initially, those processes should fluently appear among the closest circle of stakeholders: the newcomer, the team they join and the manager(s) as all they have common aim and resulting profits. In the next steps, knowledge sharing should

happen in every professional activity, the social situations and among all the engaged participants. Jeske and Olson (2022) claim that learning opportunities appear in several ways. They separate the onboarding process into the period of up to 3-months and then between 3 and 6 months of staying in the organization. Firstly, as they stated, there is an opportunity to learn for the employee and the team. It can be job shadowing, peer coaching or clarifying expectations as well as understanding the integration of processes and practices across departments. The second possibility to learn is for the managers and covers the issues like development of goals or giving feedback on progress. Thirdly, the learning opportunities appear for the organizations. Those include perceiving individual's impact and contribution to the organization or the answer to question: "What new knowledge emerged that needs to be integrated and shared across the organisation?" (Jeske and Olson, 2022, p.66).

Ipe (2003) adds more dimensions to the issue of factors influencing knowledge sharing between individuals that interrelated create favourable knowledge sharing environment: the nature of knowledge (considering tacit and explicit knowledge, and value of knowledge), motivation to share (comprising of internal and external factors), opportunities to share (formal and informal), and the culture of the work environment. The nature of knowledge means the division into tacit (Polanyi, 1966) and explicit knowledge, where the first one is perceived as know-how that has to be possessed by individual experience, and the latter can be easily codified, transferred and stored. Considering the ease and possibilities of sharing explicit knowledge, Weiss (1999) proposed to divide it into Rationalized knowledge that is more standardized and general, independent of individuals and thus shared easier, and Embedded knowledge, which is more rooted in the context, more personalised, and therefore much more difficult to be shared. Particular types of knowledge can by highly valued by the individuals and the organizations, they can perceive themselves as the knowledge owners with adequate status or reputation. The knowledge sharing then becomes much more complex. Motivation to share knowledge is influenced by "[i]nternal factors [that] include the perceived power attached to the knowledge and the reciprocity that results from sharing. External factors include relationship with the recipient and rewards for sharing" (Ipe, 2003, pp. 345-346). Formal opportunities to share knowledge are prepared and structured programs or technology-based systems. Most knowledge is shared during informal opportunities which means informal, face-to-face interactions, in the supportive atmosphere of trust, friendship and respect. What is the influence of culture(s) on knowledge sharing? "[T]he culture of the organization dictates to a fairly large extent how and what knowledge is valued, what kinds of relationships and rewards it encourages in relation to knowledge sharing, and the formal and informal opportunities that individuals have to share knowledge" (Ipe, 2003, pp. 352-353).

Nonaka and Takeuchi (1996) proposed a model that clearly explains the creation and transfer of knowledge in organisations, which happens similarly during onboarding. It is expressed as a continuous, dynamic cycle consisting of four stages called SECI (Socialisation, Externalisation, Combination, Internalisation) (Table 1). As Faith and Seeam (2018) explained in detail the process of Socialisation refers to the sharing of knowledge through direct, face-to-face interaction. Externalisation occurs when tacit knowledge—mentioned as the personal, experiential knowledge that individuals carry in their minds and which is often difficult to articulate—is transformed into explicit knowledge. Explicit knowledge, in contrast, is codified, documented, and can be easily communicated and transferred to others. The Combination phase involves the integration and systematisation of various bodies of explicit knowledge, while Internalisation represents the process through which explicit knowledge is absorbed and converted into tacit knowledge by individuals through learning and practice.

Table 1: SECI model (Socialisation, Externalisation, Combination, Internalisation)



Source: Nonaka and Takeuchi, 1996 adapted by Faith and Seeam, 2018.

Bauer (2010) states that there are four building blocks of successful onboarding process which are called the Four C's: Compliance, Clarification, Culture and Connection. Each phase of the Four C's provides new kinds of knowledge – the first two are mostly connected to the professional dimension of the job position, while the other two focus on the social dimension. *Compliance* supports the new employee with basic regulations, legal or policy-related rules; *Clarification* adds job-related expectations; *Culture* provides both formal and informal norms; *Connection* introduces into interpersonal relationships and information networks to join and create. It seems that between the phases of Clarification and Culture is placed the beginning of the process of transferring implicit knowledge. The degree to which each organization integrates these four foundational components determines the overall structure of its onboarding strategy, leading to the classification of most firms into one of three distinct levels.

3. Method: A Narrative Summary

The objective of the study was to analyse the previous studies and identify barriers to knowledge sharing during the onboarding process, and the ways to overcome them. To review the proper existing literature, a narrative summary review was applied (Campbell *et al*., 2018; Khangura *et al*., 2012) in the form of a comprehensive web-based search. This research method is aimed at providing evidence-based knowledge in very limited time-scale and may be an initial step towards deepen systematic review. The themes that were searched: "knowledge sharing and onboarding", "barriers to knowledge sharing and onboarding" in Google Scholar electronic database. The publications covered the last 20 years and the search and analysis were done between 1. and 28. February 2025.

To fill the methodological procedures the steps proposed by Cumpston *et al*. (2024) were as followed: (1) Identification, (2) Screening, (3) Eligibility assessment, (4) Inclusion.

The initial screening Identified over 28 000 records but as lately revealed, most referred to onboarding process only, its structure, phases and practices, which was not the dominant searching expectation. Only the articles that either linked onboarding and knowledge sharing strategies, or explaining the barriers to knowledge sharing during onboarding were chosen (about 250 articles were left at this stage). To make such a choice, deepened Screening and the gradual process of their selection was needed. The next step, Eligibility assessment, helped in identification of doubled or irrelevant articles, and led to the final result of 18 most relevant articles. The last phase showed that 18 chosen articles Included into analysis were based on the inclusion criteria that covered the onboarding and knowledge sharing facilitators, and onboarding and barriers to knowledge sharing issues; excluded were the articles that focused only on the onboarding process.

4. Results and Discussion

The efficient onboarding means gaining at the end of the process the new employee who is fully prepared to their professional role and emerged in the organisational culture. The analysis of chosen articles proved that several examples of barriers to knowledge sharing in organisations depend highly on the profession researched and appear in the organisational specific context (e.g. Balali *et al*., 2018; Brouwer *et al*., 2024; Lima *et al*., 2021; Solli-Sæther and Karlsen, 2014). That echoes the approach of Ipe (2003) who claims that the dominant barrier to knowledge transfer is the organisational culture and all its variants, like subcultures. As being strongly placed on social relations, it dictates visible and invisible norms, appreciated values, or communication schemes when, how and among whom knowledge is shared (or not).

Regardless of the specific influence of culture, there seem to be quite universal and eligible approaches that may clarify and systemize multiple areas of knowledge transfer hindrances. Bauer (2010) claims that during onboarding the newcomer learns different kinds of organizational knowledge gradually, according to the 4 C's concept (of Compliance, Clarification, Culture and Connection). Overlapping with those phases are groups of barriers identified by Balali et al. (2018) – *personal barriers* that are strongly connected to individual's features of character (both newcomers and organisational mentors); *interpersonal barriers* – appearing among newcomers, mentors and the community of employees; *process barriers* that are imposed by internal procedures, practices or by the organisation; *technical barriers* - caused by any piece of technology or other used tools. They clearly refer to the professional and the social dimension of any onboarding process.

Pitkänen (2020) proposes a bit different lens, however, they may also be applied universally. She defined generally three levels where the knowledge sharing problems during onboarding occur: *organisational level*, *team and manager level*, *newcomer level*. Depending on the specific organizational context, at each level there can appear barriers of any kind – referred to the human relations, communication flow, or access to resources

(e.g. Klein, Molloy and Brinsfield, 2012). Jeske and Olson (2022) add that "[i]t is important to review how onboarding can prevent potential attrition of new hires – by assessing which signals are being sent through the organisers, the interactions, and the representatives that show up (or do not). In summary then, a focus on the short-term needs of the employer and costs vs. the long-term interests of employees will risk undermining the success of onboarding, reducing the benefits, and potentially mutually rewarding learning opportunities for both new hires and the organisation" (pp. 71-72).

The understanding of several universal groups of barriers to knowledge transfer may support search for their solutions. That states the crucial question: how to overcome the barriers? Obviously, each profession may have both the barriers and their solutions very specified and strongly linked to their organizational and professional context. But there seem to be solutions possible to be used or being easily adapted to most organizations. The first proposal (1) could be focus on the importance of refined *onboarding experience* of the newcomer and the second proposal (2), linked to the aforementioned, conscious, systemic *uncertainty reduction*.

Proposal 1 is strongly based on Jeske and Olson's (2022) perspective of the onboarding experience of the new employee. To create it as supportive and successful, there should be strict cooperation and effort within organisation, team, manager and the newcomer. That literally means high proactivity of all the stakeholders. There are elements of the onboarding process that can and should be structured and formalised. They arrange explicit organizational knowledge into newcomer-friendly way that makes it easier to absorb and start using it, minimising potential declines. But there are also elements that should be more individualised. That means intensive bi-directional flow of information, with particular focus on feedback. Jones (1986) calls them the *socialization tactics*: *institutionalized socialization* and *individualized socialization*. "The institutionalized tactics which consist of collective, formal, sequential, fixed, serial, and investiture tactics provide newcomers with information that reduces the uncertainty inherent in early work experiences and reflects a structured and

formalized socialization process" (Saks and Gruman, 2017, p. 17). Individualized socialization tactics are rather informal, lack in structure and are random. Both socialization tactics create the newcomer's experience enhancing to stay longer in the organization. That perspective links to Proposal 2 providing organizational actions that lead to reducing uncertainty of the newcomer. Saks and Gruman (2017) propose a conceptual model outlining a novel pathway to newcomer socialization, wherein socialization resources, personal resources, and job demands collectively influence newcomers' work engagement and subsequent socialization outcomes. In the final phase of the onboarding process, the newly hired employee should possess a clear understanding of their value proposition. This aligns with the frameworks proposed by Bauer et al. (2007) and Van Maanen and Schein (1979), which emphasize the reduction of uncertainty through proactive information-seeking behaviors by newcomers from various organizational stakeholders. Similarly, Brouwer et al. (2024) highlight the significance of access to clear contractual information, essential resources, and effective communication as critical components contributing to successful onboarding. In those actions also mentoring may help.

Any process of onboarding is expected to provide organizational support in both: its professional and the social dimensions. At its end, the newcomer should not only understand and be able to play their job role, but feel that *belongs* to the team and organization. It follows also the concept of Klein, Molloy and Brinsfield (2012) that accentuate a continuum of psychological bonds[1] the employees proceed in the organizations. The type of bond change along with the employee's psychological involvement growth. The initial one is *acquiescence* that is characterized by low task significance, minimal effort to be put in the tasks and indifferent attitude. The second bond on the continuum is *instrumental*, when the calculated acceptance of the bond exists. Both bonds are based on the attitude "have to". The next appearing bond is *commitment* with the employee's volition, dedication and responsibility for the tasks. And the last step in the continuum of engagement is *identification* when the employee merges oneself with the target, puts high concern and effort into the task and becomes involved. The latter two forms of commitment are associated with a 'want to' attitude. This prompts an important question: what are the potential outcomes of effective and engaging onboarding processes? Specifically, can such practices foster a sense of identification of the newcomers with both their assigned tasks and the organization as a whole? Undoubtedly, this stage is of critical importance to any organization and should be followed by thoughtful preparation of each onboarding process.

[1]They reconceptualize employee's commitment as a distinct form of bond, characterized by intentional dedication and a sense of responsibility toward a specific target – in the literature there are also distinguished bonds that do not follow the target.

5. Limitations and Further Research

he search and analysis are limited to just 18 articles but they state a first, important step towards more elaborate systematic review. The topic seems to be fundamental if any organization expects the newcomer to become an efficient and engaged part of their team. Further research could be more profiled to different types of organizations: business, public and non-profit and conducted in the quantitative form of a survey.

Also, good practices of knowledge transfer are crucial not just during onboarding period but may have also relevant long-term results, particularly if the organization is attempting to build a KLC culture (the synergy of knowledge, learning, and collaboration). The KLC approach is crucial in organizations based on knowledge. The investigations of Kucharska and Bedford (2020) and Kucharska (2021a-b) proved that to gain organizational intelligence development tacit knowledge sharing is essential, which happens when trust appears in KLC culture. "Moreover, the mistakes acceptance component of learning culture supporting trial-error-learnings is tremendous for knowledge-sharing processes, organizational intelligence (change adaptability), and innovativeness" (Kucharska and Bedford, 2024, p. 27). During onboarding process there is usually higher mistakes acceptance for the obvious reason of its character as an initial, introductory period, which also assumes the trial-error learning. Although it is generally well understood that it is impossible to learn without mistakes, the acceptance of mistakes decreases after onboarding process. Ellis et al. (2014) claim that the organization is able to learn from mistakes if there appears communal reflexivity – the actions collegially created in particular context. KLC approach well supports trial-error learning in organizations (Kucharska and Bedford, 2024; Kucharska and Szeluga-Romańska, 2025).

6. In Conclusion

While knowledge sharing during onboarding is undoubtedly beneficial for organizations, it is often hindered by various challenges that manifest across social, technical, and organizational dimensions. These barriers, shaped also by both tangible and intangible cultural norms, can be difficult to overcome. However, deliberate efforts to design the onboarding experience and implement practices aimed at reducing uncertainty may foster an organizational culture conducive to more open and effective knowledge exchange. Such a culture not only enhances knowledge sharing but also fosters newcomers' commitment and strengthens their identification with the organization as a whole.

Ethics declaration: There was no need to receive any permissions in writing this paper. No ethical clearance was needed.

AI declaration: I have not used an AI tool in writing the paper.

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Navigating with Knowledge: The Lighthouse Metaphor for Understanding Context, Value, and Motivation

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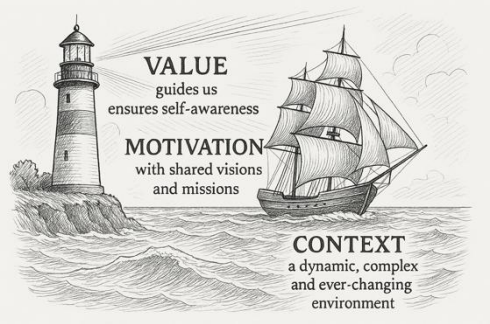
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Abstract: People look differently at local and global challenges based on their knowledge and information related to their contexts. Our research focuses on the roles knowledge plays in contemporary times, using the lighthouse metaphor. A lighthouse keeps us on track, reaching our purposes and dealing with changing circumstances. Some follow the lighthouse, and others flow with the waves of the sea. Our journeys depend on our values, motivations, contexts, and knowledge (exchanges). Decisions and knowledge(management) concern the stakeholders' perspectives: are we individually (Me) oriented, do we reason within the context of our organisations (We), or is the societal (All) impact leading? Our paper examines the role of knowledge and information in handling societal challenges. We analyse the aspects in the different contexts and explain why value and motivation matter in our journeys[1]. Value in the lighthouse metaphor, guides us as a lighthouse and ensures self-awareness, giving purpose to our journeys. Motivation is like a ship where the organisational cooperation of the crew shares visions and missions. Context is like the sea, a dynamic, complex, and ever-changing environment that challenges us differently as individuals, organisations, or societies. The article intends to spark discussion. We are not obsessed with scientific proof but aim to initiate a debate on a balance we must find between the Me, We, All contexts and knowledge perspectives in society.



Keywords: Knowledge, Context, Value, Motivation, Change

1. Introduction

The roots of today's local and global challenges come from short-term thinking that ignores societal values like sustainability, fairness, and public well-being. Prioritising profit over ethical practices can result in short-termism and neglect of long-term societal impact, causing environmental harm, degradation and exploitation, inequality, manipulation, labour exploitation, and a breakdown of the social contract. The long-term consequences of ignoring societal values include reputation damage, legal ramifications, and economic instability, which can ultimately harm the organisations and their staff's ability to thrive, not leaving a liveable environment for our successors.

The trend of individualism and profit-making clash with societal values when pursuing financial gain becomes the driving force behind decisions, leading to actions that exploit people, harm the environment or undermine social well-being. The conflict arises because societal values often emphasise ethical principles such as fairness, sustainability, human rights, and social responsibility, while many prioritise short-term financial returns at any cost. The topic has gained growing interest in the scientific world, as shown in some interesting overviews (França et al., 2024; Martins et al., 2019)

[1] Picture generated with ChatGPT on April 4th, 2025

People and organisations are starting to recognise that balancing their own interests and goals with societal values is crucial for long-term success. Companies that fail to consider the broader impact of their actions risk facing public backlash, regulatory intervention, and financial collapse, ultimately harming the society and their own future viability.

A vision of the future influences motivation and how we define value in specific contexts. By shifting focus from short-term, immediate returns to long-term goals, innovation, sustainability, and resilience, we expand the concept of value and offer motivation. This impacts individual or organisational success and shapes broader societal progress.

To better understand the complex reality, this article employs metaphors, as they play a crucial role in the conceptualisation of abstract ideas, highlighting certain characteristics while concealing others (Andriessen, 2008). In line with this, Lakoff and Johnson (2020, p. 476) stated that the concepts governing our thoughts are not merely matters of intellect. They also guide our everyday functioning, down to the most mundane details. Our concepts shape what we perceive, how we navigate the world, and how we relate to others. This necessitates, and facilitates, a change in mindsets.

However, before proceeding, we echo Andriessen's (2008) warning that metaphors can mislead us when taken literally.

To implement a significant change in mindsets, we utilise the Lighthouse Metaphor, where

- The Lighthouse is the Value & Knowledge Repository of core values and foundational knowledge, providing stability and guidance with ethical principles in an ever-changing world.
- The Light Beam is our Motivation & Knowledge Flow driving individuals and organisations moving forward. Without motivation, values and knowledge remain unused.
- The Ship represents individuals and organisational teams steering through challenges, guided by direction (value) and driven by motivation. The Crew comprises the Knowledge Network & Collaboration, mentors, and knowledge management systems that facilitate decision-making. Effective teamwork guarantees smooth navigation.
- The Ocean is the context, the external environment (Challenges & Opportunities). It represents the constantly changing world that requires adaptability and continuous learning.

This article shows that knowledge management facilitates effective navigation, as a lighthouse guides a ship through an unpredictable ocean.

2. The ‘Me-We-All’ Approach

The challenges we face became increasingly disruptive, often originating from local and/or global sources. It is no longer valid that individuals (Me) face local challenges, while global challenges are tackled collectively (We) at a global level (All). The Me-We-All approach (Abcouwer, Takács, Schilstra, et al., 2022) advocates balancing the needs of the individual (Me), the collective (We), and the society/planetary whole (All). It fosters personal wholeness, social unity, an ethic of global stewardship, and a paradigm shift from the dominant individualistic model to a more systems-oriented, ecological one. It trusts the power of individuals and organisations, who must pay attention to societal needs and interests.

Examining diverse perspectives fosters understanding, acceptance, and respect, promoting a balance between individual well-being, sustainability principles, and a more just world. Organisations connect individuals and society to address both local and global challenges (Schönveld, 2025).

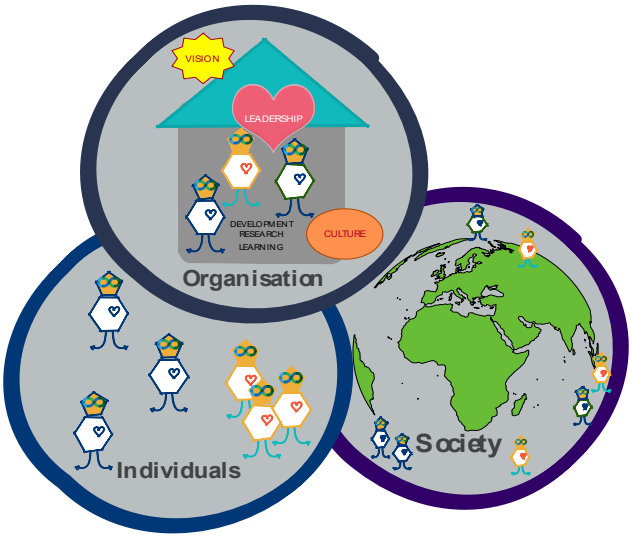


Figure 1: 'Me-We-All' – Individuals-Organisations-Society (Takács et al. (2022)

The 'Me-We-All' approach encourages decision-making that considers the diverse perspectives and needs of individuals (Me), communities, companies, and organisations (We), as well as society and the environment (All). This holistic view can contribute to a more just and equitable future for all living beings within the existing biosphere. It seeks natural solutions that ensure diversity, equity, inclusion, and opportunities for everyone and their surroundings in our societies. The approach balances the needs of the identified sectors through sustainable and circular development, aiming to address environmental, economic, and social needs simultaneously. It drives societies to reconcile social health and justice, economic vitality, and environmental stewardship(Hawken & Cox, 1993). By applying this approach to contemporary challenges, we can better focus on the roles that knowledge and competencies play and how we can educate individuals to develop the necessary insights (knowledge) and competencies to fulfil their roles in this larger context. It also illuminates the role education and schools have in achieving this new balance.

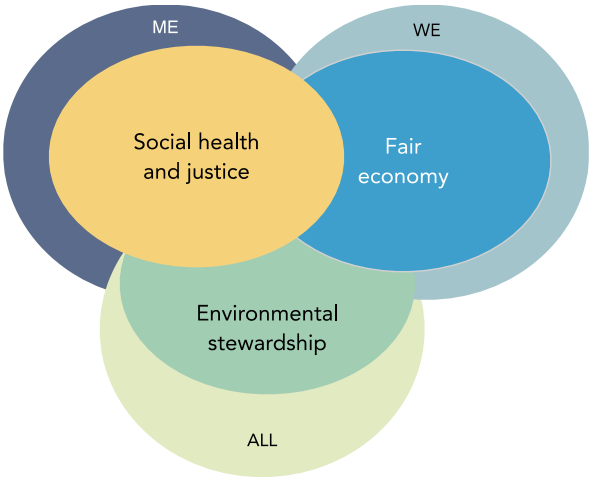


Figure 2: 'Me-We-All': The art of balancing

2.1 The Role of Knowledge and Learning

Learning to enhance knowledge has various objectives, motivations, approaches, and outcomes based on who needs it, the reasons for it, and the contexts in which it occurs (Takács et al., 2022).

2.1.1 'Me'

Individual welfare globally has driven our societies over the past decades with personal well-being in mind. The emphasis on neoliberalism fosters a society in which individuals can thrive. This 'Me' approach rests on the belief that enhanced individual well-being should lead to a better world overall. Thus, within the Me-paradigm, the individual is viewed as the most significant entity on the planet (in science, the term Anthropocentrism is used, interpreting the world through human values and experiences). Knowledge for individual purposes is driven by

personal motivations and tailored to the individual's context. Learning is meant to build the knowledge needed to fulfil this role. It relies on other people and/or organisations to achieve established goals. The acquired and processed knowledge results in smarter members (Me) of teams (We) with enhanced skills and competencies, valuable for individuals, organisations, and society.

2.1.2 'We'

Knowledge plays a distinct role in the 'We' context. It surpasses what individual members could have achieved alone, nurturing competencies and skills that transcend personal boundaries.

Learning in a 'We' setting focuses less on individual gain and more on a shared, higher-level objective (Schilstra et al., 2019), where all members are actively engaged in achieving it. The motivation for building knowledge and competencies by learning can be both individual and organisational. Cooperative learning enables organisations (We) to achieve a balance between personal and group objectives, resulting in enhanced knowledge structures.

The awareness that individual well-being in an increasingly complex world is difficult to achieve alone illustrates that cooperation enhances individual welfare and aids in achieving shared objectives, involving all members of the community or organisations actively. In this view, it is crucial to recognise that every individual contributes based on their abilities. The objectives of the We-paradigm were primarily grounded in contributing to the goals of cooperation, such as those of organisations, resulting in individual prosperity. In this perspective, the realisation of individual prosperity is vital; however, in contemporary times, there is a growing recognition that we cannot ensure our well-being without also contributing to a better society and world. The focus shifts from an ego-centric view to an eco-centric perspective, seeking a balance between personal and societal prosperity.

2.1.3 'All'

Knowledge for 'All' entails engaging with society. It focuses on equipping individuals to tackle real-life challenges. This approach not only emphasises past knowledge but also promotes future-oriented practices. But how do we acquire the necessary knowledge in the contexts where it is needed? How do we cultivate the essential knowledge when gaps exist? The objectives are often vague or unclear because the situation is too expansive and beyond the comprehension of individuals, groups, and organisations involved. Consequently, the responsibility is diffuse, resting with no one in particular, or everyone, for that matter. It is this conviction that makes learning is an 'all' context so important.

Additionally, questions concern the societal differences in learning. Cultural aspects play a major role in the way learning is shaped. Learning styles and education differ in various cultures (Manikutty et al., 2007). Cultural values and practices influence motivation and subsequent achievement in learners (Salili et al., 2001). The foci of studies researching the influence of culture and context on student learning and motivation differentiate cultural values (Stevenson et al., 1990), practices (Hess & Azuma, 1991; Salili, 1995; Stevenson & Stigler, 1994) and beliefs (Hess et al., 1987; Holloway & Hess, 1985).

As early as 1966, Kenneth Boulding stated, "Anyone who believes exponential growth can go on forever in a finite world is either a madman or an economist." (Boulding, 1966) From this widely cited perspective, exponential economic and population growth could ultimately lead to sudden societal collapse if humanity fails to recognise the finite nature of Earth's resources. The acknowledgement of limited resources makes people increasingly aware that we must strive for a better and just world. The All-paradigm emphasises this viewpoint on contemporary developments and the necessity of adopting a broader perspective on human development with values that illuminate the right path.

3. Values: The Lighthouse

Values are the core principles that guide our lives and shape us internally, influencing our everyday behaviours. They are rooted in our childhood and our culture and are passed down through generations. Ownership and greed develop at an early age, leading to a desire to acquire more as we grow up: money for individuals and profit for organisations. Our values should serve as our moral compass, and inform our perspectives on family, community, religion, and politics, and define our relationship with nature. Values are imparted to individuals through direct parental and educational guidance and indirect influences from the outside world (Schwartz, 2012).

3.1 Defining Values

The Millennium Declaration emphasises the individual and collective responsibility to uphold the principles of human dignity, equality, and equity to create a more peaceful, prosperous, and just world (United Nations, 2000). It reinforces values and principles respecting social structures (as territorial integrity and political independence), individuals (including human rights and respect for the equal rights of all without distinction of race, sex, language, or religion), and international cooperation in addressing global problems of an economic, social, cultural, or humanitarian nature. Fundamental values are

- *Freedom*: Humans have the right to live and raise their children in dignity, free from hunger and the fear of violence, oppression, or injustice.
- *Equality*: No individual and no nation must be denied the opportunity to benefit from development and equal rights and opportunities for humans.
- *Solidarity*: fairness, equity, and social justice.
- *Tolerance*: respecting each other, with all their diversity of belief, culture, and language. Differences within and between societies should be cherished as a precious asset of humanity. A culture of peace and dialogue among all civilizations should be actively promoted.
- *Respect for nature*: Prudence of all living species and natural resources, following the precepts of sustainable development, preserving nature and passing on to our descendants.
- *Shared responsibility*: to manage worldwide economic and social development and the threats to international peace and security.

This complex interplay of personal and societal values must be balanced so that no living things or the biosphere are disadvantaged, and all elements of the natural environment are valued. Our personal attitudes and behaviours in organisational or societal settings demonstrate the need to pay attention to one another and our surroundings. Focusing solely on financial and economic information falls short of grasping this crucial societal shift towards a more collective view of a developing future.

We will explore knowledge about the impact of human values and how they shape the connection between nature and people. The relationship between humans and the environment can be described by anthropocentrism, which values goods based on their utility for humanity. However, anthropocentrism has also been claimed to be the root of the global environmental crisis (Droz, 2022). Another perspective is based on ecocentrism, the idea that all assets (living and non-living) possess intrinsic value (Washington et al., 2018). Correcting the trajectory of anthropocentrism requires a fundamental change that will embody polycentrism and EcoJustice, producing balance through a holistic approach. Respecting Me, We and All encourages us to consider different perspectives, enhance ourselves, contribute to others, and simultaneously protect the planet.

Table 1: Distinguishing value along the 'Me-We-All' viewpoints

Me	We	All
Emotional Value: The psychological impact, such as satisfaction, trust, or peace of mind **Experiential Value**: The personal experience derived from using something (e.g. enjoyment)	**Economic Value**: The financial benefit derived from a product, service, or decision, such as cost savings or revenue generation **Functional Value**: The practical or utilitarian benefits something provides, like efficiency or reliability	**Social Value**: The contribution to societal or relational well-being (e.g., ethical impact, reputation, community benefits) **Transformational Value:** The long-term impact on personal or organisational growth and innovation.

Values, as lighthouses, are the fixed reference point, helping individuals and societies navigate their decisions and behaviours. They are standing firm in the storm; values provide consistency and meaning even in changing circumstances. The lighthouse represents knowledge: a stable, structured body of information that helps individuals and organisations navigate challenges. Just as a lighthouse contains essential tools for navigation, knowledge serves as a guiding framework for decision-making and problem-solving. The light of the lighthouse represents knowledge dissemination and application. It is the way how knowledge is shared, accessed, and used. Knowledge management ensures that the proper knowledge reaches the right people at the right time, just as a lighthouse's beam helps ships navigate effectively.

3.2 Values and Timelines

A future-oriented perspective shapes how individuals, businesses, and societies define value by aligning their goals with anticipated needs, opportunities, and challenges. This forward-thinking approach affects the types of

value we prioritise—whether economic, social, or environmental—and how we measure success in the long term.

Table 2: Differences in values for short or long-term

Short-Term Value (for **Me** and **We)**	Long-Term Value (for **(Me)-We-All)**
• immediate gratification, profits or results • reactive mindset • management • decisions based on shareholders' needs and requirements • financial returns • functionality and productivity, disruptive technologies • individual and business goals and interests without any alignment with respecting others • risks and disruptions threaten stability, strengthening vulnerability	• lasting value in a changing environment • respect, sustainability and resilience • stewardship • decisions integrate social value and environmental responsibility • social, environmental, and ethical impacts • creativity, innovation, efficient use of resources, expanding possibilities and opportunities • global goals like the UN Sustainable Development Goals (SDGs) • adaptation to and mitigation of risks and disruptions

Neither the people (Me) nor the organisations (We) can operate in isolation from the world (All). We are all embedded within broader societal contexts. Societal value reflects how we contribute to (or detract from) the well-being of communities, environmental sustainability, ethical standards, and economic equity.

Today, when value is multidimensional, we must align our own goals with the values of all living things, our societies and our world. This holistic approach leads to sustainable, meaningful value creation.

A challenge for our current thinking is how to motivate ourselves and each other not only to care about ourselves (Me) and our close environment (We) but also others, including the more vulnerable ones and non-human species, to live in harmony in the world together (All). Research in environmental education shows that the mere transmission of facts about climate change or biodiversity loss is insufficient; we need to feel personally connected and capable of making a difference. Eco-conscious motivation for people includes experiential learning (outdoor activities, observing and learning from nature), place-based engagements that tie global issues to our local contexts, and initiatives that give them agency. These engage people in hands-on problem-solving and action, leading them to develop "attitudes of concern for the environment and motivation to improve or maintain environmental quality".

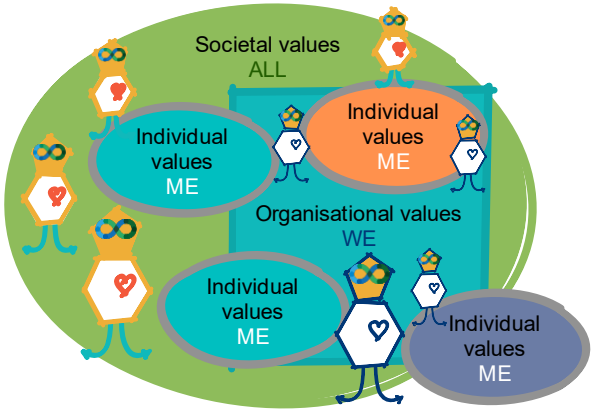


Figure 3: Overlapping values of 'Me-We-All'

4. Motivation: The Crew / the Ship

The 'Me-We-All' approach encourages decision-making that considers the diverse perspectives and needs of individuals (Me), communities, companies, organisations (We), and the society/environment (All), contributing to a more just and equitable future for all living beings. Recognising that the paradigms of Me, We, and All are not contradictory is essential. In an open, dynamic, complex, and interconnected world, all three paradigms foster a better and fairer society. Finding the right balance among these paradigms depends mainly on our personal contexts.

4.1 Needs and Motivations of the Crew

When facing a challenge, the character of the problem space determines how we view the need and motivation for addressing the process of finding a solution. From an individual perspective, we follow Maslow's primary theory on needs fulfilment, later extended by others McLeod (2020).

People's motivation to contribute to a better world is heavily influenced by their level of needs fulfilment. Distinguishing between decreasing and increasing needs is crucial for achieving that balance, as these needs are closely linked to the contexts in which people operate. Striving for greater justice, alongside polycentrism and a balance between ego- and eco-centrism, provides a strong foundation for developing new knowledge management approaches. The ability of individuals to contribute to problem-solving using knowledge and competencies determines their relatedness in a broader perspective.

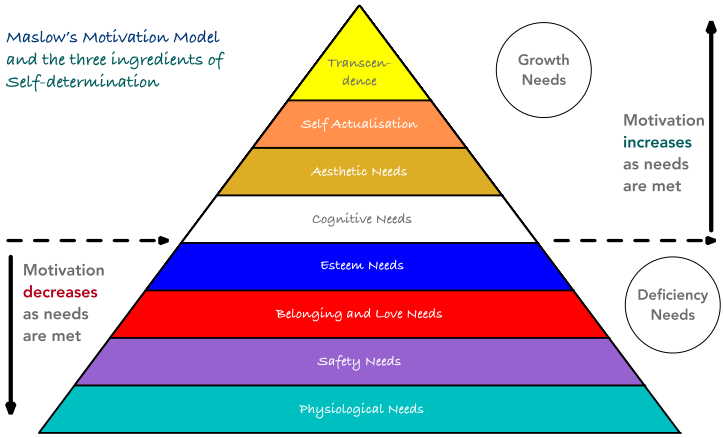


Figure 4: The extended Maslow Needs Pyramid (McLeod, 2020)

When the focus is on the lower levels of the extended Maslow pyramid, the emphasis on fulfilling decreasing needs means individuals will largely thrive through principles of anthropocentrism. Individual well-being forms the basis for their behaviour. Once these needs are met, increasing needs can become a more significant force for contributing to a higher level of EcoJustice.

However, even with an anthropocentric approach, individuals' knowledge and skills are often inadequate to address all the challenges they may encounter. Consequently, collaboration within teams is becoming increasingly essential. Identifying colleagues who can provide the necessary knowledge and skills is vital to manage the difficulties arising from the challenges faced.

In such a setting, teamwork is often viewed to combine the competencies necessary for addressing the challenge, presuming that we understand its nature. But how does this function in a context where the challenge is unclear or not yet defined? How do 'We' unfold in such a situation? This issue becomes more pronounced when we confront societal challenges that requires a polycentric approach.

4.2 Cooperation and Teams

The definition of teamwork in the problem space involves combining the knowledge and competencies to address the challenge. When someone knows what knowledge is needed, locating the right individuals can be clear or complicated. When the nature of the challenge is uncertain, collaboration becomes necessary, harnessing the creativity that underpins our future work. Inspiring each another can effectively address the challenges we encounter and prepare organisations for unforeseen or unknown challenges. Uncertain environments evolve knowledge management.

4.3 Directing the Crew: Management-Leadership-Stewardship

When we are certain about what we want and what we must do, managers perform effectively. However, during times of uncertainty, creative leaders are better equipped to adapt to new circumstances through innovative ideas that restore certainty. Stewardship encompasses values, ethics, and morals, safeguarding all resources with a human responsibility to care for the natural world (Davis et al., 1997; Takács & Abcouwer, 2024). Stewardship shifts the focus from 'solving immediate problems, ' which managers and leaders often prioritise, to a broader and longer-term perspective, resulting in a sustainable present and future for individuals (Me), communities (We), and our environment (All).

While coordinating efforts different interpretations appear based on the stakeholders' backgrounds and micro-contexts, and we encounter dynamically changing contexts.

5. Context: The sea

The role of knowledge in addressing challenges is linked to the participants' visions influenced by their experiences and contexts, norms and values, although unforeseen contexts may prove relevant without our prior knowledge.

5.1 Understanding Reality

The significance of various contexts lies in considering how they affect our perception of reality.

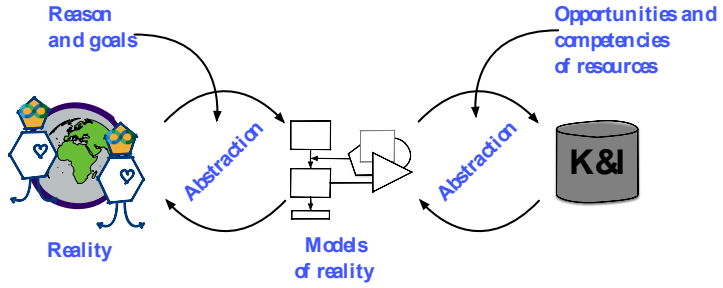


Figure 5: Reality and abstractions Adapted from Abcouwer et.al. (2022)

Given the complexity of reality, we omit elements that are not pertinent to the reasons and goals we pursue. To gain insight into the knowledge relevant to the challenge, we further abstract, as not all phenomena of complex reality can be distilled into knowledge models. Both abstractions occur within the context these considerations take place.

The context is guiding the translation from reality to knowledge representation. It is essential to recognise that everyone creates various translations and related abstractions from and within their own contexts. For a knowledge-based intervention, we must consider its originating context. Knowledge sharing is thus influenced by the differences in context.

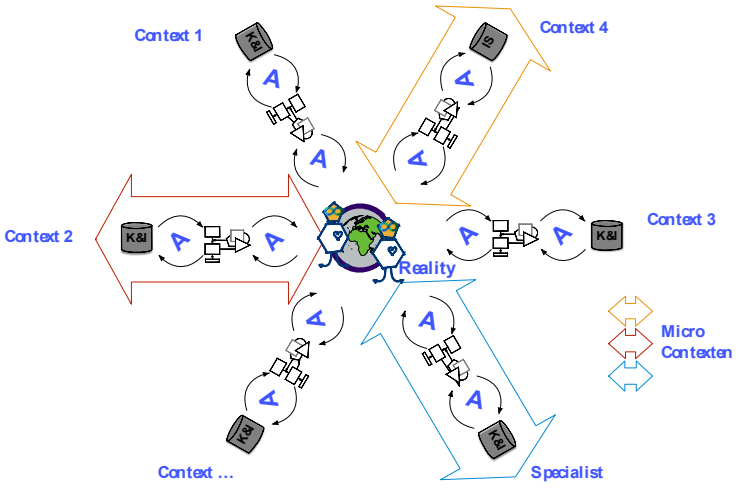


Figure 6: Combining micro texts to a macro context (Abcouwer et al., 2024)

Preparing for uncertain futures, we assume that the past knowledge and experiences are sufficient.

Confronting a real crisis, a situation where traditional problem-solving methods prove insufficient, requires us to seek new interventions. Consequently, we cannot reason from the past in a new context.

Examining the challenges we face, we recognise that we need capacities (skills, knowledge, etc.) to develop interventions for the specific situation. The better we understand the challenges' nature, the more precisely we can identify the necessary capacities. The extent of our knowledgebase in anticipating significant events is vital for recognising the challenges' root-contexts. To respond appropriately, we need interventions.

As both dimensions can be high or low, it spans a two-by-two matrix for dealing with the future. Once we understand the challenges and we have available interventions, ***forecasting*** is an appropriate strategy. Being unsure about suitable interventions, ***analogical reasoning*** will fit. Not understanding the challenge but having several interventions at disposal, we use ***contingency planning***. And finally, we follow ***scenario planning*** in cases of uncertainty (Tsoukas & Shepherd, 2004). These four quadrants illustrate different contexts we might encounter. However, every stakeholder has a specific background influenced by their contexts. When directing change, both forecasting and analogical reasoning require rational *managers*. Scenario planning and contingency planning primarily rely on the guiding competencies of *leadership*. Recognising the continuous nature of change *stewardship* is a solution.

5.2 Adapting to Changing Reality

Any advancement towards an improved world is an ongoing process filled with constant disturbances. The Adaptive Cycle of Resilience (ACoR) model (Takács et al., 2019; Takács & Abcouwer, 2020) rooted in ecology (see a.o. Folke et al. (2002); Holling and Gunderson (2002)) and organisational change theories, (see a.o. Chandler (2014); Crawford and Nahmias (2010); Dervitsiotis (2011); Smith (2006); Walker and Salt (2006)) understands that human development materialises through change and grapples with the dilemma of what we desire, must do, and can accomplish in a given situation(Heene, 2002). The symbol of eternity embodies this continual process of change. Development begins from an equilibrium (bottom left quadrant) within a context where we comprehend what we desire, must do, and are capable of doing. Change introduces challenges that require us to utilise available creative competencies and co-create potential solutions for implementation. Operationalising the selected intervention can establish a new equilibrium that differs from the previous one and anticipates future changes. This model implicitly distinguishes between management capabilities on the left side and leadership on the right side. In general, the model includes the link between short-term problem-solving on the left and being resilient in dealing with unforeseen futures (plural) right.

As the eternity symbol indicates, change does not halt but rather evolves. Adaptability to new situations and resilience in facing challenges are vital for sustaining oneself throughout the change process.

Adaptability and sustainability are crucial challenges for all of us in our rapidly changing world. We need to address ever-evolving societal challenges, and in addition to adapting with specific skills, knowledge, and attitudes during different stages of change, we acknowledge the various perspectives of experiencing and acting, along with the effects on individuals (Me), communities or organisations (We), society, and the environment (All) (Abcouwer, Takács, Schilstra, et al., 2022).

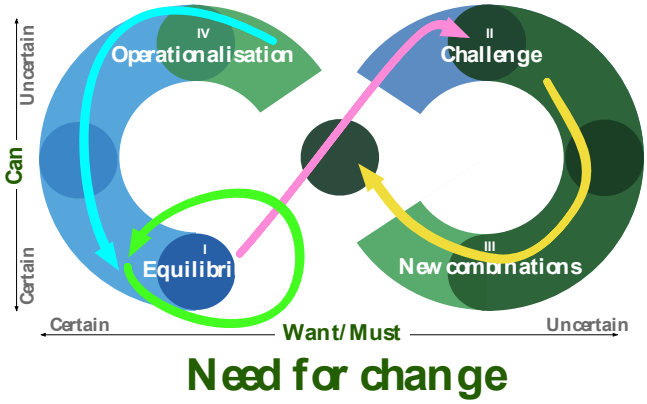


Figure 7: The Adaptive Cycle of Resilience

6. Sailing in the Unknown

In line with the lighthouse metaphor, we recognise the need for continuously improving our knowledge and competencies. The current education system does not prepare students for future developments. Theoretical insights to reorganise education along equality and equity appear and may be relevant.

6.1 Equality, Equity and the Disappointing Reality of Education

Today's societal developments increase the divide between rich and poor, although 75 years ago all the United Nations' member states agreed that 'All human beings are born free and equal in their dignity and rights' (United Nations, 2023), with equal rights to opportunities. In education, this is often implemented by ensuring that

everyone has equal access to the same basic education, emphasising the value of education for all. Providing equal facilities to ensure that everyone can enhance their knowledge and skills. However, not everyone is the same. Gardner (1985), state that people possess different intelligences, learn in various ways, and contribute to society's well-being differently. Standardised education allows only some individuals to contribute to society to the best of their abilities, while those left behind may be undervalued from a societal perspective. Therefore, today's educational offerings do not provide equal opportunities.

The concept of ***equity*** (Sowell, 2001) forms an alternative perspective on education. By enhancing the knowledge and competencies of the people, their contribution to society becomes personal and is valued based on the intrinsic worth that everyone can offer. This perspective shifts the understanding of education's role in a modern societal context. Based on the student's background, education should adapt to the necessary level of support to optimise their contribution both to themselves and to society. Here, optimising the contribution and value of each individual input to society is not assessed using an absolute standard, where only the best ones are celebrated. Every contribution is essential, valuable, and indispensable for society's sake.

Current practice reveals a third approach to education: ***reality***, within its societal context. In many countries, there is a trend towards increasing private education. Publicly facilitated education for everyone typically offers basic and standardised education, often at a low(er) level. Privileged parents can obtain better-quality education by paying fees to private educational institutions. This results in increased inequality rather than a reduction.

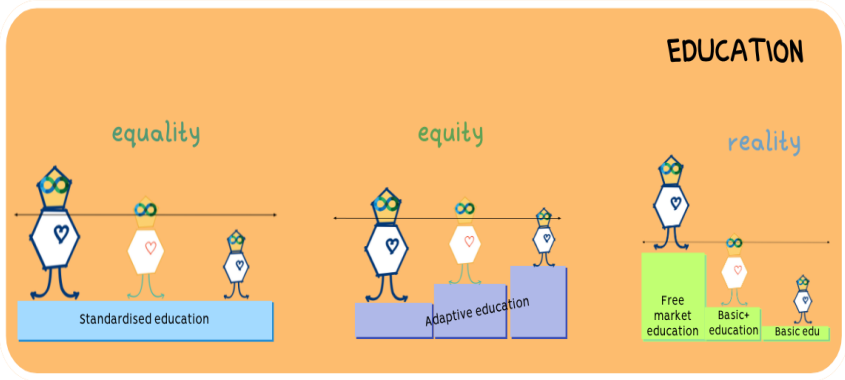


Figure 8: Education needs change (Adapted from Sowell (2001)

Understanding the differences between these three views on learning relies heavily on the fundamental insight that people are different. Everyone is with own competencies, abilities, skills, and backgrounds or contexts and roles within the society.

7. Conclusions

A responsible way of living harmonises with nature, preserving planet Earth for both current and future generations while enhancing the well-being of all. In an era of increasing environmental challenges (e.g., biodiversity degradation, climate change, species extinction, resource depletion), it is crucial to find ways to ensure that human prosperity does not compromise the environment and our social heritage.

The need to redefine human development emphasises the core principles of the interconnected environmental and social pillars of sustainability. In this article, we highlight the importance of knowledge, which plays a crucial role in changing or deepening values and motivations across various contexts. We must respect and treat nature and other living beings fairly, reconnecting our lives to the natural world to live in balance, cooperation, and harmony. Throughout history, humanity has embraced this awareness, understanding that everyone's contribution forms the foundation for future development. However, this role of the individual has evolved in recent decades into a form of extreme ecocentrism. Balancing the diverse interests of individuals (Me) and communities (We) alongside our environment while respecting the needs of all living beings (All) is crucial for future development. (Abcouwer et al., 2022). We need to restore ancient wisdom, modern science, and planet-friendly technology to ensure sustainable human development for our planet through cooperation. This perspective provides a substantial foundation for education that prepares children and younger generations for a bright future. In this paper, we showed the roles of knowledge in dealing with individual and societal challenges and navigating different values, motivations and contexts from various views.

In other words, the individual level (Me), health and justice are essential for the global well-being of both people and the biosphere we inhabit, as they together form the All perspective that we described. A range of fundamental human needs can be identified to enhance individual and societal well-being, including social health and justice, which foster sustainable societal, social, and personal development.

From this perspective, the roles of knowledge management can be summarised as follows:

- A clear vision of the future, just as a lighthouse, encourages a broader, more sustainable definition of value.
- It drives the crew of the ship for innovation, strategic decision-making, and pursuing long-term goals.
- It fosters adaptability, helping individuals and businesses thrive in an ever-changing environment.

The lighthouse metaphor supports change by offering fixed reference points: foundational values and knowledge to assist captains navigating safely in cooperation with the crew, who possess diverse knowledge to stay on course in the unpredictable ocean. At times, the waters are calm and stable, while storms (crises, misinformation, rapid change) can set the ship off course. A ship performs optimally when its crew communicates knowledge effectively and collaborates. Thus, knowledge management saves lives by ensuring the right information reaches the right people and that the given context is addressed. However, as stated in the introduction, we again echo Andriessen's (2008) warning that metaphors can mislead us when taken too literally. For us, this metaphorical approach was intended to spark discussion.

Ethics declaration: for this paper is no ethics clearance required

AI declaration: AI tools are used for improving the language and to generate the picture on page 1.

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Integrating Organisational and Spiritual Capital: A Pathway to Corporate Sustainability

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Abstract: As corporate sustainability becomes increasingly essential, businesses are recognising the significance of intangible assets such as organisational and spiritual capital. Organisational capital, encompassing knowledge management, company culture, climate and philosophy, enhances efficiency and innovation. Spiritual capital finds its expression in what the organisation believes, in the reason for its existence, what it strives for, and what it takes responsibility for. The integration of these two forms of capital provides a distinctive pathway to sustainable organisational success. This study aims to examine the relationship between organisational and spiritual capital and their combined impact on corporate sustainability. It explores how companies can leverage these intangible assets to enhance long-term performance, environmental responsibility, and stakeholder engagement. A comprehensive literature review was conducted, synthesising insights from various academic sources on organisational capital, spiritual capital, and sustainability. The research identifies a positive correlation between well-managed organisational capital and the development of spiritual capital, leading to enhanced corporate sustainability. Companies that build spiritual capital have a strong sense of wholeness and interconnectedness. They realise that business is part of a broader human enterprise, part of a larger global scenario. They feel they are part of society and perceive themselves as responsible to society, the planet, and life itself. These companies demonstrate greater adaptability and resilience. Furthermore, cultivating a strong foundation of spiritual capital strengthens employee engagement, fosters innovation, and supports corporate social responsibility initiatives. Collectively, these factors contribute to long-term competitive advantage and corporate sustainability. The findings suggest that companies should adopt a holistic approach to managing organisational capital by embedding spiritual principles within their frameworks and processes. Businesses rich in spiritual capital prioritise communication, equity, trust, and transparency, fostering an inclusive and purpose-driven corporate culture. Companies that successfully integrate these forms of capital will be better equipped to address economic, social, and environmental challenges while generating sustainable long-term value. The topics presented in this paper invite academics and practitioners to relate the topic of intellectual capital to very practical aspect of achieving sustainability and creating companies with purpose. In this paper we argue that the path toward corporate sustainability is by leading organisations, with care, responsibility, purpose. This approach should be further examined and applied.

Keywords: Intellectual capital, Organisational capital, Spiritual capital, sustainability

1. Introduction

In the current business environment, more and more organisations see the need to look beyond the traditional concerns of running a business for immediate profit and to begin to deal with factors in the greater world that impinge on their medium to long-term success (Fairfield et al., 2011). To reach sustainability, organisations need to find the balance within three different areas: environment, economy and society. Organisations around the world (including N. Macedonia) are facing high levels of criticism for their limited role in a number of social, environmental and economic issues (Taneva-Veshoska et al, 2014). Sustainability issues are gaining importance and are progressively incorporated into strategies of organisations. In recent years, the concept of sustainable development has been increasingly addressed by the business sector (Hahn and Scheermesser 2006).

The integration and coordination of strategic focus and business processes aligned with sustainability are fundamental to achieve effective and efficient results (Crittenden et all, 2011). This can be enabled by a development strategy, which embeds sustainability elements and an adequate sustainability performance measurement system (Labuschagne et all, 2005). There is still a challenge to corporate sustainability regarding the integration of sustainability into the business strategy. More specifically, there are certain circumstances that influence and are related to the need for transformation of the organisation toward achieving sustainable performance (Trajkovska, 2019):

- Complex operating conditions and risks in the company and its environment,
- Pressure to follow the trend of investing in research and innovation in companies, as major a development driver in the modern global economy and important strategic priority of the European Union,

- Rapid technological development, rapid obsolescence of technologies and technological skills, as well as the necessity for long-term planning, upgrading the knowledge and organisational memory,
- Stage of the life cycle in which the company is at - which imposes the need to seek goals and directions that will continue the trend of an upward line of development, and prevent stagnation and decline.

What kind of a business paradigm is appropriate to meet the new challenges and trends in sustainability? Organisations are positioning to incorporate different performance measures integrating them in their organisational goals and strategy. This also implies a change in their business models and management systems. Nowadays, the trend is toward holistic sustainability management systems, methods and tools. Intellectual capital (IC) and knowledge management (KM) are the basic building blocks (cornerstones) of an effective 21st-century management model. With proper management of intellectual property and knowledge, companies are able to act intelligently, achieving sustainable competitiveness. KM and IC are believed to influence each other, and the relationship between the two constructs is of vital importance to organisational effectiveness and efficiency (Seleim and Khalil, 2011). IC is a major player and a foundation for sustainable competitiveness and efficiency. Human, structural, organisational, spiritual and relational capital can all be explored in the light of sustainability (Januškaitė and Užienė, 2018).

In addition to business strategies and managing organisational capital, companies need to build their spiritual capital because it is closely related to sustainability (Zohar and Marshall, 2000). An organisation with a high moral intelligence tends to have a better value-based vision, global concern and compassion, and long-term thinking than low moral intelligence. The founders' personal and spiritual values are central to creating values-centered organisations that are intentional about investing in workplace spirituality and nurturing the soul of the organisation. When these values are clear, it is important to be able to translate them into specific organisational practices and to embed them in the culture (Neal 2013). One of the first steps for a modern business is to create a favourable organisational culture. Furthermore, organisations that have been successful at integrating workplace spirituality always appear to have strong and effective cultures (Betters-Reed et all, 2020).

This paper aims to examine the relationship between organisational and spiritual capital and their combined impact on corporate sustainability. It explores how companies can leverage these intangible assets to enhance long-term performance, environmental responsibility, and stakeholder engagement. A comprehensive literature review was conducted, synthesising insights from various academic sources on organisational capital, spiritual capital, and sustainability.

2. Literature Review

2.1 Organisational Capital

Edvinsson and Sullivan (1996) defined intellectual capital as "knowledge that can be converted to value." IC is viewed as the economic value of two categories of intangible assets, namely organisational and human capital (Seleim and Khalil, 2007). Therefore, the true value of the knowledge-based firms lies in their knowledge flows (i.e. knowledge management) and knowledge bases (i.e. intellectual capital). Considering the importance of integrating sustainability in the overall management process IC is a suitable starting point for reaching sustainability performance in organisations. Simply measuring key performance indicators does not provide an organisation profound guidance in reaching true sustainability. Organisations need an understanding of their practices to reach their objectives (Hadders, 2011). Human capital, organisational capital, and relational capital enable organisations to form, develop, and manage knowledge.

In contrast to the industrial economy that required the management of manual labour, the new information economy involves turbulence, change and management of "knowledge workers", whose jobs performance depends on specialized knowledge. Since knowledge workers require self-motivation, the old 3-C (command, control and compartmentalization) model that was used to manage manual labour is widely viewed as outmoded. The leader's primary task becomes embedding trust, leading change, and creating a sense of purpose. Leaders led by articulating a vision and mobilizing meaning. The dissemination of meaning happens through symbolic management that communicates a set of beliefs and values.

Why do some companies systematically outperform their competitors and maintain their leadership positions for long periods of time — some over multiple decades — despite persistent competition and changing business landscape? The answer is organisational capital – a critical part of an enterprise, which every executive should understand how to effectively measure and manage (Lev et all, 2016). Organisational capital is an important

resource (asset) at both the micro (firm) and macro (economy-wide) levels. It is arguably, the most important, value-contributing asset companies have — an asset that cannot be easily imitated by competitors, and therefore conferring sustained competitive advantage on its owners. Organisational capital enables tangible and intangible resources, such as machines, patents, brands and human capital, to be productive. As such, organisational capital is the prime intangible asset of businesses.

Organisational capital is dynamic, and investments to create, monitor and foster it need to evolve and change to maintain competitiveness in a rapidly changing business landscape.

Organisational capital enables tangible and intangible resources, such as machines, patents, brands and human capital to be productive. As such, organisational capital is the prime intangible asset of businesses. Enterprise resources, such as equipment, labour, patents, etc. are inert by themselves. Organisational capital is the means through which the CEO and his or her management team makes them productive. It is comprised of four elements: 1. Human capital 2. Values & norms 3. Knowledge & expertise 4. Business processes & practices (Bontempi and Mairesse, 2015).

2.2 Spiritual Capital

Increasingly the demands of globalization, fuelled by an exclusive bottom line mentality, appear to define the identity of many modern organisations and their leaders. The role of the leaders is to create and to maintain good and harmonized human relations, fostering motivation for efficient business operations, within a favourable business climate an environment, to accomplish the basic goals of the organisations. This is especially important for the long run of the business and their success in the era of globalization and the existence of strong competition in the global market. One principle that is central to adopt is the commitment to the human first, before seeing them as "employee" or as "customer." This view of the dignity and worth of each human being drives everything from hiring practices to leadership style to customer service. (Betters-Reed et all, 2020).

Zohar and Marshal (2000) defined spiritual intelligence as intelligence which people address and solve problems of meaning and value, place their actions and live meaningfully. Spiritual intelligence can be used to identify and understand the thought patterns, beliefs and goals that form the foundation of our behaviour. Spirituality forms an internalised general regulative ideal, based on four common aspects of spirituality: self-transcendence, interconnectedness, meaning and one's ultimate concern, that governs what individuals perceive and value and how they act (Drakulevski and Taneva-Veshoska, 2014). These moral values practiced over time become virtues. Spiritually virtuous individuals contribute significant benefits to organisations (Zsolnai, 2004).

Peter Pruzan (2004) argues about new perspective on leadership: spiritually-based leadership. He explains that strong trend toward flatter, less hierarchical organisations, greater use of self-organizing project-teams, new types of production and production processes, value-based leadership, social and ethical accounting, corporate social responsibility, corporate branding, and ethical investing. Ethical behaviour is necessary for successful organisations and is considered as a key to great performance and long prospers life for the organisations. Being ethical is a concern to all employees, no matter on what position they are in the organisation. Spiritual capital may influence the recognition of opportunities and bolster perceptions of personal agency to innovate. Also, spiritual capital is positively associated with innovation (Neubert el al., 2015).

Ethical behaviour is considered crucial for the growth of every organisation, for promoting team work among colleagues and building confidence and trust as well (Zarezankova-Potevska & Taneva-Veshoska, 2012). Building on these ideas, Fry (2003) was among the first to approach workplace spirituality from the leadership perspective and propose a theory of spiritual leadership. Fry defined spiritual leadership as: comprising the values, attitudes, and behaviours that are necessary to intrinsically motivate one's self and others so that they have a sense of spiritual survival through calling and membership. This entails: 1. creating a vision wherein organisation members experience a sense of calling in that their life has meaning and makes a difference; 2. establishing a social/organisational culture based on altruistic love whereby leaders and followers have genuine care, concern, and appreciation for both self and others, thereby producing a sense of membership and feel understood and appreciated.

Zohar and Marshall (2004) proposed that spiritual capital (SC) should be seen as a new paradigm. According to their view, it implies in a radical change in our mindset, particularly in "the philosophical foundations and the practices of business" (p. 21). Moreover, SC does not focus on gaining monetary wealth, yet it does not put aside such a possibility through approaching business under the perspective of building "meaning and value". Zohar and Marshall (2004) suggested that SC "can generate profit that both draws on and adds to the wealth of the human spirit and to general human well-being".

A thematic analysis of the key elements approached in the definitions of SC revealed at least six salient features:

- Wealth - Wealth creation is derived from three forms, namely, social, environment and economic, which is commonly translated into the so-called triple bottom line or people, planet and profit. Zohar and Marshall (2004) wisely recognized that SC provides a sort of "wealth that enriches the deeper aspects of our lives" (p. 3).
- Faith and belief - By and large, spiritual theme presupposes a strong belief in something ethereal, which is not easily touched or seen. Fry (2003) noted that "Faith is more than hope or the expectation of something desired. It is the conviction that a thing unproved by physical evidence is true" (p. 713).
- Values – Values are the by-product of our personality, more spiritually-oriented workers tend to show higher values in performing their work and duties.
- Virtues – The virtuousness frame requires alignment between our actions and character. Conceptually, virtue is also associated with integrity, discernment, love, respect, humility, diligence, temperance and courage (Lanctot and Irving, 2010).
- Vision - A good vision has the power to integrate good aspirations, purposes and wishes into the same frame. A good vision is attractive because it joins the scattered individual perceptions toward the same goal.
- Benefits - Spirituality in the workplace is associated with better productivity; valued employees; more positive working conditions; job satisfaction; organisational commitment; purpose and meaning driven organisations; integrity, honesty, love, hope, kindness, respect and nurturing managers; sense of community; sense of belonging in the workers; empowering, delegation and cooperation; and improvement in morale and loyalty (Altaf and Awan, 2011).

Spiritual capabilities underpinning sustainability-based core competencies meet the established criteria for creating sustained, difficult to imitate competitive advantages for organisations operating in today's sustainability-rich business environment. Organisations today seem to understand that building tangible sustainability-based capabilities can improve their profitability. (Mitchell et all, 2021)

3. Methodology

This paper is based on a comprehensive literature review and conceptual synthesis. Sources include peer-reviewed journal articles, working papers, and academic conference proceedings related to organisational capital, spiritual capital, and sustainability. The authors did systematic literature review, taking in consideration several databases: Scopus, Web of Science, Google Scholar. Several keywords were applied to filter the number of research and papers, such as "spiritual capital", "workplace spirituality", "organisational capabilities", "corporate sustainability", combined with focus in the Western Balkans and development countries.

4. Results

The concept of organisational performance in literature refers normally to financial aspects such as profit, return on assets, return on equity, and economic value added (Kaplan, 1983). While financial measures of performance are among the most widely used by businesses, many researchers have criticized the short-term thinking and emphasize the importance of the non-financial components of performance measurement (Otley, 1999). Organisations are positioning to incorporate different performance measures integrating them in their organisational goals and strategy. This also implies a change in their business models and management systems. Nowadays, the trend is toward holistic sustainability management systems, methods and tools.

The research identifies a positive correlation between well-managed organisational capital and the development of spiritual capital, leading to enhanced corporate sustainability. The investments in knowledge and IC are directly linked to increasing the potential of human capital and the competitive advantage of the organisation (Trajkovska et all, 2020). Companies that build spiritual capital have a strong sense of wholeness and interconnectedness. They realise that business is part of a broader human enterprise, part of a larger global scenario. They feel they are part of society and perceive themselves as responsible to society, the planet, and life itself. These companies demonstrate greater adaptability and resilience. Furthermore, cultivating a strong foundation of spiritual capital strengthens employee engagement, fosters innovation, and supports corporate social responsibility initiatives. Collectively, these factors contribute to long-term competitive advantage and corporate sustainability.

The findings suggest that companies should adopt a holistic approach to managing organisational capital by embedding spiritual principles within their frameworks and processes. Businesses rich in spiritual capital

prioritise communication, equity, trust, and transparency, fostering an inclusive and purpose-driven corporate culture. Companies that successfully integrate these forms of capital will be better equipped to address economic, social, and environmental challenges while generating sustainable long-term value. In one study where to aim was to analyse the relationship among spiritual intelligence and terminal and instrumental values among employees and managers, it was concluded that there are no significant differences in the rankings on terminal and instrumental values, the hypothesis was confirmed. The most important terminal values were: happiness, family security, inner harmony, true friendship and a world of peace. Instrumental values that were most important for both managers and employees are: honesty, independence, decisiveness and resourcefulness. Results of SISRI show that both managers and employees have average score on spiritual intelligence and are not always behaving ethically in their working environments (Drakulevski and Taneva-Veshoska, 2014). The results of the survey that Drakulevski and Taneva-Veshoska (2012) conducted showed that Macedonian employees can tell the difference between what is right or wrong, they know what ethical and no ethical behaviour is. Macedonian employees have good values and most of them tend to work in an honest way. They are people oriented and still value human relations and friendship. They are not aggressive or lying on purpose just to make profit of it. But still the situation isn't as good as they tend to represent it. The answers that they gave were socially acceptable and they knew that they were questioned something about them and what kind of people they are, are they ethical or not. That's why we can't take all the answers for granted and look more deeply in to the matter. This is how we may see that our respondents are very aware of the reality, and even though they tend to be honest, sometimes they perceive the situations differently and they react toward that perception – which means that are trying to get the benefit of every situation and make profit. Regarding the part where they were asked about their attitude toward corruption, even though they said it's not ethical and should be punished, they were also the one who in a way supported the corruption and didn't stand up against it. We think that one of the reasons for this is there not believing in the institutions and the system who should protect them.

Sustainability-oriented companies are transforming knowledge into new or significantly improved goods and services for the market. They take advantage of innovative opportunities in a variety of fields and achieve, through their strategy, a competitive advantage and sustainability-oriented performance. An effective and efficient use of the unique tangible and intangible assets within companies are important sources of competitive advantage.

5. Discussion

The research on organisational capital, leads us to the conclusion that greater attention should be directed towards unlocking the secret of how to successfully manage this important resource. We recommend to start with an output-based approach to measuring company-specific organisational capital and proceed with identifying the drivers of systematic differences in companies' organisational capital. Identifying such organisational capital-drivers will provide the foundation for the development of ways to manage organisational capital.

Spiritualised management opens up opportunities for personal development an individual self-realisation in organisations, rather than reducing the members of organisation to machines for the profit. Spiritual values in organisations should include making world meaningful, respect for the employees, and humanizing the complex relationships between the organisation and the society. To implement the new spiritual-based management paradigm, managers need to have the courage to see the economy in different light which requires a thorough re-thinking of our mindset and positive changes in the economy.

Recent attention to comprehensive matters of spirituality in both the academic and practitioner communities is shifting management thinking, described as the "new spiritual imperative". Today a different discourse is needed than the one with which the traditional theory is arguing. Spiritualisation of management treats organisations as systems that are based on values, but also in constant interaction with their environments. In accordance with this, we can pursuit "values-driven management" as the "strategic response" to the situation of the organisation as an entity in society. Some of the important skills for the new age are: meaningful vision, enthusiasm, and strong sense of purpose, personal integrity, ability to instil confidence, openness, trustworthiness, and emotional intelligence (Amram, 2005).

6. Conclusion and Implication

The implications of the findings presented in this study are also important for practice. Information that will help organisations starts discussing the topic of spiritual and organisational capital and become aware of the

importance of ethical behaviour in every day in business life. This research provides implications for practice in several areas: discussion on the subject, new approaches to question our ethics and creating organisations that nurture right values.

Organisational capital is very consequential. Its contribution to measured benefits, at both the macro and micro (company) levels, is very substantial. The takeaway for CEOs and corporate managers from all of this is that organisational capital can be measured at a holistic level. It is of great importance to manage this capital in order for companies to enhance their productivity and long-term competitive advantage, as well as avoid pitfalls, i.e., downside risks associated with disruptive technologies and compliance. A comprehensive measure of organisational and spiritual capital will also enable companies to inform investors and outside stakeholders to understand the value-drivers of the company. Executives and board members need to make investments in organisational and spiritual capital to ensure productive operations as well as adapt to new ways of doing business.

Fry and Altman (2013) have shown that integration of spiritual leadership into training has led to positive outcomes, such as team empowerment, overcoming resentment, conflict and fear, and consensus-based decision making. Spirituality and leadership therefore can form part of leadership development activity, and further research can help us to do this both effectively and ethically.

Spiritual and organisational capital are one of the essential capitals that drives individuals and organisations to run the business following the law and standards. As a result, organisations can gain trust and integrity by following the rules and affecting their competitive advantages. While it is understandable that there will be a broad range of individual behaviour, this range can be significantly narrowed by the context within which individuals work and live. Culture, social norms, and codified rules of conduct have all played a role in constructing the common sense of what is and is not appropriate activity. In fact, these implicit influences are often so deeply imbedded that any decision ceases to exist: This is the way things are done around here, period. Likewise, organisations create a culture that forms and informs how individuals conceptualise the appropriateness of different activities.

It can be concluded that proper management of organisational capital reflects positively in the wat knowledge, culture, clime and innovation is treated and nurtured. As organisational capital is strongly linked to spiritual capital, it will be affected in the employees' commitment to the company's purpose, care and responsibility. Integrating organisational and spiritual capital offers a transformative pathway to corporate sustainability. Businesses that build these capitals will be better equipped to meet economic, social, and environmental challenges while creating enduring value. Managers can focus their attention when managing organisational and spiritual capital on the following aspects:

- The purpose of the company to be embedded in the vision, mission, values and strategy? Making sure that the answer to WHY this company exist is the same for the owners, managers, employees.
- Reflection of the leadership style and the potential to support ethical conduct, shared responsibility and care.
- The level of trust, equity and meaningful work experience by the different stakeholders.
- Continuously monitor and strive to improve the performance metrics (financial, social environmental, etc.).

The implications of the findings presented in this paper are important from a practical perspective, as the information can assist managers to recognise the relevance of the topic and its importance, and support organisation development toward sustainability-oriented performance.

Ethics declaration: I declare that ethical clearance was not required for the research.

AI declaration: I confirm that no AI tools were used to the creation of this paper.

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Enhancing Decision-Making with Artificial Intelligence in Project Management

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Abstract: In an era of rapid innovation and complex business challenges, the integration of knowledge management (KM) and project management (PM) has emerged as a critical key driver of strategic success. Project management is a complex discipline that requires effective decision-making to ensure the successful completion of projects within scope, time, and budget constraints. Traditional decision-making methods often rely on human judgment, which can be subject to biases, inefficiencies, and limitations in data processing. The rapid advancement of Artificial Intelligence (AI) has introduced innovative solutions to enhance decision-making in project management by leveraging machine learning, predictive analytics, and intelligent automation. This paper explores how AI-driven technologies are transforming decision-making processes in project management by improving risk assessment, resource allocation, and project forecasting. AI-powered tools can analyze vast amounts of historical project data to identify patterns, predict potential bottlenecks, and recommend optimal strategies. Additionally, artificial intelligence enables real-time monitoring of project performance, providing project managers with data-driven insights that enhance their ability to make proactive and informed decisions. By integrating AI into project management workflows, organizations can reduce human errors, optimize productivity, and improve overall project success rates. Despite its numerous benefits, AI implementation in project management presents challenges such as data privacy concerns, reliance on high-quality datasets, and the need for organizational adaptation. This paper discusses these challenges and provides recommendations for overcoming them to maximize the benefits of AI-driven decision-making. By analyzing real-world case studies and industry applications, this paper highlights the potential of AI in revolutionizing project management and offers insights into future trends. The findings underscore the importance of AI adoption in modern project environments and emphasize the need for continuous learning and ethical AI deployment. Attendees will gain insights into practical approaches for incorporating KM into project management workflows and fostering a culture of continuous learning and improvement.

Keywords: Artificial intelligence, Decision-making, Project management, Predictive analytics, Intelligent automation

1. Introduction

Project management is a structured approach to planning, executing, monitoring, and closing projects to achieve specific objectives within constraints such as time, cost, and scope. Decision-making is a fundamental aspect of project management, influencing project success by determining resource allocation, risk mitigation strategies, and overall project direction (Kerzner, 2017). Effective decision-making enables project managers to navigate complexities, manage uncertainties, and optimize outcomes in dynamic environments.

Traditional decision-making in project management typically depends on expert judgment, historical data, and rule-based approaches. While these methods are valuable, they have certain limitations, such as cognitive biases, slow response times, and challenges in handling large volumes of data. Additionally, traditional approaches struggle with predicting project risks, optimizing resource utilization, and adapting to real-time changes, leading to inefficiencies and potential project failures (Turner, 2016).

The advent of Artificial Intelligence (AI) has revolutionized decision-making in project management by enabling data-driven, predictive, and automated processes. AI-powered tools leverage machine learning, natural language processing, and data analytics to enhance forecasting accuracy, risk assessment, and resource optimization. AI can analyze vast datasets in real-time, providing project managers with actionable insights to improve efficiency, reduce costs, and enhance project success rates. As AI continues to evolve, its integration into project management is expected to redefine traditional methodologies and establish more adaptive, intelligent decision-making frameworks (Marnewick & Marnewick, 2021).

2. Research Objectives and Scope of the Study

The primary aim of this study is to explore the role of Artificial Intelligence (AI) in improving decision-making processes within project management. With the increasing complexity of modern projects, there is a growing need for efficient decision-making strategies that can handle the uncertainty and dynamic nature of the project environment. This study seeks to investigate how AI can be leveraged to address these challenges and improve the overall effectiveness of decision-making in project management. To achieve this goal, the study focuses on the following research objectives:

2.1 Examing the Limitations of Traditional Decision-Making Approaches

Traditional decision-making approaches in project management have been historically reliant on human judgment, experience, and established methodologies such as the waterfall model or critical path method (CPM). However, these approaches often fall short in addressing the complexity and unpredictability that characterize modern projects. This objective aims to identify and analyze the limitations inherent in these traditional methods, including issues related to scalability, adaptability, and the capacity to process vast amounts of real-time data.

2.2 Investigating the Capabilities of AI in Enhancing Project-Related Decisions

AI has the potential to transform decision-making processes by automating tasks, predicting outcomes, and providing data-driven insights. This objective aims to explore the specific capabilities of AI in project management, such as predictive analytics, natural language processing, machine learning, and optimization algorithms. By examining these capabilities, the study will assess how AI can enhance decision-making in areas like project scheduling, risk management, resource allocation, and stakeholder engagement.

2.3 Identifying Challenges and Opportunities in AI Adoption within Project Management

While AI offers significant promise, its adoption in project management is not without challenges. This objective will investigate the barriers to AI adoption, such as organizational resistance, lack of expertise, high implementation costs, and ethical concerns. At the same time, the study will highlight the opportunities AI presents for improving decision-making efficiency, accuracy, and the overall success rate of projects. Understanding both the challenges and opportunities is essential for determining the feasibility and future potential of AI in the field.

2.4 Providing Insights into the Future Implications of AI-Driven Decision-Making

AI-driven decision-making is still in its early stages in project management, but it is expected to grow in importance as technology continues to evolve. This objective will look ahead to the future implications of AI integration within project management, considering trends such as the increased use of AI-powered tools, greater reliance on automation, and the potential for AI to collaborate with human project managers in hybrid decision-making models. The study will assess how these changes might reshape the roles of project managers, stakeholders, and teams in the future.

By addressing these objectives, this study seeks to contribute to the growing body of knowledge on AI's transformative potential in project management. Through a thorough investigation of AI's impact, limitations, and opportunities, this research aims to pave the way for a more data-driven and AI-enhanced approach to managing projects.

3. Literature Review

Knowledge Management (KM) plays a crucial role in project management by facilitating the efficient capture, sharing, and utilization of knowledge to enhance decision-making and improve project outcomes. According to Dalkir (2017), KM integrates processes that ensure knowledge is systematically acquired, stored, and applied in an organizational context, thereby reducing redundancy and increasing efficiency. In project management, the ability to leverage existing knowledge assets can lead to better risk assessment, enhanced problem-solving capabilities, and increased project success rates.

Nonaka and Takeuchi (1995) emphasize that effective knowledge utilization directly correlates with project success. Their SECI (Socialization, Externalization, Combination, Internalization) model underscores the importance of both tacit and explicit knowledge in organizational learning and innovation. In the context of project management, applying this model can lead to improved collaboration, more informed decision-making, and overall better project performance.

Decision-making is a fundamental aspect of project management, influencing project planning, execution, and closure. Traditional decision-making models, such as those proposed by Simon (1997), highlight a rational approach wherein decision-makers follow a structured process of identifying alternatives, evaluating options, and selecting the most optimal solution. However, real-world decision-making in projects is often constrained by time, incomplete information, and the cognitive limitations of human decision-makers.

Kahneman and Tversky (1979) introduced the concept of cognitive biases and heuristics that impact human decision-making. Their Prospect Theory suggests that individuals tend to perceive potential losses more

significantly than equivalent gains, leading to risk-averse or risk-seeking behaviors depending on the context. In project management, these biases can result in suboptimal decisions, such as underestimating risks, overconfidence in project schedules, and anchoring on initial estimates without considering updated data. Artificial Intelligence is transforming project management by enhancing decision-making capabilities through data-driven insights, predictive analytics, and intelligent automation. Over time, AI applications in project management have evolved from simple rule-based systems to sophisticated machine learning algorithms capable of handling complex project variables and uncertainties.

Russell and Norvig (2020) highlight the impact of machine learning, predictive analytics, and intelligent automation on decision-making. Machine learning models can analyze historical project data to identify patterns, forecast risks, and optimize resource allocation. Predictive analytics enhances decision-making by providing probabilistic assessments of project outcomes, enabling proactive interventions. Furthermore, intelligent automation streamlines repetitive tasks, such as scheduling and reporting, allowing project managers to focus on strategic decision-making. The integration of AI in project management presents significant opportunities for improving efficiency, reducing human biases, and enhancing decision accuracy. However, challenges such as data quality, ethical considerations, and the need for human oversight remain critical areas for further research and development.

4. AI-Driven Decision-Making in Project Management

Artificial Intelligence is increasingly transforming decision-making processes in project management, offering sophisticated tools to optimize project outcomes. From risk assessment and resource allocation to performance monitoring, AI applications have demonstrated significant potential in enhancing the efficiency and effectiveness of project management practices. This chapter delves into three key areas where AI is revolutionizing decision-making in project management: risk assessment and mitigation, resource allocation optimization, and project forecasting and performance monitoring. Risk management is a critical component of project management, as identifying and mitigating potential risks can significantly impact the project's success. Traditional risk assessment methods often rely on historical data and expert judgment, which can be limited and subjective. AI, however, brings a new dimension to risk management through predictive analysis and advanced algorithms. AI-powered systems can perform predictive risk analysis, using data from past projects to identify patterns and anticipate risks that may emerge in the current project. Shen et al. (2021) highlight the ability of AI to analyze large datasets, identify trends, and assess complex risk factors with higher accuracy than human analysts. Machine learning models can predict various types of risks, such as financial, technical, or schedule-related, and assess the probability and impact of these risks on the project.

4.1 Risk Assessment and Mitigation

AI-driven risk management frameworks are designed to automate the risk identification process, continuously monitor the project for emerging risks, and provide early warnings. These frameworks incorporate data from various sources, including project reports, environmental factors, and historical data, to offer real-time insights into the risk landscape. By identifying risks early and suggesting mitigation strategies, AI enhances decision-making capabilities, allowing project managers to proactively address potential issues before they escalate.

4.2 Resource Allocation Optimization

Effective resource allocation is vital for the successful completion of a project. The ability to forecast resource needs accurately and allocate them efficiently can reduce costs, improve productivity, and ensure project deadlines are met. AI is revolutionizing resource allocation by providing tools that optimize forecasting and allocation processes. AI-driven resource forecasting and allocation utilize machine learning algorithms to predict future resource requirements based on historical project data and real-time variables. According to Smith & Jones (2019), AI can analyze factors such as team skillsets, project timelines, and resource availability to determine the most efficient allocation strategy. This predictive capability ensures that resources are distributed optimally, reducing waste and ensuring that critical project tasks are supported by the right expertise and materials at the right time.

In one AI project, a construction firm used AI to predict the need for labor and materials across multiple projects, allowing them to allocate resources dynamically as project requirements evolved. The AI system enabled the company to minimize downtime, optimize crew schedules, and reduce the need for costly last-minute resource adjustments. Similarly, in software development projects, AI tools have been used to allocate developers based on skill specialization, ensuring that teams are well-equipped to handle complex coding tasks efficiently. By

automating resource forecasting and allocation, AI reduces the potential for human error and enhances project managers' ability to make informed decisions regarding resource distribution.

4.3 Project Forecasting and Performance Monitoring

One of the most valuable applications of AI in project management is its ability to enhance project forecasting and performance monitoring. AI-driven systems can track the progress of a project in real time, providing insights into the project's health, performance, and potential future outcomes. These systems employ AI algorithms to continuously assess project data, enabling project managers to make data-driven decisions throughout the project lifecycle. AI-enhanced project tracking systems enable real-time monitoring of key performance indicators (KPIs) such as budget adherence, schedule performance, and resource utilization. Lee et al. (2020) emphasize that AI-powered platforms use predictive analytics to evaluate the likelihood of project success based on ongoing performance metrics. These platforms can analyze factors such as task completion rates, team productivity, and external factors like market conditions to forecast potential delays, cost overruns, or resource shortages.

Furthermore, AI applications can provide early warnings and suggest corrective actions when project performance deviates from the planned trajectory. Predictive analytics in AI-driven project forecasting tools also enables project managers to anticipate the outcomes of various decisions. For example, they can evaluate the potential impact of changing project scopes, reallocating resources, or adjusting deadlines, enabling more informed and strategic decision-making. The use of AI for performance monitoring ensures that project managers are not only reacting to problems but are equipped with the tools to anticipate and address challenges before they become significant risks to the project's success.

5. Challenges in AI Implementation for Project Management

The integration of Artificial Intelligence in project management has the potential to greatly enhance decision-making and overall efficiency. However, as with any emerging technology, its adoption comes with several challenges. This chapter outlines the key issues that organizations face when implementing AI-powered systems in project management, focusing on data privacy and security, the dependency on high-quality data, and organizational adaptation and change management.

5.1 Data Privacy and Security Concerns

One of the most critical challenges in AI-powered project management is ensuring the privacy and security of the data that AI systems rely on. AI algorithms require large datasets to provide accurate insights and recommendations. These datasets often contain sensitive information related to project operations, financial data, and employee performance. As such, protecting this data from unauthorized access or breaches is paramount. Zhou et al. (2022) highlight the importance of robust data security protocols in the successful implementation of AI in project management. These include encryption, secure data storage, and compliance with data protection regulations like the General Data Protection Regulation (GDPR). Failure to safeguard sensitive data can not only lead to financial losses but also undermine the trust of stakeholders and clients in AI systems.

In addition to security, ethical considerations in AI decision-making are crucial. AI systems often function as decision support tools, analyzing large datasets to provide recommendations for project managers. However, these systems must be designed in a way that minimizes bias and promotes fairness in decision-making. Ethical issues such as transparency, accountability, and explain ability of AI decisions are central to ensuring that AI systems are used responsibly in project management. This involves creating guidelines for how AI systems are trained, validated, and deployed, with a focus on maintaining fairness and equity in decision-making processes.

5.2 Dependency on High-Quality Data

AI systems in project management are highly dependent on the quality of data they process. For AI algorithms to make accurate predictions or provide meaningful recommendations, they must be fed with reliable, accurate, and timely data. Unfortunately, many organizations face challenges related to the availability, accuracy, and completeness of data. Challenges related to data accuracy include issues such as incorrect or outdated project information, incomplete datasets, and inconsistencies between different data sources. For example, if project timelines or budgets are inaccurately recorded in project management tools, the AI system's predictions regarding project success or resource allocation may be skewed.

To address these challenges, organizations must implement strategies to improve the reliability of their AI datasets. This includes establishing robust data management practices, regular data audits, and ensuring that data entry processes are standardized and consistent. Additionally, organizations can leverage data cleansing techniques to remove errors and inconsistencies in the data before it is used in AI models. Enhanced data governance frameworks that ensure data accuracy and integrity will play a pivotal role in improving the performance of AI-powered project management systems.

5.3 Organizational Adaptation and Change Management

Adopting AI in project management also presents significant organizational challenges. One of the primary obstacles is resistance to change. Employees and project managers may be hesitant to adopt AI technologies due to concerns about job displacement, a lack of understanding about how AI works, or simply a reluctance to change established workflows. Overcoming these barriers requires a comprehensive change management strategy. According to various studies, including those by Alon-Barkat et al. (2021), successful AI implementation in project management requires clear communication, leadership commitment, and a well-defined vision for how AI will enhance decision-making rather than replace human involvement.

A crucial component of this process is training and skill development. As AI tools become more prevalent in project management, it is essential to equip project managers and other stakeholders with the skills needed to effectively use these tools. This includes not only technical training on AI software but also training on how to interpret AI-generated insights and make informed decisions based on them. Upskilling employees and fostering a culture of continuous learning will help organizations transition smoothly to AI-driven project management environments and ensure that the technology is used to its full potential.

6. Traditional Decision-making and AI-Enhanced Decision-Making Comparison

In the evolving landscape of project management, decision-making processes are undergoing a profound transformation. The integration of Artificial Intelligence (AI) is redefining how projects are planned, monitored, and executed. Unlike traditional methods that often rely heavily on human intuition and static data, AI-enhanced decision-making leverages real-time analytics, predictive modeling, and adaptive learning to support more accurate, efficient, and proactive management. As organizations increasingly adopt digital tools and intelligent systems, AI-driven decision-making is emerging not only as a more effective approach but also as the cornerstone of future working styles in project environments. In the following table, these two approaches to decision-making - traditional and AI-enhanced - are compared across key dimensions of project management.

Table 1: Comparison of Traditional vs AI-enhanced Decision-making in Project Management

Dimension	Traditional Decision-making	AI-enhanced Decision-making
Data Handling	Relies on historical data, intuition, and static reports	Processes large volumes of real-time and historical data
Speed of Decision-making	Slower due to manual analysis and hierarchical approvals	Faster through automation and algorithmic recommendations
Accuracy and Objectivity	Prone to human bias and limited perspectives	Increases accuracy and reduces bias through data-driven insights
Risk Assessment	Based on subjective judgment and limited scenario analysis	Performs dynamic risk modeling and predictive analytics
Resource Allocation	Often based on experience or fixed rules	Optimized through machine learning and real-time data inputs
Scenario Simulation	Limited what-if analysis using spreadsheets or tools	Advanced simulation and forecasting using AI models
Adaptability	Low flexibility to changes in real time	High adaptability via continuous learning from new data
Collaboration and Communication	Dependent on meetings and manual reporting	AI tools facilitate integrated dashboards and automated updates
Cost Efficiency	Higher due to inefficiencies and reactive decisions	Improved through predictive resource planning and automation
Scalability	Difficult to scale due to reliance on human judgment	Easily scalable across multiple projects and teams

7. Case Study and Industry Applications

Artificial Intelligence has increasingly been leveraged to enhance decision-making and optimize project management processes across various industries. By examining successful AI applications in real-world projects, we can identify best practices, challenges, and the impact of AI on project management outcomes.

As a case study in the IT sector, managing complex projects - such as software development or systems integration - has always been challenging due to their inherent unpredictability. However, AI-powered project management tools, such as Jira with machine learning integration, have enabled organizations to improve timeline estimation and allocate resources more efficiently. Machine learning models analyzed historical project data, including feature request patterns, bug reports, and sprint completions, to predict potential delays and optimize task assignments. AI also provided valuable insights into resource workloads and helped manage stakeholder expectations by providing early warnings of potential bottlenecks. AI in IT project management helps improve resource allocation, predict timelines, and optimize team productivity. Predictive analytics can mitigate risks by foreseeing potential delays and bottlenecks. Machine learning models offer better decision-making support based on historical data and trends.

Across various industries, the application of AI in project management has provided valuable lessons. One of them is data quality and integration. AI systems rely heavily on accurate, high-quality data. Successful AI implementations in project management have been underpinned by a solid data foundation, including historical project data, team performance metrics, and resource allocation information. Inaccurate or incomplete data can significantly impair the effectiveness of AI predictions and decision-making.

Introducing AI into project management requires a cultural shift within the organization. Teams need to be trained to trust AI-driven insights and integrate them into their daily workflows. Resistance to change and lack of buy-in from key stakeholders can hinder the successful adoption of AI tools. AI tools must be customized to fit the unique needs of specific industries or organizations. A one-size-fits-all approach may lead to suboptimal results. Successful projects have shown that tailoring AI applications to the specific requirements of a project or organization maximizes their impact.

AI should be viewed as a supportive tool for decision-making, not as a replacement for human judgment. Successful applications have emphasized the collaborative nature of human-AI interactions, where AI assists project managers in making informed decisions rather than making those decisions autonomously. AI models need continuous updates and improvements based on new data and changing project requirements. Organizations that have successfully integrated AI into their project management practices ensure that AI tools are regularly monitored and adapted to reflect evolving project dynamics.

8. Future Trends, Recommendations and Future Research Directions

As AI continues to mature, its role in project management will expand, presenting both significant opportunities and challenges. This chapter explores the emerging trends in AI-driven project management, policy and strategic recommendations for adopting AI in project workflows, and the ethical and regulatory considerations that must be addressed to ensure responsible AI deployment.

While this study highlights the current applications and benefits of artificial intelligence (AI) in enhancing decision-making within project management, further research is needed to deepen and broaden these findings. Future studies could explore sector-specific implementations of AI tools in project environments, particularly in high-uncertainty or high-complexity projects. Longitudinal research could examine how AI-driven decision-making evolves over the project lifecycle and its long-term impact on project outcomes. Additionally, interdisciplinary studies combining AI with behavioral science may offer insights into how project managers interact with AI recommendations, including trust dynamics and adoption barriers. Investigating ethical considerations and the transparency of AI algorithms in decision-making processes also represents a critical area for future exploration.

8.1 Emerging Trends in AI-Driven Project Management

AI is revolutionizing project management in several key areas, with new technologies and approaches emerging on the horizon. Key trends include as follows:

AI-Powered Predictive Analytics: Project managers are increasingly leveraging AI-powered predictive analytics to anticipate risks, forecast project timelines, and optimize resource allocation. Machine learning models, for

example, can analyze past project data to predict future outcomes, helping managers make proactive decisions to avoid delays or cost overruns (Gartner, 2024).

Natural Language Processing (NPL) for Communication: AI-driven tools utilizing NLP are enhancing communication and collaboration within project teams. These systems can automatically process and interpret vast amounts of project-related data from emails, messages, or meeting notes, thus reducing the time spent on administrative tasks and improving decision-making (Avasarala et al., 2023).

AI in Resource Management: AI systems are being designed to optimize resource management, including human and material resources. These systems use real-time data to adjust schedules and predict resource needs, ensuring that projects remain on track without overburdening personnel or exceeding budgets (Goswami & Sengupta, 2023).

Automation of Routine Tasks: Routine tasks such as scheduling, reporting, and status tracking are increasingly being automated through AI. These innovations help project managers focus on more strategic aspects of the project, thus improving productivity and efficiency (Makridakis, 2023).

AI and Agile Project Management: AI is being integrated into agile project management frameworks, enabling better alignment between project goals and the iterative nature of agile methodologies. AI can assist in sprint planning, backlog prioritization, and performance tracking, thus streamlining agile workflows and boosting team productivity (Hussain et al., 2024).

8.2 Policy and Strategic Recommendations for AI Adoption in Project Workflows

As AI technologies continue to evolve, organizations must adopt clear policies and strategies to incorporate AI into their project workflows effectively. The following recommendations are critical for successful AI integration:

Adopting an AI Roadmap: Organizations should develop a comprehensive AI roadmap that outlines the steps for AI adoption across all project management processes. This roadmap should include both short-term and long-term goals, investment strategies, and timelines for integration (Choudhury et al., 2024).

Training and Upskilling Project Managers: To fully capitalize on AI's potential, it is essential that project managers are adequately trained in AI technologies. Educational programs should focus on AI fundamentals, tools, and their applications in project management, ensuring that professionals can leverage AI insights to make data-driven decisions (Davenport & Ronanki, 2023).

AI Integration with Existing Tools: AI adoption should not require an overhaul of existing project management systems. Instead, AI should be seamlessly integrated into current project management platforms to enhance their capabilities without disrupting established workflows (Binns et al., 2023).

Data-Driven Culture: Organizations must foster a data-driven culture that supports the use of AI in project management. By encouraging data-driven decision-making, organizations can ensure that AI systems are used effectively to inform project decisions (Santos et al., 2024).

Collaboration Between AI Experts and Project Managers: Collaboration between AI specialists and project managers is essential for designing AI tools that are practical, intuitive, and aligned with the project's goals. This collaboration will enable the development of AI solutions that truly enhance project outcomes (Boakye & Agyei, 2023).

8.3 Ethical and Regulatory Considerations for AI Deployment

As AI becomes increasingly integrated into project management, it is crucial to address ethical and regulatory concerns associated with its deployment. One of the primary ethical concerns with AI in project management is ensuring that AI systems are transparent in their decision-making processes. Project managers should be able to understand and explain how AI systems arrive at their decisions to maintain trust and accountability (Rahwan et al., 2023).

AI systems must be designed to avoid bias, especially in critical decision-making areas such as hiring, resource allocation, and risk assessment. Bias in AI can lead to unfair treatment of individuals or groups, undermining the integrity of project outcomes (O'Neil, 2024). The use of AI in project management involves processing large amounts of data, including sensitive information. It is essential to implement robust data privacy measures and ensure compliance with data protection regulations such as the GDPR to safeguard project data (Zeng et al., 2023).

Organizations must stay informed about the evolving legal landscape surrounding AI deployment. There are several regulations that may affect AI usage in project management, including labor laws, data protection regulations, and industry-specific guidelines (Brynjolfsson & McAfee, 2024). Ensuring compliance with these regulations will be vital to avoid legal issues and safeguard organizational reputation. Although AI can provide valuable insights, human oversight remains critical in decision-making. AI should be seen as a tool that assists project managers rather than replaces them. Human judgment is essential to contextualize AI recommendations within the unique circumstances of each project (Müller et al., 2023).

As AI adoption accelerates, organizations must develop clear strategies, provide adequate training, and address ethical and regulatory concerns to ensure that AI tools are deployed responsibly and effectively. By taking proactive steps, organizations can unlock the full potential of AI to enhance project management practices and achieve more successful project outcomes.

9. Summary of Key Findings

The integration of Artificial Intelligence in project management has been demonstrated to significantly enhance decision-making processes. This study explored various ways in which AI tools can support project managers in improving efficiency, risk assessment, resource allocation, and overall project success. The key findings from this research are as follows:

AI-Driven Decision Support: AI has the potential to augment human decision-making capabilities by providing data-driven insights. By leveraging machine learning algorithms, AI systems can analyze historical data and predict potential challenges or opportunities, thus supporting timely and informed decisions.

Automation and Efficiency: AI facilitates the automation of routine tasks such as scheduling, budgeting, and progress tracking, which frees up time for project managers to focus on strategic decision-making and problem-solving.

Improved Risk Management: AI can assess project risks more effectively by identifying patterns and forecasting potential issues based on past projects. This helps project managers mitigate risks early in the project lifecycle.

Resource Optimization: AI assists in the optimal allocation of resources by analyzing project data and recommending the best use of available human, financial, and material resources. AI can lead to significant cost savings. AI tools enable better communication and collaboration among project teams by providing real-time data updates, thus improving coordination and minimizing misunderstandings or delays.

Ethics statement: Ethical clearance was not required.

AI statement: AI tools were not used.

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Technology, People and Processes in Universities in 2025: Is BYOD the Solution?

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Abstract: In recent years Technolog:y has been putting enormous pressure on higher education. The change has been being felt since the nineties and it became radical with the COVID-19 pandemic and the rise of artificial intelligence as ChatGPT. That change was felt among everyplace in the classroom which is our main unit of research. In this paper we describe that change and then analyse it within a conceptual analysis on the current situation and in the scope of three models of analysis; Bring Your Own Device – BYOD, Technology People and Processes - TPP and Head Hand Heart - 3H. We include other known ideas on Knowledge Management like those related to the types of knowledge logic, emotional and spiritual. In order to substantiate our findings, we perform a small Literature review using the SCOPUS database and known data. We conclude that the sharp and deep technical evolution poses a big challenge for higher education and that only if the Hand will be used intensively, the organizations will fulfil their mission in full – this conclusion brings into question the use of technology in the classroom. In this context, Bring your own device seems to be a very important model. However, its success is only guaranteed in higher education if coupled with a sound and wise application of the TPP model and of the 3H model. This idea put much responsibility on the lecturers but also on the students for the success of the institutions themselves. This idea is somehow original in the current times in which technology dominates the discourse. The paper is limited because we would need more empirical evidence to base our intuitions.

Keywords: Higher education, Knowledge management, BYOD model, TPP model processes. 3 H model

1. Introduction

This paper is written from the point of view of a university lecturer. Its aim is to analyse the introduction of technology in the classroom, put this fact into the current context – namely 2025, within a globalized economy, with internet, after the COVID-19 pandemic, and with massive Artificial Intelligence developments such as ChatGPT and try to derive some insight into future.

We believe that a good way to present the problem is to go a bit down memory lane. Therefore, we divide the timeframe into four parts: 1) early 20th century, 2) late 20th century, 3) early 21st century and, 4) the last years. Namely:

1. In most of the 20th century classes were somehow dull places. Students would use pen and paper to take notes. They could distract others by trying to speak with them, pass paper notes, or write on the colleagues' notebook. Students sitting in the last rows could have more freedom and be more difficult to control by the lecturers. What we will call external isolation was total because while in the classroom students and lecturers would not be in contact with the outside world. Also, internal isolation was very significant because it was difficult to contact other classmates – apart from using the paper notes.
2. Things began to change in the last decades of the 20th century when mobile phones were invented. At first only a small number of lecturers and students used them. Also, in the last two decades of the last century, devices such as the Walkman and the MP3 made it possible for students to hear music by themselves but the utilization of these mechanisms in classrooms was usually strictly forbidden. Therefore, the ambience could be cheerful but usually was quite boring and students continued to be confined to the classroom with no possibility of external contact. Also, the lecturer was also confined to the classroom and could not find any external help without leaving the premisses. The lecturers had little technology available, and the most common help was transparencies.

Quite curiously and as a side note we must refer that in the 20th century personal computers were almost non-existent and typewriters were the main machine that could replace handwriting. In this context, the first personal computers (Armstrad etc) that were made were desktop computers and it was not possible to carry them into the classroom. Also, in the 20th century the internet was making its first steps, there was no electronic

social media – social media at the time was the individuals' gossip circles, mouth to ear. Notes would be essential for students even if transparencies, exercises, summarised notes and textbooks were provided by the lecturers. The written notebook on paper was the main instrument of students.

3. Change began to increase in the early years of this century when mobile phones were invented. Suddenly it became possible for a student to be in the classroom and contact anybody outside by using an SMS; and also, it became possible for students to be in the classroom and send messages between themselves without the knowledge of the lecturer. The lecturer could also send and receive SMS messages while in the classroom, but this would most commonly not happen because of the distraction it may cause. For this reason, if a student would want to receive or to make a call, he / she would need to leave the room, the same for the lecturer. Anyway, the great and decisive novelty was that technology made it possible for people and mainly students to be in the classroom and maintain contact with the outside world – we would say the external isolation diminished - and it also made possible for them to contact between themselves while in class – we would say the internal isolation decreased also. We define external isolation as the possibility of being in a classroom and have contact with the outside world. We define internal isolation as the possibility of being in the classroom and contact other persons present in the classroom. Also, decisively in the first years of the 20th century, laptops came to exist, and although they were expensive and with limited capabilities – namely word processing – it became possible to take them to classes. Also, at the same time the internet began to exist, some platforms were created like Hotmail. In that time, PowerPoint slides become more and more widely used as a replacement to more traditional forms of lecturing – and this led to having less students taking notes and a decrease of the importance of written notebooks.
4. Finally, the tendency for a massive decrease both in external isolation and internal isolation was accentuated since 2010, with the development of smart phones, increasingly lighter and stronger laptops, increased access to the internet, new and bigger social media platforms like WhatsApp, and Artificial Intellgence tools like ChatGPT. In consequence, in current times, it is expected that in the classroom students will have their smartphone, as well as their laptop, and the same is true regarding the lecturer. Therefore, the probability of a student contacting members of their inner circle during a 60 to 90 minute lecture, is very large; students may also contact other students in the same class; students may access lecture related sites in the internet via smartphone or laptop computers; and students may contact sites with no relation to the lecture. The lecturer should not contact members of their inner circle during the class but may use the smartphone or the computer to search for some information that may be of relevance for the occasion. One of the ways the lecturer may use the improved technology is to ask the students to search for data using their own devices. This strategy effectively may give some rhythm and dynamic to the class, may have a positive effect on the group and also a positive effect on learning. Quite curiously, using that technique, the lecturer decreases the pressure of having to know all the data for a lecture beforehand, and by the same token increases the possibility of creativity. The creativity of the lecturer might pose a problem to the student because with all the technology available, laziness tends to increase, or at least there is more opportunity for it – i.e. if the lecturer writes something on the board that it is not in the PowerPoint slides, the student might take a photo using the smartphone. It is possible to be in the class listening to music due to improved headphones known as "ear buds". Of all the possible behaviours, making and receiving phone calls remains the limit and the line that must not be crossed. Consequently, in the post- Covid-19 and artificial intelligence world, very few students still take handwritten notes, and some use word processors in their computers to take notes.

All that was previously said is summarized in the following Table 1:

Table 1: One century of classroom evolution in a nutshell

	Early 20th century	**80s and 90s**	**Early 21st century**	**2010s Onwards**
Internal Isolation	Complete	Complete	Decreasing	Almost non-non-existent
External isolation	Complete	Complete	Decreasing	Almost non-existent
Mobile phones	Non-Non-existent	Very few	Vulgar	Smartphones
Computers	Not in class	Desktops	Some laptops	Strong laptops

	Early 20th century	**80s and 90s**	**Early 21st century**	**2010s Onwards**
Internet	Non-Non-existent	Beginning	Increasing	Dominant
Social Media	Non-Non-existent	Beginning	Increasing	Dominant
Work in class by students	Notes	Less notes, transparencies	Even less notes. PowerPoints'	Almost no notes. Photos. Internet or intranet
Type of material available	Handbooks	Transparencies	PowerPoints	Internet Artificial Intelligence

Source: Own elaboration

Having said that, the question that remains is – what are we heading towards, and how will this new reality be framed in social and economic terms. We will address this situation according to three models – Technology People and Process, Brain Head Hand and also the concept of BYOD – bring your own device. We will also discuss the situation within the known theories about Knowledge Management.

To achieve the objectives of this paper, we will develop our thoughts in the following sections – 2 Concepts, 3. Theory, 4. Data from the SCOPUS database, 5. Discussion, and 6. Concluding Comments.

2. Concepts

To address the problem defined in the previous section we need to make some initial statements:

- 1. The main concept of this paper is the Classroom, defined as the place (Ba, in Nonakas terminology) in which learning and knowledge creation and acquisition takes place; in this space a group of Students and a Lecturer evolve (Nonaka, 1988).
- 2. We define External Isolation as the possibility of the classroom being more or less isolated from the outside world – the classroom may be totally isolated from the outside world as in a written exam and in this case the external isolation will be maximum, or the students may use the internet and the mobile devices, in this case, the external isolation is minimal. Currently the only limit to external isolation is receiving phone calls, and sometimes listening to music, but this situation is more difficult to address by the lecturer
- 3. We define Internal isolation as the possibility of being in contact with other members of the public present in the room. In a written exam that possibility is minimal and during a regular class it is very wide given the connections that students are using like smartphones.
- 4. Depending on the models, the classroom experience should increase the competences of students (HRD perspective) (McGuire, 2014), their Intellectual Capital (IC perspective) (Edviinsson and Malone, 1987) or their Knowledge (KM perspective) (Nonaka and Takeuchi, 1995). In fact, the three perspectives complement each other (Tomé and Gonzales-Loureiro, 2014). In this paper we will address the KM perspective.
- 5. In the classroom there will be technology, people and processes (Edwards, 2010) as defined in the model explained in the next section.
- 6. Regarding technology and because each student has many different possibilities for using it, we in fact live in a Bring Your Own Device world. Even if the State or the University may provide technology to the students there is always an individual element defining the technology each student uses in the classroom.
- 7. When we address technology, we may refer to computers, mobile phones, the internet connectivity and social media; all these four elements are very important in shaping what happens in the classroom nowadays.
- 8. The kind of lecture may also vary a lot: traditional lectures, discussions, role playing, exercises solving or presentations of work by students being some of the possibilities).
- 9. The kind of support provided by the lecturer may also be very different as: slides, summaries, books, cases, movies etc.
- 10. The work made by students while in the classroom may also vary a lot: they may take notes, solve problems, take photos, or just listen, to the professor or to music using headphones or they just be distracted and having their minds far away even if their bodies are present.

- 11. While taking notes, students use their Hands, which are related to the Brain and also to the Heart. This very basic triad that is used by palaeontologists and by neurologists to explain the development of mankind from the apes to the Homo Sapiens, quite crucially could have important consequences in the results of the activity in the classrooms.
- 12. All what was previously described only applies to University and Higher Education institutions and not to primary or secondary schools

3. Theories

According to the TTP model, institutions may be defined by the technology they use, which decisively is to be combined with the human capital to get a good performance. (Edwards, 2010). That performance can only be achieved through processes. Therefore, in any organization the first phase of knowledge management implementation is based on technology; afterwards, suddenly administrators understand that machines are not everything that is needed and that the people must upgrade their competencies and skills in order to make the best of the technology available. Quite surprisingly, this tends not to be the end of the story nor of the problems. In fact, even with the best technology at the hands of the most competent people, organizations struggle because they have to find the right processes, and that need may cause significant organizational change (Edwards, 2010). From here follow all the relevant analysis on technology and change (Evenson Westphal 1995); and on the maturity levels about using technology even digital maturity in this 4.0 industry (Gill VanBoskirk 2016).

The Triple H approach states that to achieve balance in life individuals need to put together three dimensions – the Head is linked with rationality, the Heart is a dimension with emotions, and the Hand is about actions (Kohle, 2023). This model is very close to a very well-known approach on knowledge management which states that in every situation there is rational knowledge (logic), emotional knowledge (emotions) and spiritual knowledge (values) (Bratianu, 2017). The decisive apport of the Triple H model is the idea that actions matter and that without them no logic, emotions or values will materialize. This idea is very important in the context of higher education and particularly about what should be happening in the classrooms. Two other notes should be on the importance of the Hand:

Firstly, it is well known that the development of the human brain through millennia was closely related to the development of the use of the hands and the development of language. Therefore, the use of the hand is very important in education. Even further, in order to facilitate the memorization of matters and creativity, written notes are better than iPad or any kind of electronic summaries (Neupsky Key, 2023).

Secondly, following the work of neurologists, it is known that the brain and the heart are closely linked in the human species and the emotions and reason are associated. Therefore, we do not think first and feel secondly or vice versa, we think and feel at the same moment (Damasio, 1994). We believe and assume that also we might have values, at the same instant, and all this put together generates actions which in a class are basically developed using the hands. And when using hands the most basic and trivial and original ideas are made with pen paper and pencil only as stated above.

4. Data From the SCOPUS Database

We searched the SCOPUS database for papers on TPP model, 3H model and BYOD. The result of the search is shown below in succession:

4.1 The Model of Technology People and Processes

We only found six papers in SCOPUS using Technology, People and Processes as a framework and related to the Social Sciences or to the Business Management and Accounting fields. The most recent reference was dated from 2024 and generically related to data, AI and Trust for costumers (Kihn and Lin, 2024). One paper was about information literacy Del Massa, Damian, and Valentim, (2018) and the other about knowledge systems Sharma, Gupta, and Wickramasinghe (2005). The other papers addressed very specific economics fields; Civil Engineering (K. Witt, E. Lill, I. Banaitienė, N. Statulevičius, M, 2022) nuclear plants (Kovesdi, C.R. Le Blanc, K.2020) and property management bty local authorities (Malaysia Razali, M.N. Ramlan, R. Manaf, Z, 2006).

Therefore, we reach the idea that, rather surprisingly, the TPP model has not been used to address the question of higher education in current times. This fact offers researchers a very nice opportunity.

4.2 The Model of Head, Heart and Hand

We found 19 papers in SCOPUS using this model and related to the Social Sciences or to the Business Management and Accounting fields. Szelwach, and Matthews, (2023) addressed the pos-Covid-19 reality and proposed "embodied organizational development" as a mixture of "*Thinking (Head), Feeling (Heart), Doing (Hands), and Being (Whole Body)".* This idea is very close to the theoretical ideas we exposed in the previous section and is very relevant for whatever the future will be in Higher Education. In this context "embodied cognition" was put forward by Rittelmeyer (2022) as a new way of pedagogical success amplifying the 3 H model. Futhermore, Nonet, Dobreva and Meijs 2022) consider 3 H is fundamental in order to make business schools more in line with the 2030 Sustainable Development Goals and to move them from a students' individualist perspective to a perspective with multiple contexts of wellbeing: individual, collective and planetary. Furthermore, the 3H model was studied on health professional students with high impact on self-reflexivity (Mills, Creedy, Sunderland, Carter, and Corporal, 2022); on international visiting scholars it was used to establish the importance of transformative learning and the process of learning (Zhao and Liu 2022) and it was also successful on the mentorship relation between instructors and students (McCullough and Pelcher, 2021). The model is seen as important to design the future of art schools away from scholastic universities to more ethical and creative institutions with the help of "humour" (Woods, 2021). This idea is very much linked with the KM theories on kinds of knowledge (Bratianu 2017). The model was also used as a measure of the possibilities of the improvement that robots and visual programming may make in STEM education (Blackley and Howell and 2019). Another experiment analysed the impact of the model in environmental and natural sciences learning (Jagannathan, Camasso,Delacalle 2018) in science knowledge and grades in mathematics, science and language arts. Also, and closely linked to the last paper we mentioned, the model was tested as a way to improve science teaching for engineers (Panthalookaran, 2017). The same positive effect was observed regarding the human rights law curriculum (Smith,c2013) environmental education using art (Deverman, 2005) and on theology studies (Masson, 1986). Finally, the model was also tested in primary schools (Liu, 2024) foster care (McDermid, Trivedi, Holmes, and Boddy, (2022) nurse mentoring (Jangland, Gunningberg, Nyholm, 2021) local citizens namely as teachers, experienced farmers or fishermen, unemployed youths with a certain educational background, and students (Eto, 2018).

Therefore, we found many insights on the use of the 3H model in higher education and many links to traditional KM theory (Bratianu, 2017).

4.3 The Concept of Bring Your Own Device

In the SCOPUS database we found 17 papers published since 2020 on the concept of BYOD in higher education and related to Social Sciences and Business, Management and Accounting. BYOD is seen as a feature of Industrial Revolution 4.0 (Vakeel, Kaushik, Dwivedi, 2023). BYOD can be seen as an important tool to foster learning and engagement (Demeke, 2023). However, some problems and complications exist with the solution: in one hand there are cybersecurity issues (Moloja, Ngqondi, Mpekoa, 2024) and technical issues (Masilo, Simelane-Mnisi, Mji, and Mokgobu 2021) and in the other hand affordability and compatibility (Fioravanti,. Ozimek, Rodriguez, Crothers, Dielmann, 2024) the potential for inequalities (Clark, Welsh, Mauchline, Whalley, and Park, 2023) were also described as concerning situations. A solution for the implementation of BYOD would be discussions between and joint effort of students and managers (Santos. Bocheco, Vizzotto, Moro, 2021). Teachers should decide it they want to use BYOD in a traditional or in a constructivist way and adapt the classes accordingly. Within a social constructivism way of teaching student learning may be enhanced through the use of smartphones as a tool to promote collaborative learning (Lötter, Jacobs, 2020). Finally, the students' context, culture and main stakeholders' opinion should also be taken into consideration (Santos, Bocheco, 2020).

An evaluation on the effect of BYOD in the wellbeing of students gave mixed results pointing to the fact that that the implementation was decisive (Al-Said, 2023). One study found that BYOD would increase motivation and autonomy of students (Sánchez, López-Belmonte, Moreno-Guerrero,. Sola Reche, Cabrera. 2020).

Therefore, BYOD is seen as a very possible model for higher education nowadays, and the use of technology depends very much on the way it is done and on the posture of the lecturer. Social constructivism may be a decisive way of making students benefit from technology in the 21st century.

5. Discussion

If we put together the facts described in the Introduction with the concepts, theories and data enunciated after, we end up with the very interesting conclusion that the use of technology in the classrooms might be very useful, when it is compounded with 3H strategies and when Processes became more important than people or

technology. This idea put much responsibility on the lecturers but also on the students for the success of the institutions themselves. Given that BYOD seems to be a "fait accompli" because students are free to bring almost all technology to the class, and therefore the problem is how to benefit from this technology. In this context, the consideration of the three types of knowledge described by Bratianu 2017, coupled with the 3H model seem to be the best way to ensure the greatest application to the TPP model.

We only deal with University and higher education because it is the one we know better by our experience, but if we would have to extend the analysis to secondary or primary schools we would say that the problems are even greater at those levels because the students are less informed about on how to use technology correctly for their own benefit and therefore, the potential for damage that technology may have in their own upbringing and education is far greater than in higher education.

We do not deal with assessments, but we believe that Chat GPT makes one to one and written old school assignments necessary for undergraduates. Regarding Masters or PhDs, essays may be an option, but close monitoring is essential because the voice of the student must be apparent in the work. If we ask 10 students to describe the white wall that stands on the back of the classroom, they will write ten things differently and if we know them enough we will be able to assign each description to the right student. It is this type of social knowledge and complicity that we need to prevent that very soon Universities will become a chaotic and non-ethical space dominated by fraudulent use of technology. Because "bad money expels good money" in this case the future of universities will be doomed but we sincerely do not hope and believe this will happen because ethics will prevail.

6. Concluding Comments

There is no escaping to the fact that technology is here to stay and will inevitably increase in the near future in societies and in classrooms. In this context, Bring your own device seems to be a very important model. However, its success is only guaranteed in higher education if coupled with a sound and wise application of the TPP model and of the 3H model. This idea put much responsibility on the lecturers but also on the students for the success of the institutions themselves. These ideas have already been expressed sparsely and we put them together for this paper. A new equilibrium of cognition in learning will emerge that will most probably lead to a change in the organization of lectures and of the classroom. As a future study we propose a big mixed study to test our model empirically.

Ethics declaration: No ethical clearance was needed for the research referred to in this paper.

AI declaration: No AI tool was used in the development of the paper. We used conventional techniques like laptops, google search, all human based.

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Beyond SECI Model: Custodian–Successor Roles in TK Transfer in Construction Academia

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Abstract: This paper presents the first results of a doctoral research project on the management of scientific tacit knowledge of employees with long scientific seniority (LSS), defined as 25+ years post-doctorate, focusing on knowledge transfer in the academic environment related to construction. The primary goal of this doctoral research is to create a model that supports the transfer of LSS tacit knowledge to other employees. The research question is: How should the tacit knowledge of LSSs be managed to preserve and pass their legacy on to younger generations? The SECI knowledge spiral model was adopted as the foundation for the development of the proposed model. However, the classical SECI framework has been extended by incorporating two critical roles: The Custodian, responsible for preserving, structuring, and documenting the tacit knowledge of LSS; and The Successor, an individual actively acquiring and applying tacit knowledge in practice, ensuring its continuity in scientific work. The model was developed based on a triangulated research approach combining an online survey, in-depth interviews, and an extended literature review. Thirteen research organisations participated in the study: six from Poland and seven from Europe. 52 completed surveys were obtained (100%) and 51 interviews were conducted (98%). The results were subjected to both qualitative and quantitative analysis. The proposed model operationalises tacit knowledge transfer through a structured process aligned with the SECI phases: socialisation, externalisation, combination, and internalisation, adapted to the realities of scientific institutions. It introduces mechanisms for actively acquiring and preserving knowledge through a combination of traditional methods such as mentoring and coaching, and modern technological solutions, ensuring that the legacy of experienced researchers remains accessible and functional for future generations. This study contributes by proposing a structured, role-based framework that enhances the practical applicability of tacit knowledge management in construction academia. The paper concludes by discussing the practical applications of the model and its potential for broader adaptation to knowledge-intensive institutions.

Keywords: Tacit knowledge management, Long Scientific Seniority (LSS), Knowledge transfer, Construction academia, SECI model adaptation

1. Introduction

1.1 Background

Tacit knowledge (TK) has always been an asset for a competitive advantage. In times of advantageous technological solutions, we look at the organisation's resources more carefully than before. In the case of science, the situation is slightly different; there are some commonly known foundations, but there is also tacit knowledge relating strictly to science. This study aims to introduce the concept of scientific tacit knowledge in construction and a model supporting its transfer.

The research topic stems from the author's professional experience related to her work at the Building Research Institute (ITB) since 2016. The ITB is an esteemed Polish institution with a rich 80-year history of pioneering construction research that maintains a diverse team of over 300 employees. Two opposing mechanisms of tacit knowledge management have been observed in the ITB. The first mechanism concerns the challenges of transferring knowledge from senior researchers because their impending retirement may result in a significant loss of expert knowledge. The second illustrates the successful acquisition of tacit knowledge through interactive observation, a process that the author experienced personally during her cooperation with the scientific secretary of ITB, an outstanding scientist in the field of civil engineering.

The main focus of this study is an employee with long scientific seniority (LSS), an individual who obtained a PhD degree at least 25 years ago (for this study, 1999 and earlier), and tacit knowledge relating to the field of construction science. This field is characterised by a conservative and formal approach, resulting from the obligations involved in designing and erecting buildings. This attitude can hinder knowledge diffusion. In addition, tacit knowledge can be an essential resource for further development of construction science.

1.2 Research Focus

1.2.1 Scientific gap

The noticed scientific gap refers to the primary process of sharing scientific tacit knowledge (and, more broadly, other processes) by LSS employees, who, thanks to their unique life, professional, and scientific

experience, have unique scientific tacit knowledge, which translates into high scientific and research potential. The determinant here is not the employee's age, but his or her scientific experience counted from the year of obtaining a doctoral degree. Construction is a field characterised by formality and conservativeness because of the obligation to design and erect buildings. In this context, the tacit knowledge of construction scientists, which is a combination of experience, skills, and engineering intuition, is an important resource that can influence the development of scientific knowledge in the field of construction.

1.2.2 Research problem definition

The primary aim of this study was to develop a model that will support the management of scientific tacit knowledge of LSSs in scientific institutions in the field of construction science. This tacit knowledge can be a foundation for future studies, giving younger researchers a plethora of guidelines and ways of conducting research that have been proven through time. The main research question of this study is: “How should the tacit knowledge of LSSs be managed to preserve and pass their legacy on to younger generations?”

2. The Theoretical Foundations

2.1 The SECI Model

Nonaka and Takeuchi’s (1995) SECI model was chosen as the best model for managing and transferring tacit knowledge. It conceptualises knowledge creation as a dynamic and continuous process, structured into four modes of knowledge conversion: Socialisation, Externalisation, Combination, and Internalisation. Socialisation involves sharing tacit knowledge through shared experiences, whereas Externalisation transforms tacit knowledge into explicit concepts using dialogue, metaphors, and models. Combination integrates and systematises explicit knowledge to create new knowledge structures, whereas Internalisation enables individuals to absorb explicit knowledge and convert it back into tacit knowledge through practice and experience. The model emphasises the interplay between individual and collective learning processes, highlighting the importance of context, interaction, and organisational support in fostering innovation and knowledge retention.

2.2 Scientific Tacit Knowledge

Several studies on scientific tacit knowledge (STK) exist in different research contexts but not specifically in construction. Collins (2001) indicated that tacit knowledge is essential for replicating complex scientific experiments, particularly in physics. He highlighted personal contact and social interactions, particularly in complex experimental settings. Senker (1995) associates’ tacit knowledge with cognitive concepts, such as schemata, paradigms, and mental models. Starikova and Sereda (2023) suggest that tacit knowledge is structured according to specific problems, indicating a systematic role in scientific cognition. Carsten Conner et al. (2018) emphasise the role of mentorship and apprenticeship, primarily associated with being a field scientist. The author defines scientific tacit knowledge as subjective knowledge inextricably linked to the researcher and the scientific context in which they operate. It is acquired in the process of scientific and cognitive studies and research, including experiences, experiments, trials, informal observations, laboratory or field practices, and conclusions, reflections, and value judgments collected on this basis. It manifests itself as a subjective view and assessment of an objectified research process aimed at reaching the essence of scientific truth, influencing the findings of the process. It includes practical skills, research strategies and procedures, and contextual and interpretative understanding, which are crucial for conducting research but are difficult to convey to others. No publications were found referring to scientific tacit knowledge in construction. However, it should be noted that the definition of tacit knowledge in construction has been defined by Pathirage et al. (2008) as "understanding, abilities, skills and experience of the person concerned; often expressed in action as thoughts, viewpoints, evaluations, and advice; produced and acquired by past experiences [...]".

3. Methods

3.1 Research Design

A qualitative approach was adopted in this study. The following methods have been utilised:

- Review and critiquing the literature
- Online questionnaires (pilot and main survey)
- In-depth interviews
- Literature review

The study employs methodological triangulation (Denzin, 1978)—combining an online survey with in-depth interviews—and theoretical triangulation by contrasting the empirical results with insights from a focused literature review on barriers to tacit knowledge management in academic settings

The pilot study was conducted in December 2023. The main online survey was conducted from March 2024 to November 2024. The in-depth interviews were conducted from April 15th, 2024, until March 11th, 2025.

3.2 Sample Selection

The research has been conducted across 13 scientific institutions, six from Poland and seven from European countries. Five research institutes were involved (two from Poland and four from Europe) and eight construction faculties of polytechnics/universities. A purposive non-random sampling strategy was adopted, which included:

- 16 LSS individuals
- nine individuals serving as LSS leaders, L-LSS
- 27 individuals cooperating with LSS, C-LSS

The pilot online survey was conducted in one Polish research institute, and the main survey and the in-depth interviews were conducted in all 13 scientific institutions.

3.3 The Online Survey

Firstly, the anonymous pilot survey was conducted in one Polish institution (Tomiczak, 2024). As a result, some changes were introduced to the actual questionnaire, adding more context and detailed descriptions to ensure a better understanding of the questions. The actual online survey was designed in Polish and English using the startquestion.com website. The survey questionnaire consisted of 94 questions divided into five Areas: I. Statements concerning the awareness of hidden knowledge; II. Statements concerning personal motivation to share (or not) the LSS persons' tacit knowledge; III. Statements concerning traditional vs innovative approach; IV. Statements concerning the organisation's support for knowledge sharing; V. Statements concerning generation diversity management. The respondents were asked to rate the statements on a Likert scale (1-5), where one means "I strongly disagree" and five means "I strongly agree." There were no restrictions on the time needed to complete the survey, and the survey was anonymous. As there were three different groups of respondents, the questions in the first two Areas were differentiated according to the role of the individual. The remaining three Areas were identical for all the groups. At the end, there was a space for comment on the survey, and so-called metrics for each group. The questionnaire was sent as a PDF document a week before the link to the survey was sent so the individuals could have more time to familiarise themselves with the statements. The main goal of this survey was to explore how the LSS persons and their knowledge are perceived in the construction academia environment. Based on the results from this survey, the questionnaire for in-depth interviews was designed.

3.4 The in-depth Interviews

The questionnaire for the in-depth interviews, in Polish and English, consisted of a glossary of terms used in the interview and seventeen open questions. There were two versions of the questionnaire: one for LSS persons and one for leaders and co-workers of LSS persons. The questionnaire was sent to an individual a week before the interview. The online interviews were conducted when only one individual from the institution was involved in the interview, or there were unforeseen problems. The maximum assumed duration of the interview was 2.5 hours. The main goal of the interviews was to deepen the understanding of the LSS's role in the organisation and the ways of involving LSS persons in the daily activities connected to sharing tacit knowledge – from different perspectives, but also to understand the impact of the organisational environment.

3.5 The Literature Review

Two databases were used for this review – Scopus and Web of Science (WoS). The research question was: "What are the key challenges and barriers in the application of knowledge management in research and academic institutions, and how do they vary across different employee groups and knowledge-intensive roles?" The following inclusion criteria were used: only papers in English published between 2013 and 2025; Areas: Business, Management and Accounting, Social Sciences, Decision Sciences, Psychology, keywords: "knowledge management," "knowledge sharing," "knowledge transfer," "knowledge-sharing," open access: green and gold. The exclusion criteria were Areas of Computer Science, Economics, Econometrics and Finance.

The result in Scopus was 991 papers. Then, abstracts of those papers were screened using the keyword "knowledge management" in the title or abstract (using the Zotero tool). The result (updated on March 3rd, 2025) was 457 papers. Twenty-six articles were removed due to unavailability of the full text. In the next stage, 431 papers from the Scopus database were considered. The result of the research in the WoS database was 65 papers. After removing the duplicates (four papers) and one retracted paper, 491 papers from both databases were selected for the deeper review.

4. Results

4.1 The Research Sample Structure

Fifty-two individuals from 13 institutions took part in the study. 37% of participants were from European institutions, and 63% were from Polish institutions. Below (Fig. 1, Fig. 2) is the summary of data characterising the research sample in more detail.

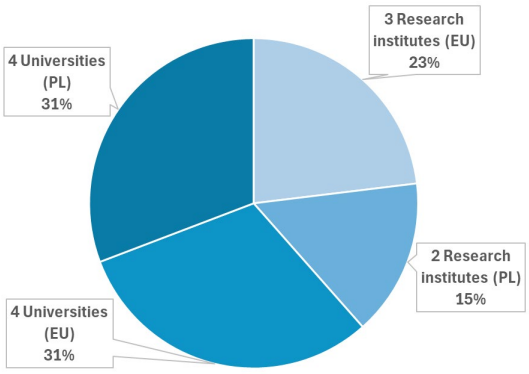


Figure 1: Research sample structure by institution and region

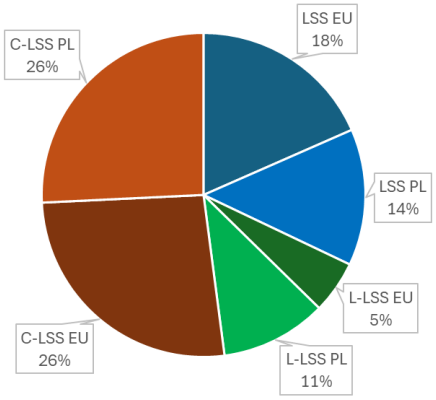


Figure 2: Groups of participants split

The smallest group of respondents is the leaders of LSS persons due to the specific nature of the university's activities, where the LSS person often serves as a leader. It should also be noted that some European institutions were represented only by one individual - two LSS and one C-LSS person.

4.2 Survey Results

A complete set of 52 completed questionnaires from thirteen institutions was obtained: 33 from Poland and 19 from European institutions. There is a common agreement that the LSS person is an authority and an expert in the field of construction – their tacit knowledge is essential, they have unique skills that are very helpful for the team, and their knowledge and experience are valuable as the foundation for the future development of younger generations. The responses of co-workers of LSS persons in European institutions were slightly different from those of other groups – the responses "I don't know" were more frequent here. The main discrepancies in the responses were Area I. (Awareness of hidden knowledge) and Area II. (Personal motivation to share (or not) LSS's hidden knowledge). These themes were then developed through in-depth interviews. There was a general agreement between Polish and European institutions regarding the statements in Area III. (Traditional vs. innovative approach), Area IV (Organisation's support for knowledge sharing), and Area V. (Generation diversity management).

4.3 IDI Results

Fifty-one interviews were conducted: 46 on-site (90%) and five online (10%) interviews using the MS Teams application. Fifty interviews were recorded, and transcription was performed using the AI tool Turboscribe, adding notes from the interview that was not permitted to be recorded. The interviews revealed key insights into tacit knowledge transfers. Respondents emphasised the fundamental role of effective communication and informal interactions in transferring TK. Mentorship, especially through joint projects, observation, and structured support, was considered central. Institutional support was highlighted, mainly in recognising and rewarding LSS persons and providing networking platforms and interdisciplinary collaboration. The participants emphasised that TK is deeply rooted in intuition and the ability to recognise patterns, which enables experienced researchers to foresee long-term scientific trends. There is also a need to develop new knowledge documentation methods including digital repositories and AI-driven platforms. Additionally, encouraging curiosity-driven questioning and interdisciplinary collaboration serves as a catalyst for innovation.

4.4 Literature Review Results

After screening 491 papers by Elicit, 40 were analysed using the tool. Subsequently, the Excel file generated by Elicit was manually reviewed, and seven publications that best matched the research criteria were selected. Five of them are strictly academic environment, one focus on engineering industries and one is about knowledge hiding. The main findings, with repeated barriers described by various authors, are in the Table 1. Additionally, Riege (2005 as cited in Liu, 2021) indicated low awareness of the value of knowledge and problems resulting from diversity (age, gender, experience) as possible barriers. Mabey and Zhao (2017) explored five paradoxes of knowledge exchange, of which *Paradox 1: the more knowledge is formally managed, the less likely effective knowledge exchange will occur* is especially worth noticing.

Table 1: Repeating barriers in sharing tacit knowledge as indicated by various authors

Barriers in sharing tacit knowledge	Authors
Lack of top management support	Kanyundo et al. (2023), Fullwood et al. (2019), Thi Chung & Thi Tram Anh (2022)
Lack of trust	Fullwood et al. (2019), Thi Chung & Thi Tram Anh (2022), Riege (2005 as cited in Liu, 2021)
Lack of time	Fullwood et al. (2019), Riege (2005 as cited in Liu, 2021)
Lack of motivation / rewards	Kanyundo et al. (2023), Thi Chung & Thi Tram Anh (2022), Riege (2005 as cited in Liu, 2021)
Cultural (organizational) problems	Fullwood et al. (2019), Riege (2005 as cited in Liu, 2021)
Problems with organizational structure	Fullwood et al. (2019), Alves & Pinheiro (2022), Riege (2005 as cited in Liu, 2021)
Employee reluctance to share knowledge	Kanyundo et al. (2023), Fullwood et al. (2019), Riege (2005 as cited in Liu, 2021)
Importance of direct (face-to-face) contact	Alves & Pinheiro (2022), Mabey & Zhao (2017), Fullwood et al. (2019)

5. Presentation of the Model

5.1 Key Roles in the Model

Based on the survey, interviews, and literature review results, new roles have been defined for the SECI model to transfer the scientific tacit knowledge (STK) of persons with long scientific seniority (LSS), also defining the LSS person criteria in the field of construction science in more depth.

The LSS person is an individual with extensive research experience (over 25 years since obtaining a PhD) and scientific practice who, through long-term scientific activity, has acquired unique tacit knowledge in the field of construction. The tacit knowledge of LSS individuals includes the ability to interpret data and derive conclusions deeply; a profound contextual and interpretative understanding of scientific processes; and unique technical competencies resulting from years of observation, experimentation, and solving scientific problems. Common characteristics of LSS persons are advanced formal education in construction (and related fundamental sciences) in-depth knowledge of scientific literature related to construction; the ability to recognise patterns and structures related to science; the ability to simplify complex statements through the

use of analogies and metaphors related to everyday life; extensive experience in expert evaluations, meaning the practical verification of scientific theories and an extensive network of professional and scientific contacts.

The Successor regards the LSS person as a master and mentor, seeking to acquire the LSS's tacit knowledge because they consider it valuable and necessary. The Successor recognises the need to utilise this knowledge for personal and scientific development, including their own fields of research. The Successor intends to and declares a commitment to continuing the LSS approach: thoughts, ideas, and paradigms.

The Custodian values LSS tacit knowledge and strives to collect and preserve as many resources documenting this knowledge as possible. The main duties of the Custodian include managing digital libraries containing recordings of LSS seminars, lectures, webinars, podcasts, and interviews; collecting and organising LSS scientific publications, aiming for their complete digitisation; recording and integrating into the system's informal practices or statements conveyed by the Successor, structuring, sorting, and categorising them; and disseminating the LSS's legacy.

The Leader is the direct supervisor of the team, in which the LSS, Successor, and Custodian work. As the primary representatives of the employing institution, they are responsible for the organisational forms and conditions of collaboration, including technological aspects. The main tasks of the Leader include identifying and recruiting participants of the process; creating a space for knowledge exchange by organising various forms of interaction—both individual and team-based; supporting the knowledge transfer process by selecting technological tools, establishing rules for knowledge documentation, organising meetings in on-site, remote, and hybrid modes, and defining online and offline communication channels; and fostering an organisational culture that promotes knowledge exchange.

5.2 Model Description

Following the classical SECI model, each phase was assigned specific roles, activities, and tools to transfer the hidden knowledge of the LSS person.

SOCIALISATION is a phase in which the scientific tacit knowledge of the LSS person transforms into the scientific tacit knowledge of the Successor. The main goal of the socialisation phase is for the Successor to assimilate LSS tacit knowledge through shared experience. **EXTERNALISATION** is a phase in which the scientific tacit knowledge of the LSS person transforms into scientific explicit knowledge. The main goal of this phase is to trigger scientific tacit knowledge through conversations and discussions between the LSS person and the Successor. **COMBINATION** is a phase in which the scientific explicit knowledge of the LSS person transforms into scientific explicit knowledge. Scientific tacit knowledge has been externalised, allowing the Successor to develop new knowledge based on it. A Custodian is responsible for the storage and dissemination of the LSS person's knowledge. **INTERNALISATION** is a phase in where scientific explicit knowledge gained from the LSS person transforms into scientific tacit knowledge of the Successor. The Successor can convert LSS's scientific tacit knowledge, enriching their own tacit knowledge and laying the foundation for new scientific knowledge in the field of construction science. The roles and main tasks in each phase of the SECI model are presented in the Table 2 below.

Table 2: Role Distribution in the Author's Model of Scientific Tacit Knowledge Transfer

ROLE	SOCIALISATION *tacit → tacit*	EXTERNALISATION *tacit → explicit*	COMBINATION *explicit → explicit*	INTERNALISATION *explicit → tacit*
LSS PERSON	Act in accordance with their STK and simultaneously share it through mentoring, joint activities, observation, and informal conversations.	In response to the Successor's questions, they explain informal practices, provide a research context, and explain their principles of conduct. As a result, there is a joint reflection with the Successor. They conduct seminars where they share their STK with the broader community.	Provide written but unpublished materials related to scientific activities. Review materials prepared by the Custodian and Successor. Support knowledge classification and structuring.	As a mentor, they help interpret past research failures and support the application of knowledge in practice. Adapt their researcher's workshop concerning the knowledge acquired from the Successor and the Custodian (learns from students).

ROLE	SOCIALISATION *tacit → tacit*	EXTERNALISATION *tacit → explicit*	COMBINATION *explicit → explicit*	INTERNALISATION *explicit → tacit*
SUCCESSOR	Learn through observation, collaboration, and participation in research activities alongside the LSS.	They trigger the LSS's STK by asking questions. It leads to joint reflection with the LSS. Together with the Custodian, they document and preserve STK acquired through observation, collaboration, and conversations.	Integrates scientific knowledge from various sources, including the LSS's STK, and creates its own tools and procedures. They categorise and organise the documented STK, adding structure and classification. Support the Curator in developing training and information materials on the LSS's STK.	Applies LSS's methods in practice and transforms explicit knowledge into tacit knowledge through experience and independent research activity - automating activities acquired from the LSS. Develop their own STK. Eventually became a *mentor* in a chosen area for less experienced staff.
CUSTODIAN	Observe the collaboration between LSS and Successor. Take notes of the remarks.	Record seminars led by the LSS. Together with the Successor, document STK (including procedures, principles, and checklists).	Digitises and provides access to materials related to LSS's STK. In cooperation with the LSS and Successor, develop training and informational materials.	Acquire competencies in preserving and disseminating LSS's STK. Improves own methods of handling STK. Eventually became a *scientific knowledge architect*.
LEADER	Create organisational conditions and environment for collaboration between LSS and Successor; promote a culture of knowledge sharing and intergenerational cooperation.	Initiate and organise seminars conducted by LSS. Provide necessary tools to preserve acquired STK. Motivates process participants to share knowledge.	Oversee the collection and integration of explicit knowledge within the institution; ensure alignment with knowledge management strategy. They monitor the process of transforming data into organisational knowledge – e.g., reports, guidelines, and regulations. Provide the necessary tools.	Implement documented STK as organisational standards, update team and research management strategies. Evaluate the effectiveness of the process.

Table developed by the author based on the SECI model (Nonaka & Takeuchi, 1995) adapted to the context of scientific tacit knowledge transfer in construction academia.

5.3 Organizational Environment

In an organisation, several variables can influence the effectiveness of the model. A culture of openness, stable employment, active leadership, flexible structures, and incentive systems support this process. Conversely, siloed thinking, high staff turnover, disengaged leadership, bureaucratic structures, lack of recognition, inadequate infrastructure, and generational or technological resistance can significantly hinder knowledge-sharing and succession efforts.

6. Discussion

This study highlights the importance of tacit knowledge transfer within construction academia and the necessity of a structured, role-based approach. Informal mechanisms such as observation, mentoring, and shadowing remain central to successful knowledge transfer. Institutional support, including leadership engagement and technological tools, is crucial for preserving the scientific legacy of employees with long scientific seniority (LSS). The proposed Custodian–Successor model adapts the SECI knowledge creation process to the specific requirements of construction science.

The literature review (Section 4.4) identified several organisational, cultural, and individual barriers to tacit knowledge sharing. These include lack of leadership support (Kanyundo et al., 2023), organisational culture issues (Fullwood et al., 2019), limited awareness of knowledge management importance (Kanyundo et al., 2023), and the critical role of trust and face-to-face contact (Thi Chung & Thi Tram Anh, 2022; Alves & Pinheiro, 2022; Mabey & Zhao, 2017).

The findings of this study largely confirm these observations. Participants indicated that leadership engagement and organisational support play crucial roles in facilitating tacit knowledge transfer. Similar to

Kanyundo et al. (2023), a lack of formalised structures and incentives was perceived as a barrier. However, the study context in construction academia highlighted that while leaders' presence is important, it is their integrity and ability to foster an environment of collaboration — rather than traditional hierarchical authority — that enables effective knowledge sharing, aligning with Fullwood et al. (2019).

Trust, extensively discussed by Fullwood et al. (2019) and Thi Chung & Thi Tram Anh (2022) as a key enabler of knowledge sharing, was also relevant in this study. However, the findings suggest that among Long Scientific Seniority (LSS) persons, trust developed naturally through long-term cooperation, shared experience, and professional reputation. In this group, trust was an intrinsic characteristic rather than externally enforced. It should be noted, however, that broader barriers related to trust and willingness to share knowledge may still exist within the wider construction academia environment, beyond the LSS population analysed in this study.

The importance of face-to-face interaction and informal encounters in promoting tacit knowledge sharing, as stressed by Alves & Pinheiro (2022) and Mabey & Zhao (2017), was strongly confirmed. Participants consistently emphasised the role of joint projects, direct mentoring, and daily collaboration as crucial mechanisms for transferring non-codified expertise. These findings also reflect the paradox described by Mabey and Zhao (2017), where increasing formalisation of knowledge management can reduce the effectiveness of knowledge exchange. The Custodian–Successor model addresses this challenge by structuring support roles while preserving the informal, relational nature of tacit knowledge transfer.

Organisational structure was perceived as supportive of knowledge sharing when flexible and integrative, resonating with the findings of Alves & Pinheiro (2022). However, the lack of formally assigned roles or programmes for structured transfer of tacit knowledge was evident. While the existing literature addresses informal mentoring and communities of practice (Mabey & Zhao, 2017; Fullwood et al., 2019), no explicit role-based framework had been proposed.

Therefore, a significant contribution of this study is the introduction of the Custodian and Successor roles, operationalising tacit knowledge transfer in construction academia. Unlike previous approaches focusing on environmental factors or informal practices, this model offers a structured pathway for managing and sustaining scientific tacit knowledge within institutions.

7. Conclusions

7.1 Main Conclusions

The main conclusions of this study are as follows:

- This study confirmed that LSS employees often do not perceive their scientific tacit knowledge as unique or require structured preservation. This highlights the need for awareness-raising efforts by institutions.
- Informal learning mechanisms, especially observation, shadowing, and everyday cooperation, remain critical for internalising tacit knowledge. Organisations should cultivate environments that enable natural interactions.
- Institutional support, both cultural and infrastructural, is essential for effective tacit knowledge transfer, including providing appropriate tools, time, and incentives.
- Technological tools such as digital repositories and AI-based platforms should complement interpersonal transfers by capturing elements of tacit knowledge that may otherwise be lost.
- A new role-based model for scientific tacit knowledge transfer was developed based on the SECI framework and was adapted to the context of scientific institutions in the construction field. It defines four complementary roles: LSS (knowledge holder), Successor (learners and integrators), Custodian (preservers and disseminators) and Leader (facilitators and organisers). The success of tacit knowledge transfer depends on the synergy between the four roles. Each actor has distinct tasks that must be supported structurally, technologically, and culturally within the organisation.
- Leadership engagement is a fundamental factor. Without clear prioritisation from leaders, the transfer of tacit knowledge may remain incidental rather than strategic, limiting organisational value and sustainability.

7.2 Limitations

This study has some limitations. First, the research was mainly qualitative, and the participants' statements, despite their efforts, could be subjective. Second, the research focused on scientific institutions related to

construction in Poland and Europe, which may not translate directly to other geographical and scientific areas. Third, the proposed role-based model has not yet been tested under practical conditions; therefore, its effectiveness remains to be verified under real institutional conditions.

7.3 Implications and Future Research

The results of this study have theoretical and practical implications. The proposed role-based model offers a structured approach to managing scientific tacit knowledge, especially in scientific institutions in the field of construction. Institutions can use this framework to design more purposeful and sustainable knowledge transfer processes, particularly when working with LSS employees. The author plans to test the model in a pilot scientific unit to assess its effectiveness.

Future research directions may include, among others, the role of digital and AI-based tools in supporting the transfer of tacit knowledge, and the role of leadership styles and organisational culture for the transfer of tacit knowledge in the realities of the 4.0 economy and increasingly common remote work.

Acknowledgments

The work is financed from the Building Research Institute's (ITB) own research fund, SN-001.

Ethics declaration: Ethical clearance was not required for the research

AI declaration: I used the following AI tools in the development of the paper: Turboscribe (turboscribe.ai), Elicit tool (elicit.com), ChatGPT (chatgpt.com), and Grammarly. Turboscribe was used to prepare transcripts from previously recorded interviews in English and Polish. Transcriptions were performed in English and Polish languages. Elicit was used to screen papers selected manually by the author from the Scopus and WoS databases. During the analysis process, Elicit was used again to indicate papers that best matched the research question with manually added criteria. Afterwards, the report prepared by Elicit was used to identify the main themes, including citations of the papers. The author read the papers indicated in the References section, and the conclusions were added to the main findings of the literature review. ChatGPT was used to determine the style of the references, edit and paraphrase the selected content. Grammarly was used to check linguistic correctness - spelling, punctuation, and grammar, followed by native-speaker proofreading. AI tools are used solely as support instruments, not as original content sources or scientific opinions.

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Logistics Outsourcing as a Strategy for Business Efficiency: Mediating Role of ICT

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Abstract: The purpose of this article is to validate the impact of logistics outsourcing, a strategy that has become much more relevant in recent years, on business efficiency, as well as to investigate the mediating role of information and communication technologies in this relationship. The following investigation bases on the premise that logistic outsourcing is not only related to cost minimization but also has a positive effect on how companies adapt to the new environment that surrounds them, while also achieving efficiency in different areas and using all their technological resources from the new digital world. The study is based on a methodological design of instrumental research, using a questionnaire of 18 items, which was applied to 518 people in the sectors of interest. Subsequently, a thorough quality control and a rigorous validation of the data was carried out, consolidating the final sample in 512 respondents. With these data, statistical analyses were carried out, including descriptive and reliability measures to proceed with the exploratory factor analysis (EFA), the confirmatory factor analysis (CFA) and to continue with the process of testing the previously stated hypotheses. The results revealed adequate levels of reliability, the exploratory factor analysis reported that the 18 items load two factors, with a very acceptable KMO and a good Bartlett with an explained variance within the scientific parameters; on the other hand, the confirmatory factor analysis reported 2 models, where model 2 (M2) with 15 items is the one with most adequate 'goodness of fit' determinants that positively confirm the factor structure of the model that measures logistic outsourcing (LO) to improve business efficiency (BE) using information and communication technologies (ICTs) as a mediating variable. This study establishes substantive reference framework to future research and for companies a way to achieve business efficiency using advanced technology and outsourcing activities and/or processes.

Keywords: Outsourcing logistics, Business efficiency, Information technologies and communications, Productivity and logistics providers

1. Introduction

The current landscape is characterized by intense business competition, according to Arshad Ali & Mahmood (2024) corporations confront pressure to improve their business efficiency. Both Ali et al. (2023) and Sternberg et al. (2023) highlight logistics outsourcing as an alternative to alleviate this pressure, as it allows companies to reduce expenses and focus on their core activities. Doratiotto et al. (2023) suggest that increased collaboration in processes, including the hiring of external specialists, can result in favourable logistical performance. Valashiya & Luke (2023) emphasize the importance of cooperation with logistics providers to strengthen the supply chain. This view is supported by Gunawan et al. (2023) who assert that sustained interaction within the collaborative network positively impacts performance.

It is evident that logistics outsourcing leads to cost reduction, which is appealing to companies; however, there are other reasons and expectations associated with this strategy. For example, a Brazilian study reveals that some companies place more value on the collaboration and willingness of logistics providers (Doratiotto et al., 2023), while others prioritize efficiency in waste elimination and process streamlining (Zarbakhshnia & Karimi, 2024). Additionally, research in the pharmaceutical sector in the United Kingdom found that logistics outsourcing improved the reliability, quality, and flexibility of the supply chain, while also enhancing competitive advantage Ali et al. (2023). Essentially, the decision to work with 3PL providers is based on the reliability and capability they have to improve service efficiency, as noted by Sakas et al. (2023)

In this context, efficiency emerges as a crucial concept in business management to ensure long-term sustainability and success, maximizing results and optimizing resources. Aziegbe and Worlu (2020) highlight that businesses today are striving to offer high-quality products and services without compromising their operational margins and profitability. Geminarqi & Purnomo (2023) emphasize efficiency as a key factor impacting various areas, including "productivity, product quality, customer satisfaction, and profitability," which can be driven by both basic actions and more complex strategies. Aziegbe and Worlu (2020) recommend detailed and proactive planning of all production-related activities. In this regard, Sakas et al. (2023) point out that monitoring indicators related to inventory allows businesses to detect excess purchases or stock production that could increase operational costs.

Furthermore, technology has become involved in logistics outsourcing, demonstrating its influence on corporate efficiency. Abouzid and Saidi (2023) present the digital twin as a tool that rapidly executes processes, optimizes delivery times, and streamlines decision-making. Liu and Zhao (2023) underscore that logistics strategies supported by advanced technologies can significantly improve coordination, visibility, control, and performance within the supply chain.

Li et al. (2024), in their strategic analysis of a shared delivery point network in the last-mile logistics market, demonstrate how technology facilitates the functioning of this system, making it more efficient and cost effective. Kousiouris et al. (2019) indicate that the use of microservices-based frameworks to integrate IoT management platforms, semantic services, and AI helps to better understand and manage the supply chain. Additionally, Zhang and Ma (2022) emphasize that marketplaces enable multiple businesses to share logistics services, such as storage and dispatch, thus increasing business efficiency and reducing logistics costs.

2. Literature Review

Rivo López (1999) states that outsourcing begins with basic tasks before extending to strategic functions. Battistelli & Campanella (2020) describe outsourcing as "a phenomenon that intertwines business strategies and labour dynamics." Closa (2018) emphasizes the importance of considering both economic and productivity perspectives when making outsourcing decisions, while Wang et al. (2023) highlight that well informed decisions contribute to business growth and success.

Kumar & Singh (2012) emphasize on third-party logistic providers (3PL) being a competitive advantage for enterprises, with transportation, warehousing and custom clearance being the most outsourced activities. In addition, Giri & Sarker (2017) mention that the relationship between 3PL's and the contracting companies "lead to effective planning and mutual satisfaction of interests". Moreover, it is crucial to align logistics outsourcing decisions with the company's overall strategy and objectives (Closa, 2018). Nault et al. (2015) propose that logistics providers implement dynamic pricing strategies, which involve "adjusting prices in real time according to demand fluctuations and available capacity."

In this regard, several factors influence business efficiency, including supply chain aspects. Masson et al. (2016) define efficiency as the optimal utilization of assets and resources to deliver high-quality products. Reed et al. (2018) conceptualize efficiency as the ability to provide goods or services profitably without compromising quality. Similarly, Shaheen (2024) describes efficiency maximization as involving cost reduction and the application of effective strategies. Aziegbe & Worlu (2020) agree that ensuring superior performance requires businesses to effectively utilize their capacity and minimize costs. It is worth noting that this concept is widely recognized as part of continuous improvement strategies that drive competitive advantage and process agility (Izquierdo Gaitan et al., 2021).

In the academic field, supply chain integration (SCI) is identified as a key aspect of efficiency, Veeragoudar & Bharamanaikar (2023)describe three dimensions of SCI: Internal Integration (II), which focuses on harmonizing various departments and functions to eliminate inefficiencies; Supplier Integration (SI), which seeks coordination with external suppliers to optimize organizational performance; and Customer Integration (CI), which aims to balance supply and demand by involving customers. In this research, SI is the most relevant dimension.

Along the same lines, effective demand management is a key factor for efficiency, as it leads to reduced operational costs (Debala et al., 2023), particularly when strategies for maximizing material utilization and waste elimination are applied (Aziegbe & Worlu, 2020). Likewise, periodic and appropriate maintenance interventions minimize delays and associated costs, ensuring effective demand fulfilment (Modgil & Sharma, 2016).

Additionally, business success depends on selecting partners with specialized personnel, as these professionals are critical complementary elements for achieving efficiency (Izquierdo Gaitan et al. 2021). López et al. (2016) confirm that skilled employees facilitate "business process improvement". Geminarqi & Purnomo (2023) argue that they exhibit higher productivity levels.

Now then, since the onset of digitalization, ICT has played a crucial supporting role in corporations. In the 1980s, ICT was perceived as a valuable tool for developing strategic initiatives (Gratzer and Winiwarter, 2003). The integration of technologies for rapid data acquisition has enabled companies to deliver products to customers more accurately and efficiently (Garrido et al., 2007). In logistics, ICT usage not only enhances process efficiency and effectiveness but also significantly impacts logistics strategies and organizational structures (Liu & Zhao, 2023). Furthermore, ICT has been demonstrated as a key factor in achieving competitive advantages (Zhang &

Ma, 2022). Modern business strategies emphasize partnerships with technology-driven firms to expand supply capacity, compete globally, and meet rising consumer expectations (Garrido et al., 2007).

As a result, the evolution of ICT has reshaped industries by reducing communication, information-gathering, and transaction costs (Lollar et al., 2010). For example, identification technologies such as barcodes and RFID facilitate logistics data collection and sharing, improving both management and control processes (Pérez-López et al., 2019). Tiwari (2021) highlights that the implementation of GPS and GPRS devices in India's logistics industry has significantly enhanced supply chain visibility and control, improving logistics operations planning through real-time analysis and decision automation also according with Xiaolan (2013).

3. Methodology

To ensure representativeness, participants were selected from 71,070 actives companies registered in Peru until January 2024, this data is according to INEI (2024). To determine the specific target population for the survey, was refined by excluding 10,454 companies that ceased operations during the first quarter of the year (INEI, 2024). Additionally, companies in the categories of transportation and warehousing (4,431), business loan services (6,908), and real estate (839) were excluded, resulting in 48,438 companies, representing the firms of interest for this study. The required sample size was calculated using standard statistical parameters: a 95% confidence level, a z-value of 1.96, and a 5% margin of error. Based on these criteria, the minimum number of valid responses needed was 424.

The data collection instrument consisted of 30 questions, using a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree), and aimed to assess how companies implement logistics outsourcing (LO), its impact on business efficiency (BE), and the mediating role of information and communication technology (ICT). The instrument of this study was adapted from Sakas et al. (2023), Nga & Tam (2023) and Oledinma et al. (2021) and was elaborated using Google Forms.

Finally, it's important to mention that the final respondents were professionals with experience in the sectors that were included in this research (Food & Drinks, Agriculture, livestock, forestry and fisheries, Manufacturer, Information and communications, Mines and quarries, Retail & mass consumption, other) and contacted by mail, social and professional media or personal contacts. The details of how the data collected were validated is much more explained in point 4, which corresponds to the results obtained, but in summary responses were screened for completion, logical consistency, and duplication. The survey platform enforced single-response limitations and included control questions. Six responses were discarded for incompleteness or failure to meet quality standards, yielding a final validated sample of 512 participants to start the analysis.

3.1 Hypotheses

The first hypothesis would be "logistics outsourcing has a direct positive impact on business efficiency", with Doratiotto et al. (2023) indicating this practice as a way to enhance both logistical and business performance through close collaboration with providers, while Ali et al. (2023) mention that it can be more cost-effective and allows companies to focus on their core activities and help them achieve outstanding performance.

The second hypothesis states that "information and communication technology mediate the causal relationship between logistics outsourcing and business efficiency", as Zhang & Ma (2022) mentions that digital platforms optimize shared logistics services and reduce costs, while Kousiouris et al. (2019) highlight the use of microservices-based frameworks to integrate IoT [Internet of Things], therefore improving supply chain coordination and efficiency.

The third hypothesis proposes: "Information and communication technology for logistics positively influences the implementation and effectiveness of logistics outsourcing" based on Tiwari (2021) and Xiaolan (2013) work, which emphasize that GPS and GPRS devices enhance supply chain visibility and responsiveness, while underscoring the importance of information systems for successful integration.

The fourth hypothesis suggests "Sourcing outsourcing is a strategy that enhances the effectiveness of logistics outsourcing" as Johne & Wallenburg (2021) explain that delegating supply functions to specialized providers improves focus and efficiency, while Vázquez & Orozco (2019) mention it increases competitiveness and supply chain adaptability.

The fifth hypothesis affirms that "Transportation outsourcing is a strategy that enhances the effectiveness of logistics outsourcing", with Nikolaeva & Ivshin (2020) highlighting digital platforms to make smarter decisions

for transportation services and Yang et al. (2024) demonstrating this strategy increases flexibility, reduces costs and boosts logistics performance.

The sixth hypothesis would be "warehousing outsourcing is a strategy that enhances the effectiveness of logistics outsourcing" as Baglio et al. (2023) and Benatiya Andaloussi (2024) show that it improves inventory management, allows access to advanced systems and strengthens operational efficiency.

4. Results and Discussion

A total of 518 questionnaire responses were collected between August 21, 2024, and October 11, 2024. However, only 512 responses were included in the study, as they passed strict validation filters designed to maintain data quality. The sample was subsequently divided into two groups: one representing 60% of the responses was used to perform the Exploratory Factor Analysis (EFA), and the other 40% was used for the Confirmatory Factor Analysis (CFA).

Cronbach's alpha (α) was used to assess the internal consistency of the questionnaire, yielding a coefficient of 0.841, exceeding the 0.700 threshold required for academic research acceptance. This validates the coherence of the questions and the robustness of the method. Specifically, reliability scores were 0.759 for logistics outsourcing, 0.620 for business efficiency, and 0.717 for ICT. Additionally, **McDonald's omega** ($\tilde{\omega}$) was calculated, as it is considered a more robust alternative, according to Campo-Arias & Oviedo (2008) [7], acceptable omega values range from .70 to .90. The questionnaire achieved an overall omega of .84, confirming the strong interrelation of items. The individual scores were 0.701 for logistics outsourcing, 0.625 for business efficiency, and 0.729 for ICT. Lastly, the **Greatest Lower Bound** estimator was applied, which does not assume tau-equivalence and is useful for multidimensional constructs. The instrument yielded GLB coefficients of 0.908 for logistics outsourcing, 0.812 for business efficiency, and 0.761 for ICT, with an overall score of 0.940, indicating high reliability.

The **Exploratory Factor Analysis** using principal components with oblique promax rotation confirmed the underlying structure of the data, with factors aligning with theoretical expectations. The **Kaiser-Meyer-Olkin** scores were 0.708 for logistics outsourcing, 0.725 for ICTs, and 0.531 for business efficiency, indicating adequate item correlations and construct validity. **Bartlett's test of sphericity** showed significant results for all variables (logistics outsourcing: $\chi^2 = 1084.401$, $p < 0.001$; ICTs: $\chi^2 = 243.409$, $p < 0.001$; business efficiency: $\chi^2 = 382.518$, $p < 0.001$), confirming the suitability for factor analysis. **Total variance** analysis revealed that logistics outsourcing had two factors explaining 53.5% of the variance, ICTs had one factor explaining 40.6%, and business efficiency had two factors explaining 49.3%.

Table 1: Performance of items for each dimension of the variables

Variable	Question	Factor 1	Factor 2
LO	Experience	0.976	
	Reputation	0.891	
	Price	0.611	
	Technological infrastructure		0.713
	Knowledge of information technology		0.624
	Cost reduction efforts		0.618
	Problem-solving skills		0.618
	Speed of execution		0.547
ICTs	Extension of information	0.734	
	Facility	0.716	
	Acquisition	0.604	
	Efficiency	0.454	
BE	Shared database (company – 3PL)	1.179	
	Open access and development of technology	0.420	
	Internal promotion of digitalisation		0.659
	Technological training		0.634

Variable	Question	Factor 1	Factor 2
	Better IT infrastructure		0.525
	Digital transformation policies		0.521

An initial Confirmatory Factor Analysis (CFA) of 18 items showed that the instrument performed adequately, but the model fit indices were outside acceptable ranges, with a chi-square of 7.397, an RMSEA of 0.177, and incremental fit indices below 0.9. As a result, three items were removed, reducing the instrument to 15 items for reanalysis. The second model produced improved fit indices, with a chi-square of 2.568, an RMSEA of 0.088, and incremental fit indices (CFI, TLI, and IFI) all exceeding the 0.9 threshold, indicating better model performance with 7 items in the LO dimension and 4 items in each of the BE and ICTs dimensions.

Table 2: Confirmatory Factor Analysis

Model	Covariances	Fit indices	Variables:		
			LO	ICTs	BE
M1	18 items	R^2	0.5463	0.5378	0.3595
		Chi – square			7.397
		RMSEA			0.177
		CFI			0.898
		TLI			0.881
		IFI			0.898
M2	15 items	R^2	0.6029	0.5164	0.5513
		Chi – square			2.568
		RMSEA			0.088
		CFI			0.985
		TLI			0.978
		IFI			0.985

According to Doratiotto et al. (2023), outsourcing logistics services significantly enhances company performance, as confirmed by this study's strong correlation (0.744) between logistics outsourcing and business efficiency. Gunawan et al. (2023) and Ali et al. (2023) emphasise that outsourcing facilitates flexible operations, resource allocation, and cost-effectiveness. Cost is the most crucial factor in selecting logistics providers (0.920), aligning with Closa (2018), Shaheen (2024), and Valashiya & Luke (2023), who stress the importance of cost, trust, and innovation in achieving long-term advantages. The covariance of 0.758 between logistics outsourcing and business efficiency further supports its role in optimising operations, as noted by Geminarqi & Purnomo (2023)). Commonly outsourced services like procurement, transportation, and warehousing enhance efficiency by focusing on core competencies and reducing operational costs (Johne & Wallenburg, 2021; Yang et al., 2024; Arshad Ali & Mahmood, 2024; Benatiya Andaloussi, 2024). In Peru, transportation is the most outsourced service, with speed, problem resolution, and technological infrastructure being key factors in service provider selection (Wang et al., 2023; Closa, 2018; Veeragoudar & Bharamanaikar, 2023). Despite ICT's potential to improve logistics through data sharing (Tiwari, 2021; Kousiouris et al., 2019), this study found a lower covariance (0.602) between ICTs and logistics outsourcing, indicating underdeveloped integration. While ICTs show a strong correlation with business efficiency (0.694), their relationship with logistics outsourcing remains weak, suggesting the need for further research into their complementary roles (Zhang & Ma, 2022; Sakas et al., 2023). As noted by Ismail & Sharifi (2020) and Patel & Padhi (2022), ICTs have transformative potential, but their integration in logistics outsourcing requires stronger infrastructure and willingness to innovate (Pérez-López et al., 2019).

4.1 Hypothesis Testing

The mediation analysis was conducted using the SEM method with a bootstrap estimator (5,000 replications) to ensure result reliability. A strong direct relationship was identified between logistics outsourcing (LO) and business efficiency (BE), with key items such as LO1 (price importance) significantly impacting BE1 ($p = 0.045$). Additionally, LO3 (3PL responsiveness) and LO5 (technological infrastructure) had notable effects on BE1 and BE5. Regarding ICTs' mediating role, LO1 had an indirect effect on BE1 through TIC1 (technology acquisition

efficiency) ($p = 0.003$), while LO4 negatively influenced BE1 via TIC1 ($p = 0.011$), suggesting that excessive reliance on outsourcing problem-solving may hinder ICT effectiveness. LO6 (ICT knowledge) and LO7 (reputation) mediated through TIC1 and TIC2 to BE1 and BE2, reinforcing ICTs' role in facilitating outsourcing adoption for efficiency gains. Overall, ICTs partially mediate the relationship, amplifying but not solely determining the impact of LO on BE. Confirmed hypotheses include H1, H2, H3, H5, and H6, with statistically significant effects such as LO1 ($p = 0.003$) confirming H2, TIC1 and TIC2 impacting BE2 ($p = 0.002$) supporting H3, and LO3 strongly influencing BE5 ($p < 0.001$) validating H5. However, H4 was not supported, as no evidence indicated that outsourcing procurement significantly determines business efficiency.

5. Conclusions

This study analysed responses from a sample of over 500 individuals to examine the relationship between logistics outsourcing, ICT adoption, and business efficiency in Peruvian context. The results reveal a close relationship between logistics outsourcing and business efficiency, consistent with the findings of Doratiotto et al. (2023), who highlighted the direct impact of outsourcing on company performance. Additionally**,** Ali et al. (2023), emphasized how this practice allows organizations to focus on core activities, improving market adaptability.

Regarding the relationship between ICTs and logistics outsourcing, there is an opportunity for deeper investigation. Observations by Kousiouris et al. (2019), indicate that while ICTs optimize logistics management, their implementation is not always fully aligned with outsourced services. Thus, examining this connection in greater detail would be ideal. On the other hand, the study confirms the importance of technology in improving business efficiency, supporting the claims of Zhang & Ma (2022). Organizations that incorporate advanced technologies into their daily operations and processes significantly enhance performance and market competitiveness, achieving a differential competitive advantage.

In conclusion, this study offers new insights and contrasting perspectives on the complex relationship between logistics outsourcing, ICTs, and business efficiency. It also provides valuable contributions to the supply chain field, encouraging companies to establish relationships with third-party logistics (3PL) providers to optimize operations and improve logistics management by leveraging advanced technologies. Finally, this study acknowledges its limitations, including its focus on Peru and the exclusion of certain industrial sectors, which may restrict the generalizability of its findings. Nonetheless, it establishes a solid foundation for future research in this impactful field across dynamic and evolving markets.

Ethics declaration: The present investigation did not involve any human participants, animals or protected data that require ethical clearance. Consequently, no ethical approval was necessary for the research.

AI declaration: AI tools were used during the making of this research as a guide to structure the sections of the investigation and make it coherent. Nonetheless, all content, results and interpretation were entirely conducted by authors. The AI-generated material was meticulously reviewed and adapted to preserve authenticity and accuracy.

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Bridging Minds and Machines: Emotional Intelligence as Intellectual Capital for Human-AI Collaboration

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Abstract: As AI evolves from a tool to a key collaborator and co-creator across industries, its effectiveness is influenced by humans' abilities to guide, interpret, and refine AI-generated outputs. This study examines how self-awareness, emotional regulation, empathy, adaptability, emotional expression, and interpersonal skills- the core emotional intelligence competencies- moderate human-AI collaboration for creative problem-solving. The research positions emotional intelligence within the intellectual capital framework as a dimension of human capital that enhances both individual performance and organizational capital. Through empirical research with marketing professionals, the study ranks emotional intelligence competencies based on how they improve AI-generated creative outputs. The findings reveal that emotional expression is the most effective competency for enhancing creative outcomes, while adaptability shows negligible influence. This evidence suggests that professionals who can communicate emotional context effectively generate more innovative AI responses than those who focus solely on technical parameters. The study further examines professionals' specific interaction strategies, comparing emotionally informed prompt engineering, iterative refinement, and role-based interaction approaches. The results indicate that prompt clarity consistently ranks as the most effective strategy for enhancing AI responses, while emotional context remains significantly underutilized despite empirical evidence supporting its benefits. This gap between research findings and current professional practice highlights an important opportunity for targeted emotional intelligence development within organizations adopting AI technologies. Indeed, while the emotional context of human-AI interaction remains underutilized despite its proven benefits, organizations that invest in emotional intelligence competencies can achieve improved technological integration, effectively connecting human creativity with AI capabilities. The research presents a structured framework for developing these competencies, with a particular emphasis on emotional expression and contextual prompting techniques. These findings carry significant implications for businesses creating AI implementation strategies, educators designing curricula for future professionals, and policymakers setting guidelines for responsible AI adoption, all while aiming to enhance AI-driven creativity without sacrificing human-centered innovation principles.

Keywords: Keywords: Human-AI collaboration (HAC), Artificial intelligence (AI), Creative problem-solving (CPS), Emotional intelligence (EI), Intellectual capital (IC), Knowledge management

1. Introduction

Intellectual Capital (IC) is widely recognized as a fundamental intangible asset that facilitates innovation, strategic agility, and sustained performance within organizations. It is typically categorized into three components: human capital, which pertains to employees' knowledge, skills, experience, and motivation; structural capital, covering organizational routines, systems, databases, and intellectual property; and relational capital, involving the relationships and networks that organizations maintain with external stakeholders such as customers, suppliers, and partners (Kianto et al, 2020; Melnichuk, 2023).

Among these, human capital is often considered the foundational element because it directly contributes to the formation and reinforcement of structural and relational capital (Kianto et al, 2020). Companies that invest in staff expertise and development are better positioned to transform personal knowledge into organizational assets. This type of relationship is especially important for small and medium-sized enterprises (SMEs), where resource limitations make the effective use of IC critical (Melnichuk, 2023).

Recent empirical research confirms the significant impact of intellectual capital (IC) on organizational outcomes, particularly in SMEs and knowledge-driven environments. Studies indicate that companies with stronger IC achieve better performance, especially when human, structural, and relational elements are effectively integrated with knowledge-sharing practices and innovation initiatives (Jegerson et al, 2024).

In parallel, a study by Ayranci and Çolakoğlu (2014) explores the connection between Emotional Intelligence (EI) and IC by analysing how top managers' emotional capabilities influence their perceptions of IC components. Their work shows that leaders who possess self-awareness, empathy, and social fluency perceive and evaluate human capital, organizational commitment, and knowledge sharing differently than those without these emotional competencies. Although EI is not formally classified as a component of IC, these findings suggest that

emotional capabilities may support the effective interpretation and utilization of IC, particularly through their impact on managerial judgment related to human and structural capital.

The evolving integration of Artificial Intelligence (AI) into organizational workflows has introduced new opportunities and challenges for human capital. In particular, the effectiveness of human-AI collaboration increasingly relies on EI as a key enabler of meaningful interaction and co-creation between humans and machines.

As Artificial Intelligence (AI) becomes increasingly embedded in all industries, its role shifts from being a tool to a co-creator, giving rise to the concept of "assisted creativity", where AI collaborates with humans to expand outcomes rather than acting independently. Effective Human-AI Collaboration (HAC) depends on the user's ability to guide, evaluate, and refine AI outputs, especially in creative problem-solving contexts. EI plays a central role in the current process, helping users generate context-rich, emotionally attuned prompts and make informed final decisions. Research shows that human emotions and their expression improve both the interaction and the efficiency of AI-generated responses (Ameen et al, 2022; Vinchon et al, 2023). In practice, human involvement typically unfolds in two stages: problem identification, where users craft prompts, and final verification, where they review and validate outputs—each stage requiring emotional awareness and cognitive engagement.

The entire collaboration process requires emotional development and depth, allowing AI to learn from human input as it gains experience (Waikar, 2020). To produce more contextually relevant and creative results with AI, professionals will need to enhance their EI competencies in cognitive flexibility, social awareness, and adaptability (Ameen et al, 2022).

The biggest challenge is the lack of a structured framework for determining the factors that influence creativity in relation to AI. This encompasses both emotional aspects (for example, how to be empathetic or adaptable) and non-emotional aspects (such as formulating prompts and managing cognitive complexity) (Khare et al, 2024; Raz et al, 2023). Although EI competencies are acknowledged as crucial and impactful for HAC, many elements of their role in Creative Problem-Solving (CPS) remain ambiguous (Zhai and Wibowo, 2023). Without a clearly defined approach to implementing EI-driven strategies in HAC, AI will likely remain a technical tool rather than a true partner in creative tasks.

Recent studies on AI claim to enhance human creativity within organizations (Ameen et al, 2022), yet there remains a gap in understanding how to systematically improve HAC performance in creative industries. The primary objective of this study is to enhance HAC in cyber-physical systems by identifying and developing specific core competencies across various fields. Furthermore, one of the research goals is to prioritize the most essential EI competencies for HAC, aiming to foster a structured approach to boosting team performance and innovation. By addressing this research objective, we close knowledge gaps and offer actionable strategies to strengthen human-AI synergy in creativity-driven industries.

The current project will focus on developing EI competencies of key HAC in the CPS CREATIVE process, specifically within the marketing industry. The choice of the marketing field is due to CPS being crucial for business success, generating competitive advantage, and fostering long-term growth and profitability (Ameen et al, 2022; Titus, 2000). AI has facilitated progress in marketing by enabling more rapid real-time data analysis, product optimization, tracking product trends, analysing user engagement, and making informed content creation decisions (Ma and Sun, 2020; Stone et al, 2020). Consequently, the convergence of AI-driven efficiency and human creativity makes marketing an excellent area to examine HAC in CPS.

2. Literature Review

2.1 Human-AI Collaboration

HAC consists of collaborative entities that mutually support one another to achieve shared goals. The human oversees the AI outcomes in the current partnership while adjusting and optimizing the results for improved performance (Terveen, 1995; Vössing et al, 2022).

The success of Human-AI teams lies in their ability to achieve objectives by allowing both groups to function within their areas of expertise and natural leadership skills. The computational power of AI facilitates information analysis and prediction tasks, while humans maintain control over ethical decision-making, as well as empathetic and creative processes. Human-led performance consistently surpasses AI systems when tasks require strategic thinking, emotional insight, and creative skills. The objective may involve routine process work or optimization, areas where AI exhibits superior capabilities. Research by Hemmer et al (2023) indicates that

collaborative efforts between humans and AI systems yielded optimal results, with the human-machine team making 0.15 classification errors, compared to 0.30 and 0.25 errors recorded by individuals alone, respectively.

According to Anantrasirichai and Bull (2021), AI is a tool that eliminates laborious tasks, allowing humans to engage in more complex and creative processes. In marketing, the interaction between humans and AI is referred to as “balanced reinforcement” - AI fosters imagination, visualization, and abstract thinking, resulting in enhanced human creativity (Ameen et al, 2022).

2.2 Defining Creative Problem Solving

Many different fields, including architecture, engineering, public administration, art, entrepreneurship, and numerous other industries that impact human development, rely on the availability of creative solutions (Cardoso and Badke-Schaub, 2011). According to Ameen et al (2022), creativity arises from new and valuable ideas in product design, branding, and customer service. These tasks require out-of-the-box thinking and flexibility, aligning them with the problem-solving process. An enterprising individual's ability to effectively use creative problem-solving is fundamental in determining their level of innovation (Benner and Tushman, 2003; March, 1991).

2.3 Prompt Engineering

Prompts are arguably key to working with AI, and prompt engineering is one way for humans and AI to collaborate by exploring potential solutions based on thoughtfully structured instructions. The queries are framed appropriately so that the model can be guided towards the desired outcome (Brown et al, 2020). AI models lack autonomy, making the formulation of queries essential for the quality of responses (Zamfirescu-Pereira et al, 2023). Context, instructions, or examples that are well-worded queries assist the model in reaching the desired topic, style, or format. An effective method for creating queries enables the model to respond more accurately, logically, and usefully within the context of a specific task or knowledge domain.

2.4 Defining Emotional Intelligence

EI, as defined by Mayer et al (2004), is “the ability to reason about emotions and use emotions to improve thinking. " EI involves identifying, interpreting, and controlling emotional states, along with understanding the effects of these emotions on others' behaviour and how people react to emotionally charged situations.

2.5 Emotional Intelligence Competencies

Special EI competencies hold significant value, particularly in CPS and staff development. According to the research by Mortillaro and Schlegel (2023), emotion regulation and perception are crucial variables for maintaining focus and encouraging innovation in dynamic contexts. For instance, emotion regulation helps professionals manage stress during high-pressure tasks, while emotion perception enables them to identify emotional cues in themselves and others.

2.6 Factors Affecting Human-AI Collaboration

The purpose of this study is to determine the main factors affecting HAC, that contribute to the improvement of creativity and problem-solving ability of the AI.

2.6.1 Emotional factors

EI competencies, like empathy and openness to experience, extend the quality of prompts and facilitate creativity outputs from AI systems (Raz et al, 2023; Mortillaro and Schlegel, 2023).

Empathy enables individuals to consider the effects of AI-driven decisions on human beings, such as tailoring AI-generated content to align with customers' emotions and the experiences of employees (Heyns, 2024). Furthermore, empathy enhances HAC by helping people recognize perceived emotions and adapt AI outputs to better reflect human feelings and cultural nuances (Kolomaznik et al, 2024).

Self-awareness, recognizing personal strengths and challenges, allows individuals to engage with AI thoughtfully and purposefully. By understanding their emotional responses, they can more effectively assess AI-generated insights and avoid emotional biases that may stifle creativity.

Trust is one of the most critical emotional factors in relation to HAC in terms of both cognitive and affective dimensions. If users trust AI systems, they interact more intensely, regard AI’s recommendations as authentic, and are more inclined to include AI’s insights into the decision–making process.

Another fundamental aspect is *rapport*, which facilitates effective HAC. Connecting and engaging with the AI results in a perception of the AI as a partner rather than just a tool. The development of rapport is often supported by consistent AI responses, personalized interactions, and emotionally attuned feedback loops, all of which enhance human acceptance and engagement (Kolomaznik et al, 2024).

Finally, *anthropomorphism*, or the process of humanizing AI, influences users' emotional connection to AI systems. Studies show that the more individuals view AI as a relatable entity, the greater the engagement, the deeper the trust, and the better the collaboration. While not mandatory, the anthropomorphic factor, as shown by Kolomaznik et al (2024), positively affects users' comfort and emotional responsiveness during interactions with AI.

2.6.2 Non-emotional factors

Clear instructions greatly enhance AI responses, leading to accurate, relevant, and organized content with minimal confusion. Specific guidelines regarding response format, tone, or length boost AI performance and practical value (Raz et al, 2023; Ekin, 2023; Park & Choo, 2024). For example, instead of asking, "Explain what AI is," a more effective prompt would be, "Summarize three key applications of AI in marketing in two sentences." Vague prompts result in inconsistent responses; therefore, users may benefit from checking whether their instructions are clear. Encouraging AI to seek clarification, such as "If additional details are needed, please ask before responding," reduces errors and aligns results with user expectations (Lo, 2023; Park & Choo, 2024; Bansal, 2024).

Iterative refinement enhances response quality by testing and adjusting prompts based on AI outputs. By altering wording, providing context, or reorganizing queries, users can fine-tune results to align with their intentions (Dang et al, 2022; Abdoelrazak, 2023; Rodriguez et al, 2023). This approach enables AI to cater to specific needs, boosting both accuracy and creative potential.

Step-by-step prompting breaks complex tasks into logical sequences, enhancing AI reasoning and precision. Chain-of-Thought techniques guide AI to explain its thought process before reaching conclusions, creating transparency and organized problem-solving. For instance, instead of simply asking, "If a car travels at 60 miles per hour for 3 hours, how far does it travel?", a more effective Chain-of-thought (CoT) prompt would be, "Let's solve this step by step. First, recall the formula for distance. Then, substitute the values for speed and time. Finally, calculate the total distance travelled" (Raz et al, 2023; Karakaya, 2025; Wu et al, 2022).

Role assignment enhances domain-specific accuracy and relevance. Guiding AI with "You are a financial analyst; provide an investment strategy for beginners" yields more structured insights (Wu et al, 2023; Park & Choo, 2024; Sikha et al, 2023). Providing background context about industry specifics or audience details further improves outputs.

Applying constraints such as word limits, format requirements, and topic boundaries encourages well-structured AI content. Clear guidelines, like "Explain machine learning in two bullet points," steer AI focus and help avoid unnecessary wordiness (Ekin, 2023; Lo, 2023; Rodriguez et al, 2023).

Prompt chaining preserves context and supports logical flow in AI interactions. Instead of a single broad query, structured sequences like "List three marketing strategies; compare their effectiveness; recommend one for small businesses" enhance organization and coherence (Bansal, 2024; Sikha et al, 2023).

AI literacy helps users experience less frustration when facing AI errors and better understand system capabilities and limitations (Beretta, 2023; Ng et al, 2021; Kolomaznik et al, 2024). Misconceptions about AI capabilities can lead to overreliance or scepticism, emphasizing the need for targeted education to enhance interactions. These misconceptions can result in overreliance or distrust, underscoring the importance of targeted AI education initiatives to improve user engagement and response evaluation.

Striking a *balance* between user-defined constraints and AI's generative capabilities leads to original yet relevant outputs. Allowing for creative flexibility while maintaining control over factual correctness enhances AI-assisted innovation and problem-solving (Raz et al, 2023; Karakaya, 2025; Zhang et al, 2024; Sikha et al, 2023). *Adaptive prompts* tailor AI responses based on user expertise and task complexity.

Additionally, retrieval-augmented generation techniques incorporate external knowledge sources into AI responses, enhancing factual accuracy and reducing AI hallucinations (Rodriguez et al, 2023; Zhang et al, 2024; Bansal, 2024).

3. Methodology

Moving forward to the methodology part, the process started with a comprehensive literature review. The literature review includes reliable and recent articles, conference papers, and educational websites that are highly relevant to the topic of integrating AI and human creativity and enhancing team collaboration. The following phases were the EI test and survey distribution, followed by collecting data from both and analysing their correlation.

3.1 Emotional Intelligence Test

The EQ ProfDialog assessment evaluates workplace emotional intelligence across key dimensions, including self-awareness, emotional regulation, empathy, adaptability, emotional expression, and interpersonal skills. The certified test consists of 117 questions that assess respondents on 11 emotional intelligence factors using a scale from 1 to 10, providing detailed feedback for each area.

Built-in validity safeguards, such as lie detection and contradiction tracking, identify questionable responses to uphold data integrity. The test was selected specifically for its availability in the Russian language and its cultural relevance to the study's participants: marketing professionals in Kazakhstan. Its adherence to European reliability standards makes it a trusted tool widely used by Kazakh companies for staff evaluation purposes.

3.2 Survey on AI Usage in Marketing

The purpose of this survey is to analyse the AI usage among specialists in the field of marketing. It consists of six questions that focus on the frequency of AI usage in the workplace and whether AI-generated responses are creative and effectively address the given prompts. Additionally, the survey includes questions that assess the types of tasks respondents utilize AI for and the strategies and skills they apply to obtain the desired responses, enhancing their collaboration with AI. Furthermore, respondents are asked to answer a question regarding the limitations AI in their work. All these questions aim to identify correlations between EI competencies and HAC.

The survey results indicate that most respondents (30 out of 37) reported frequently using AI in their professional activities, suggesting that AI plays a significant role in their daily marketing workflows (Figure 1). A smaller subset of respondents (6) stated they use AI occasionally, while only one reported using it rarely. Notably, no participants chose the “never” option, emphasizing that all surveyed individuals incorporate AI into their work to some extent. This confirms the survey population's relevance for studying HAC and EI in marketing contexts.

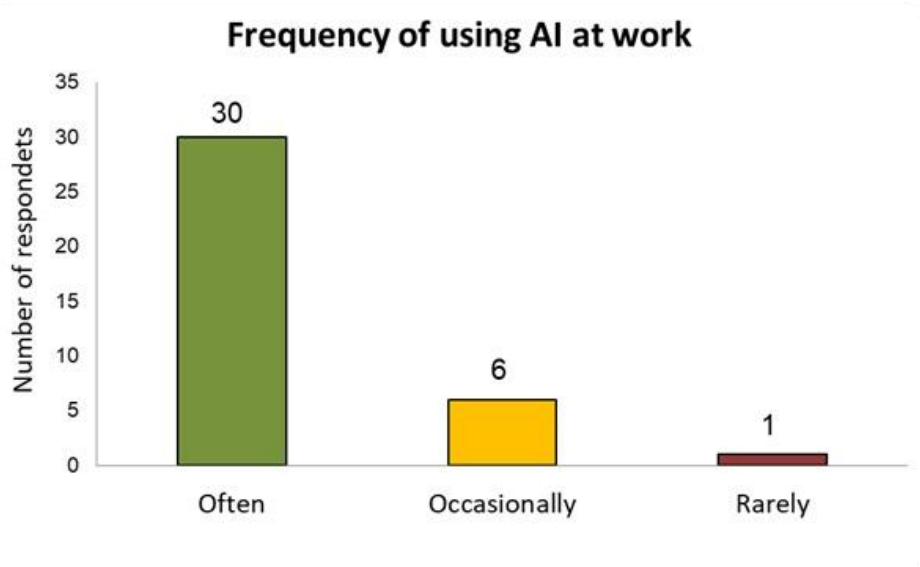


Figure 1: Frequency of using AI at work

4. Discussion

According to the survey results, the way AI is utilized influences its creativity. Users who employ AI for content creation and data analysis achieve more innovative results compared to those who use it for task automation.

This confirms that AI serves more effectively as a creative partner than as a fully autonomous problem-solving tool.

Additionally, one of the key findings of the research is that the e*xpression of emotions* positively correlates with the creativity of responses. Participants with higher levels of emotional expression (average = 3.63) rated the results generated by AI as more creative compared to those with lower levels of emotional expression (average = 3.00). A statistically significant relationship was indicated by a value of p = 0.047. This suggests that individuals who can effectively express emotions create cues that lead to more innovative and original AI responses, a finding that aligns with previous literature reviews (Hemmer et al, 2023; Li et al, 2023).

Other characteristics of emotional intelligence, such as adaptability, self-regulation, and emotional perception, did not demonstrate significant differences regarding AI creativity. For instance, the average adaptability level was nearly identical (4.105 for less creative users compared to 4.062 for more creative users; p = 0.889).

Additionally, Figure 1 presents the survey results, indicating that emotional context is one of the least utilized strategies for enhancing AI responses. This contrasts with current research suggesting that emotionally charged prompts effectively encourage AI towards more creative outputs (Li et al, 2023). However, suppose a gap exists between what the literature suggests and common practice. In that case, it may indicate that professionals are not fully aware of or are not utilizing emotionally appropriate strategies when working with AI.

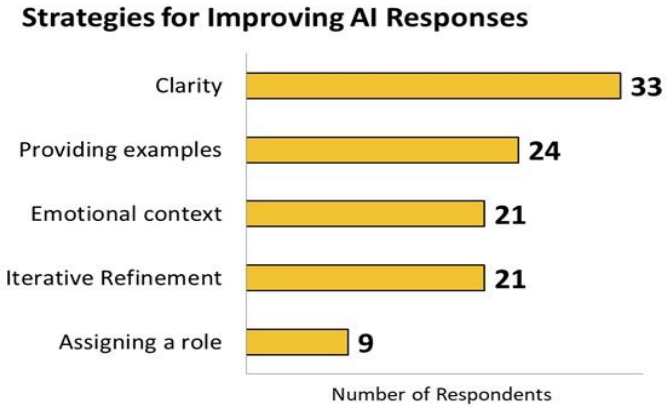


Figure 2: Strategies for Improving AI Responses

Clarity in prompting is one of the most important factors for AI creativity. The results of the survey (Figure 2), along with the literature review, indicate that well-structured, specific, and detailed prompts lead to significantly better quality in AI-generated responses. Additionally, respondents ranked clarity as the most effective strategy for enhancing the quality of AI outputs, while task misinterpretation was identified as the most common limitation of AI (Figure 3).

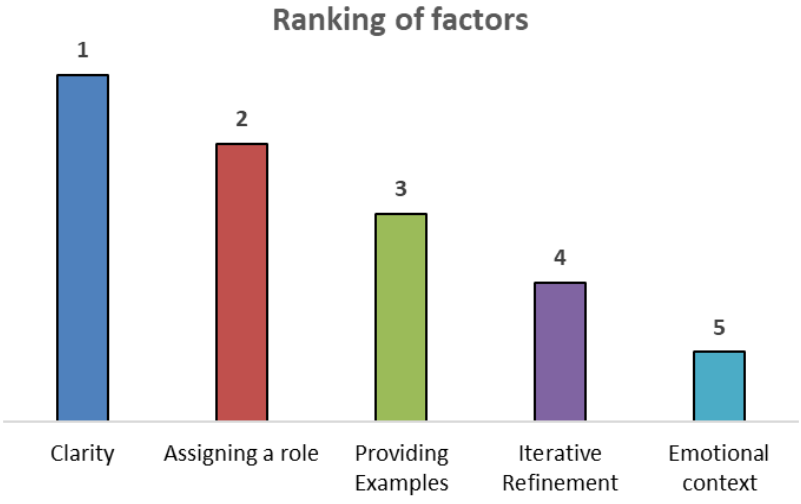


Figure 3: Ranking of factors based on respondents' experience

Iterative refinement emerged as another significant factor and became a widely adopted strategy in the survey. Consequently, this approach allows users to modify and enhance AI responses through repeated interactions, making these responses progressively better aligned with their imagination and context. Literature supports this, indicating that revising prompts improves the originality and depth of AI-generated outputs (Li et al, 2023). The implication is that professionals who do not fully leverage AI's contextual reasoning, may be helped by appropriate training in this matter.

5. Conclusion

This study contributes to the discussion on IC by demonstrating the role of EI as a strategic enabler. In AI-augmented environments, where knowledge work and CPS intersect, emotionally intelligent professionals serve as key mediators of value - translating technological potential into innovative outcomes. Among the examined competencies, emotional expression significantly influences the richness and creativity of AI outputs, providing empirical support for the strategic integration of EI into organizational innovation processes.

The research positions EI not as a peripheral human trait but as a form of embedded IC - a human capability that actively contributes to the co-evolution of organizational knowledge systems. When organizations invest in cultivating EI, they reinforce the development of structural capital, such as emotionally aware prompt engineering frameworks, and relational capital, through trust-building mechanisms that boost engagement with AI systems.

Despite the clear benefits, current practices indicate a disconnect between the acknowledged significance of EI and its application in HAC. By implementing organizational interventions that incorporate EI development into professional training and knowledge management systems, companies can foster a more effective synergy between human and machine agents engaged in technological adoption. This strategy is not only efficient but also emotionally intelligent and geared towards innovation.

By framing EI as an active enabler of IC formation, this study expands existing value-creation models in digital contexts. It also provides a pathway for enhancing organizational resilience, creativity, and learning in the age of AI.

Ethics declaration: Ethical approval for this study was obtained on 18 October 2024. The study was reviewed in accordance with national and international ethical standards for research involving human participants. All participants were informed about the study's purpose and procedures and provided written consent before participating. Data confidentiality, anonymity, and security were maintained throughout the project in accordance with GDPR and the national data protection laws of the Republic of Kazakhstan.

AI declaration: The authors declare that no generative AI tools were used to create the content, ideas, or theories presented in this manuscript. Under close human supervision, AI-assisted technologies were employed solely to enhance language clarity and readability. All AI-refined content was meticulously reviewed, edited, and validated by the authors to ensure accuracy and coherence. The authors acknowledge that while AI may assist in improving expression, it can also introduce errors or biases. Consequently, the final manuscript reflects human critical judgment and maintains scholarly integrity.

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Managers' Commonly Apply Leadership Styles to Empower and Motivate Subordinates

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Abstract: Leaders always seek to motivate subordinates to perform the tasks at hand. The study of leadership has been an area of research for many years, and there has never been one universally accepted leadership type. One of the biggest problems in the study of leadership is that there is unprecedented emphasis on the character and behaviour of the leader. The assumption with that approach is that the role played by the leader negates the impact of the subordinates as the final product of the leader's behaviour impacts the performance of the subordinates, positively or negatively. This research focuses on the role played by subordinates because they need to understand what motivates them. A leader's effectiveness is based on the ability to mobilise the followership to cooperate and deliver on the objectives of the undertaking. Using mixed methods, the study examined leadership behaviour and subordinates' expectations as motivating factors for subordinates to perform. The findings assist leaders in getting the best out of their subordinates and understanding their leadership style. A questionnaire was used to collect the necessary data based on which illustrations were constructed, which assisted in interpreting the relationship between the variables. The questionnaire was divided into a biography, a Likert scale, and an open-ended section. The open-ended section assisted in getting to other aspects that might have been left out in the structured part of the questionnaire. From the findings, it can be concluded that the subordinates prefer leaders who show empathy, are responsive, and allow for subordinate participation. Sharing with workers' problems instils loyalty to the leader and organisation. Well-informed employees know what to do and how to solve problems. Empowered employees also become engaged employees and assume ownership. Together with this is the implied consideration for a firm leader who is task-focused and understands the importance of relationships.

Keywords: Leader, Leadership style, Motivation, Performance and subordinate preferences

1. Introduction

Global financially successful organisations are based on specific decisions made to move the organisations to meet their profit objectives (Asrori, Kiswanto and Amal,2020). Amongst the critical decisions made is inevitably the choice of contingent and strategic leadership that has propelled the organisations to new heights. Chatman, Johnson and Bell (2020) affirm that selecting a manager in an organisation requires effectiveness as the principal quality for the appointment. A leader's effectiveness is measured based on the leader's ability to influence the "followership" to perform and reach the goals. Different people have different leadership styles, which are patterns of behaviour learnt by the incumbents, formally or informally. Studies on leadership styles have been summarised mainly between the transformational and transactional styles of leadership (Ramadhini and Manafe, 2022). Charismatic leadership styles have also been referenced as positively impacting followership and appealing to the followers' emotions (Kuzmin and Keates, 2021).

This research is relevant in evolving workplace dynamics, where leaders face unique challenges in motivating employees. By exploring effective leadership practices, this study provides insights to help managers adapt and thrive in today's complex business environment (Kim, Yammarino and Park, 2020). This research aimed to investigate how managers apply various leadership styles to empower and motivate subordinates, ultimately enhancing organisational performance.

2. Background

Crossan and Crossan (2023) define leadership as a multifaceted social method based on merit, intelligence, skill and the capacity to reason or think. Boeske (2023) states that leader effectiveness is the capacity to exercise the influence which leads to desired outcomes within the organisation. Transformational leadership involves encouraging subordinates or followers to manage and develop their tasks and capacities with little interference from the leader. This focuses on coaching and empowering the followers to self-manage and enables them to decide on achievement for themselves (Yam, Reynolds and Su, 2022). Creativity and effective performance are two critical attributes found at the organisation's heart among employees. Executive management, having the eyes to oversee and influence the employee's performance, can encourage the increase of productivity and hold a key that promotes competitive advantage in the organisation. Astuti, Datrini and Chariri (2023) say that creating sustainable competitive advantage implies the capacity of leaders to effectively work for their organisation to maintain efficiency and vitality for a long-term future in the

organisation. Developing leaders' competencies are required to match the organisation's strategy to its strong points and market opportunity. This requires a deliberate decision to correct the organisation's weak points, which results in the protection of employees against external threats (Figueiredo, Sousa and Tomé, 2023). This, in turn, is likely to expand the productivity capacity as well as the level of performance of the employees. Doornenbal, Spisak and van der Laken (2022) affirmed that the way the individual demonstrates leadership traits depends not only on the leader's characteristics and personal capabilities. The characteristics of the situation and environment in which a leader finds themselves are critical to what constitutes an effective or ineffective leadership style. Leadership is a leader's style of providing direction, implementing plans, and motivating people (Hoque and Raya, 2023). Leaders in the political, business, or other fields can exhibit many different leadership styles.

Le-Blanc, González-Romá and Wang (2021) define the term team as a group of people with skills and experiences who come to work together to reach specific goals. The operations of the team members are characterised by a high level of mutuality between the members. They are responsible for working in one accord by sharing the same rewards and assuming accountability for the collective performance. According to Brown, Sparapani, and Olson (2023), a team can be considered a collection of people when there is a combination of efforts between the participants. When working together, the team's efforts allow them to obtain better results, which are impossible to get alone. There is always a probability that things may not happen as expected in the organisation; however, acknowledging this thought is not in the same context as admitting it as bound to happen. Schuldt and Gomes (2020) say that organisational performance refers to the ability of an enterprise to achieve such objectives as high profit, quality product, significant market share, good financial results, and survival at a pre-determined time using a relevant strategy for action. Budianto, Susanto and Kismono (2020) say monitoring and maintaining team performance is key to leading a team. The researchers identified four critical dimensions of effective team leadership: the collective effort of the team members, team member strategies and group dynamics, knowledge and skill. By concentrating on these four points, weaknesses can be identified and corrected, and strengths fortified and improved. Followers harness the organisation's resources depending on how well the leaders value and embrace appropriate leadership approaches. Wang, Yang and Yue (2022) surmise that efficiency in resource mobilisation, allocation, utilisation, and enhancement of organisational performance depends largely on leadership style. There are different proponents for the various leadership styles, even though it has been challenging to develop a one-size-fits-all leadership style over the years. Other types of leadership styles are illustrated in Figure 1 below.

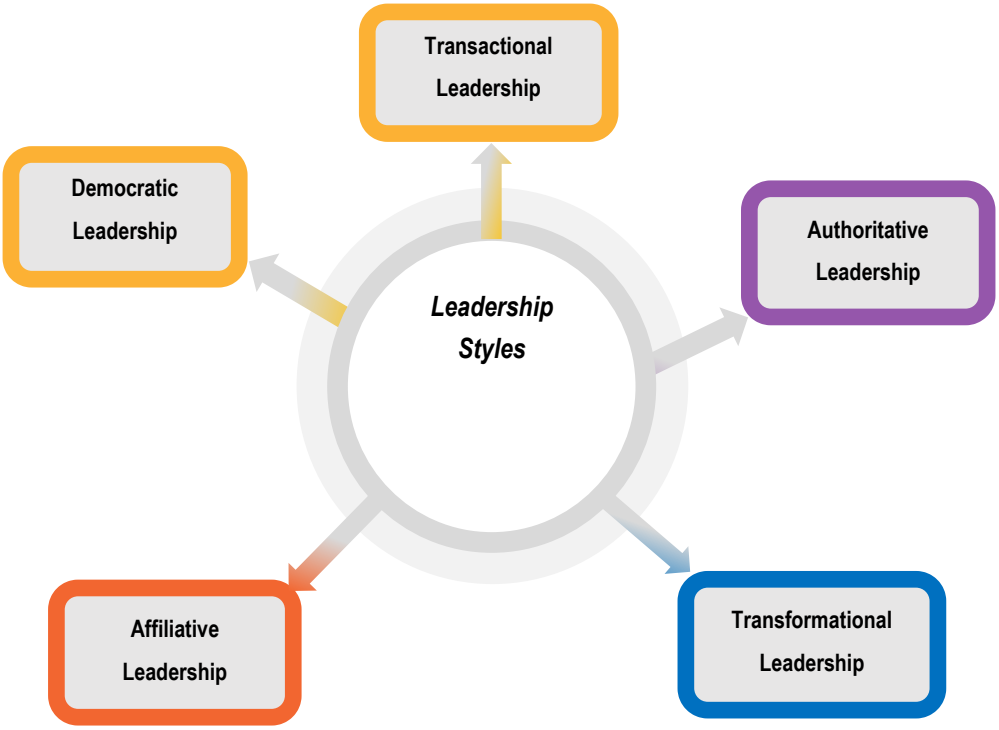


Figure 1: Different types of leadership styles (Source: Authors' construction)

Before concluding on the effectiveness of a leadership style, consideration should be made of the importance of the type of followership. Leadership may not be considered adequate without aligning the followers to the tasks. Nurani, Hartati and Pratiwi (2020) state that effective communication increases team performance by empowering, providing direction, and encouraging accountability to those working in the organisation. Team performance decreases in many organisations due to simple misunderstandings and communication breakdowns (Ataguba and Ataguba, 2020). Riyanto, Endri and Herlisha (2021) stipulate that the employees in the organisation desire to generally obtain more say in day-to-day operations from the managers (leaders). A leader who understands and accommodates the followers' expectations is most likely to be effective and successful if the leader addresses the followers' concerns. The author suggests that a visionary organisation invests in employee training to enhance employee skills, leading to better performance. A leader makes footprints others will want to follow; this goes beyond a manager – typical managers always maintain the status quo. Leaders generally bring about changes and allow for developing other innovative minds and intrapreneurship (Sewchurran, Zaina, McDonogh, 2020). Leaders have specific virtues, and these are illustrated in Figure 2.

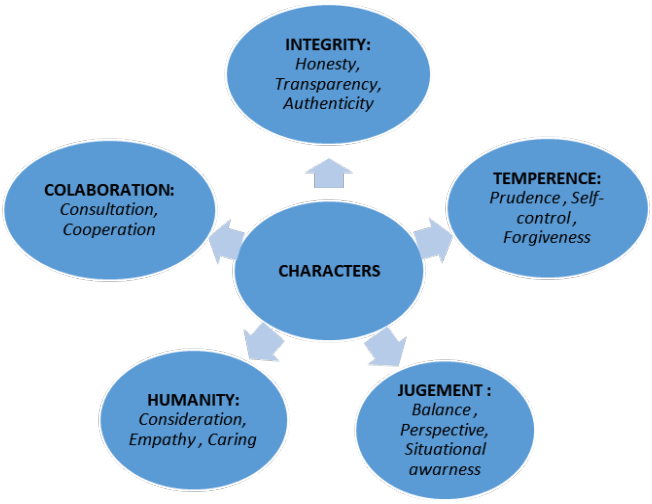


Figure 2: Leadership virtues (Source: Author's construction)

Leadership expectancy can be comprehended as a mental representation explaining how people recognise new information based on the values and perceptions of individuals who need to be led. These values and experiences present the best example of leadership styles that subordinates must focus on and consider. Rani, Shauki, and Prijadi (2020) assert that the long-lasting performance of the organisation represents the fruits of effort generated by the leader in providing specific measures that encourage productivity. The influence of a leader is meaningless if the performance is not at the organisation's heart. The more you rise in power, the more you rise in influence. This is realised when the organisation's vision and goals have been accepted and implemented by all the team members, accompanied by the strong attitude and personality of the leaders (Hearn and Louvrier, 2016). Olley (2021) suggested that a way to enhance organisational productivity is by setting a development plan for the employees consisting of training and the constant evaluation of the team's performance. Fossheim and Andersen (2022) think the leader needs to be aware of followers' situations as an impeccable process of solving problems and identifying opportunities to be effective. Leaders must know how employees think (Tibugari and Jowah, 2014). Only then can they plan on a leadership style that fits into the employee or follower's implicit leadership theory. Sanz and Gómez (2021) posit that successful organisations will focus on employee welfare to improve productivity, which leads to organisational success.

3. Research Approach

Using a quantitative approach, the study examined leadership behaviour and subordinates' expectations as motivating factors for subordinates to perform. The study used purposive sampling to ensure diverse perspectives on leadership styles. The sample size involved 100 respondents, consisting of 20 managers and 80 subordinates. Data was collected through a structured questionnaire (quantitative data), which assisted in assessing the impact of leadership style on motivation, job satisfaction and performance. The questionnaire included Likert-scale questions focusing on leadership behaviour and employee motivation. The interviews (qualitative data) were also conducted with managers and subordinates to gather detailed insight into

leadership challenges and best practices. Questionnaire data were analysed through descriptive statistics to determine the relationship between leadership styles and employees' outcomes.

4. Results

4.1 Number of Subordinates

Results also revealed that 32% of respondents represented are responsible for 6 to 10 people, 18% of managers are responsible respectively for 0 to 5 people and 16 to 20 people, 12% and 16% of managers are responsible respectively for 21 to 30 people and 11 to 15 people and only a small number of 4% of managers responsible of 31 to 50 people.

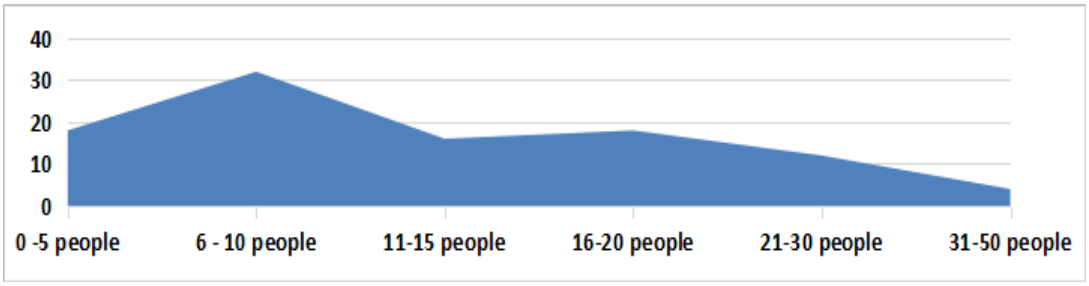


Figure 3: People under you as a manager (Source: Author's construction)

From the graph above, the mean scored an average of 7.18; the variance was 25.29, and the standard deviation was 5.03. The mean represents the average of the central point distribution, showing the number of people placed under a manager. The variance and standard deviation show moderate data spread around the mean as the standard deviation is seated at the rate of 5.03. The Coefficient Variance in this research is presented at 69.10**%**, meaning that the data's variability is relatively high relative to the mean.

4.2 Skills of Subordinates

44% of employees have technical skills such as mathematics and information technology skills. etc., 14% have mathematic skills, and 6 % of employees possess other skills. And 36% of employees have no specific skills, meaning the university has employees with no critical skills.

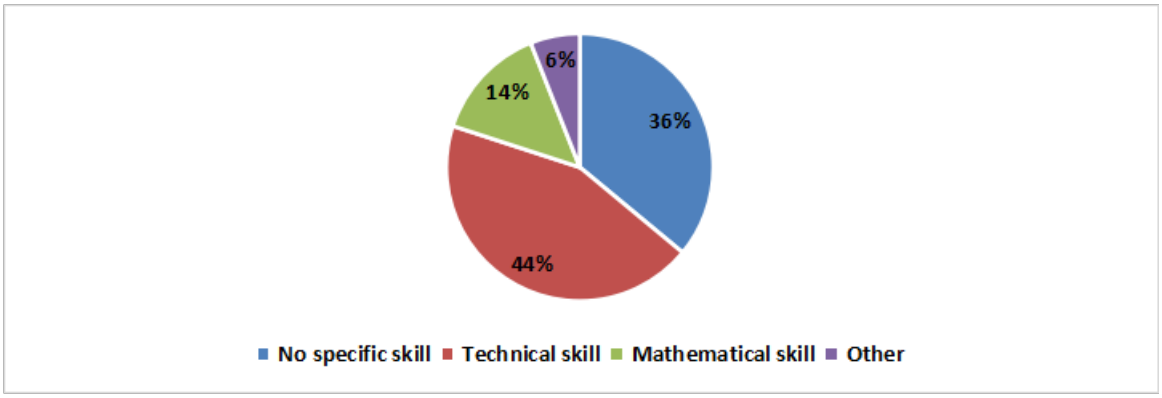


Figure 4: The skills of people who report to you have (Source: Author's construction)

From the graph above, the mean presents a score of 1.9, below technical skill; the variance is at 0,73, spreading out the data from the mean. When there is a low variance, the distribution will be concentrated around the low category as it shows lower variability. The standard deviation is at the rate of 0.85, which is low, presenting that most people's skills are close to the mean. The coefficient variance is at 44.74, demonstrating a level of variability in the skill level relative to the mean.

4.3 Transformational leadership

Table 1: Leaders use transformational leadership to enhance employee performance

Factors	SD	D	N	A	SA	U	Mean score
	1	2	3	4	5		3.30
Frequency (%)	12.0	18.0	14.0	40.0	16.0	0	

A standard deviation of 11.93 indicates a moderate variability in responses, suggesting some differences in opinions among respondents. The variance of 142.22 further supports the moderate variability in the data. Transformational leadership motivates employees by creating a shared vision. 40 % of the respondents agree, and 16% strongly agree that transformational leadership enhances employees' performance. 14% of respondents remained indifferent, and 30% disagreed (18% disagreed and 12% strongly disagreed). It can be generalised that transformational leadership will increase the performance of the employees. The results present a mean of 3.30, which shows that the responses are primarily neutral and agreeable. This demonstrates that most leaders use transformational leadership to innovate and change organisational and employee performance. Variance indicates 1.61, showing a moderate spread in responses. The coefficient variation is at 38.48, showing diverse responses (responses are mixed, not extreme).

4.4 Transformational Leadership Versus Transactional Leadership

Table 2: Transformational leadership versus transactional leadership in a business environment

Factors	SD	D	N	A	SA	U	Mean score
	1	2	3	4	5		2.54
Frequency (%)	0.0	14.0	26.0	40.0	12.0	0	

The weighted mean score of 2.54 reflects the average score when considering the frequency of each response category. A standard deviation 14.17 indicates a high response variability, suggesting differing opinions among respondents. The variance of 200.89 further supports the high variability in the data. 52% (40% agreed and 12% strongly agreed) believe that transformational leadership is more effective than transactional leadership in business; 26% were hesitant. Those in disagreement comprised 14%, allowing a generalisation that transformational leadership is more effective and encourages employees' performance. The results above present a mean with a rate of 3.26, showing that respondents tend to agree mostly, and there is also neutrality.

4.5 Employees who are accountable and reliable

Table 3: Employees who solve problems are more accountable and reliable

Factors	SD	D	N	A	SA	U	Mean score
	1	2	3	4	5		3.22
Frequency (%)	0.0	2.0	6.0	60.0	32.0	0	

The weighted mean score of 3.22 reflects the average score when considering the frequency of each response category. A standard deviation 22.35 indicates a high response variability, suggesting differing opinions among respondents. The variance of 499.56 further supports the high variability in the data. The highest score to date, 92% (60% agreed and 32% strongly agreed), allows for a generalisation, and it can be concluded that any leadership that empowers workers is most appreciated. Indifference is at 6%, with 2% in disagreement. The results show that most respondents answered between agreeing and strongly agreeing. The variance is at 0.41, showing that the responses are moderately clustered around the mean.

4.6 Informed Employees

Table 4: A well-informed employee finds easy, better ways of solving problems

Factors	SD	D	N	A	SA	U	Mean score
	1	2	3	4	5		3.02
Frequency (%)	0.0	10.0	14.0	54.0	36.0	0	

The weighted mean score of 3.02 indicates a general agreement that well-informed employees find easier and better ways of solving problems. A standard deviation 19.76 indicates a high response variability, suggesting differing opinions among respondents. The variance of 390.33 further supports the high variability in the data. Well-informed employees know what to do and how to solve problems, in agreement, 90% (54% agreed and 36% strongly agreed). This allows for a generalisation or conclusion that leadership that provides adequate and appropriate operational information reduces management pressure to supervise. The results present the mean at 4.8, indicating that most respondents agree and strongly agree to solve problems based on the information at their disposal—standard deviation indicating that the responses are 1.12 points away from the mean.

4.7 Empower Employees

Table 5: Empowering employees to think is like giving them ownership

Factors	SD	D	N	A	SA	U	Mean score
	1	2	3	4	5		3.08
Frequency (%)	0.0	12.0	12.0	32.0	44.0	0	

The weighted mean score of 3.08 reflects the average score when considering the frequency of each response category. A standard deviation of 16.23 indicates a moderate variability in responses, suggesting some differences in opinions among respondents. The variance of 263.56 further supports the moderate variability in the data. Empowered employees become engaged employees and assume ownership (full responsibility) as evidenced by 76% confirmation (32% agreed and 44% strongly agreed), only 12% were indifferent, and the other total of 12% disagreed. It can be generalised that employees can think independently and solve problems without consulting; transformational leadership is implied here. The results in the table present a mean of 4.08, showing the respondents' level of agreement. Variance is at the rate of 1.03. The standard deviation is 1.02 points away from the mean. There is some spread in responses, but not very high. Standard deviation explains how far responses deviate from the mean. The coefficient of variation is at 24.92%, showing moderate variability in response. When a CV is below 30%, this indicates that data are not too dispersed but consistent.

5. Summary of Finding

Specific responses stood out, which are worth mentioning, only where generalisations can be made. The implication is that where the scores are higher, the respondents felt strongly about those issues. The issues outstanding in this research are listed from the least to the most important according to the percentage scores. A high 62% of the managers believe that a good manager must think for workers and give them direction. A good portion (76%) of the managers believe empowering employees to feel is like giving them ownership. A good 76% of the managers think that because each one has their task, they have to perform it with no excuse – no room for personal problems. 78% believe an employee left to work alone is empowered and performs well. Many managers (80%) believe that setting tasks makes people perform because they know what to do. A majority of 84% of the managers/supervisors have a diploma or degree as their highest qualification.

Conclusion

This research seeks to bridge gaps in understanding the application of leadership styles to motivate and empower employees in diverse organisational settings. By providing actionable recommendations, this study can help managers adapt their leadership approach to meet the evolving needs of today's workforce. No clear leadership style is portrayed primarily for numerous reasons, such as the fact that leaders are different individuals dealing with others who have different expectations from the leader. The tasks cannot be ruled out, including the organisational culture and the type of power of both leader and follower, as that impacts leader-follower exchange. Two leadership styles stood out at different times, namely transactional and transformational, with transactional appearing more prominent. Effective leaders should, therefore, be those who respond and act according to the situation, the tasks, the subordinates concerned and within the cultural paradigm of the organisation.

Ethical Declaration: The paper is derived from a master's research at a local University. The Ethical Committee from the University issued a certificate of clearance granting permission for the research to be undertaken.

AI Declaration: Grammarly was used to assist with editing the paper's language. Besides that, there was no other use of AI in the paper.

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Competitive Intelligence Practices: A Case Study of a South African Academic Library Setting

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Abstract: The study explored and identified several competitive strategies employed by academic libraries to maintain and enhance their competitive edge. The presence of these strategies highlights the multifaceted approach required to stay relevant and effective in a rapidly evolving information landscape, also in an academic information support landscape. Qualitative data were collected from managers by means of semi-structured interviews. Participants emphasized the use of benchmarking exercises to stay abreast of trends and developments in the field. By comparing their practices against top institutions, libraries can identify areas for improvement and adopt best practices. Findings of the study show the importance of benchmarking as a tool for gathering competitive intelligence. Benchmarking helps libraries to align their services and resources with industry standards, ensuring they remain competitive. The study found that financial constraints impact the ability of libraries to be competitive. Participants noted that while they strive to build capacity, financial limitations hinder their efforts. Collaboration and partnerships were emphasized as critical for building capacity and maintaining international standards. Participants discussed the importance of establishing partnerships with other academic institutions, both nationally and internationally. The concept of "scrums" or interdepartmental collaboration within the academic institution is emphasized to bring together staff from different divisions to work on common goals of partnerships in enhancing library services and resources.

Keywords: Competitive intelligence, Competitive intelligence strategies, Academic libraries, Library strategy, Information services

1. Introduction

The increasingly competitive landscape of information provision necessitates a strategic approach for organisations to maintain relevance and effectiveness (Moyane *et al*., 2020). Academic libraries, central to higher education institutions, are no exception. As pillars of academic success, these libraries archive bodies of knowledge essential for teaching, research, and community service (Chopra, 2018). However, they face growing competition from alternative information providers, including online databases and search engines (Yaya, Ochonna & Osisanwo*,* 2014; Adesina *et al*., 2022). This competition challenges traditional library services and highlights the need for proactive strategic planning.

Competitive intelligence (CI) is described as a formalised, evolving process by which organisations assess their operational progress and the capabilities of existing and potential competitors to maintain a competitive edge g, 2022). It involves the ethical and legal collection, analysis, and dissemination of actionable information about the competitive environment, which is crucial for informed strategic decision-making across diverse sectors (Heppes & Du Toit, 2009; Chawinga & Selemani, 2017; Maluleka & Chummun, 2023). While CI's benefits are well-established in industries like banking and pharmaceuticals, its adoption and application within the library and information science field, particularly in academic libraries, remain less explored (Yaya *et al.,* 2014; Madukoma *et al*., 2015; Jerome *et al*., 2017).

Academic libraries, traditionally central to higher education, are facing a significant transformation driven by digital technologies and alternative information providers. These competitors, such as online databases and search engines, offer readily accessible information directly to students, often bypassing traditional library services (Moyane *et al.,* 2020; Cox, 2023). This shift highlights the need for libraries to adapt and develop proactive strategies to ensure their continued relevance (Bergeron & Hiller, 2005; Yaya *et al.,* 2014).

Despite a growing awareness of CI's potential within the library sector, a significant knowledge gap exists concerning its practical application in South African academic libraries (Gichohi, 2015; Ojo & Olaniyi, 2017; Iwu-James *et al*., 2019; Moyane *et al.,* 2020). This study directly addresses this gap by investigating the current practices, processes, and levels of awareness surrounding CI within a specific South African academic library. By examining these aspects, this study seeks to contribute valuable insights into the practical implementation of CI within a South African academic library context, providing a foundation for future research and potentially informing the development of best practices for enhancing competitiveness and service delivery.

2. Background

Academic libraries, traditionally central to higher education, are facing a period of significant transformation. Their core function; providing access to information resources and supporting teaching, learning, and research, is increasingly challenged by a rapidly evolving information landscape (Haliso & Aina, 2012; Jerome *et al.,* 2017). The rise of digital technologies and the proliferation of alternative information providers, including online databases, search engines, and commercial publishers, present both opportunities and threats (Du Plessis & Mabunda, 2016; Harland *et al.,* 2017; Hamad, Fakhuri & Jabbar, 2020). These competitors often offer readily accessible, sometimes free, information directly to students, bypassing traditional library services and potentially diminishing library usage (Bell, 2002; Moyane *et al.,* 2020). This shift highlights the need for academic libraries to adapt and develop proactive strategies to ensure their continued relevance and value within the higher education ecosystem (Bergeron & Hiller, 2005; Yaya *et al.,* 2014).

The competitive pressures faced by academic libraries are multifaceted. They include competition from other libraries (both within and outside the institution), the availability of free online resources, and the rise of commercial information providers who often sell directly to the library's constituency (Moyane *et al.,* 2020; Adesina *et al.,* 2022). These competitors often possess greater technological capabilities, more extensive resources, and more flexible funding models, making it difficult for traditional academic libraries to compete solely on the basis of their established services (Ewu-James *et al.,* 2020; Cox, 2023). The resulting challenge necessitates a strategic shift towards a more proactive and competitive approach to information management and service delivery.

In response to these challenges, the adoption of competitive intelligence (CI) methodologies is increasingly recognised as a crucial strategy for academic libraries (Moyane *et al.,* 2020). CI, encompassing the ethical and legal collection, analysis, and dissemination of information relevant to the competitive environment (Pellissier & Nenzhelele, 2013; Maungwa & Fourie, 2018; Iroaganachi, 2022), empowers libraries to make informed strategic decisions, anticipate future trends, and adapt to the changing needs of their users (Diyaolu, 2019; Moyane *et al.,* 2020; Adegbite, 2020). However, little is known about how CI is practiced in South African libraries, the extent of its use, and whether information professionals have embraced CI as a strategic tool (Gichohi, 2015; Ojo & Olaniyi, 2017; Iwu-James *et al*., 2019). This lack of empirical evidence underscores the need for further investigation into the implementation and effectiveness of CI strategies within these crucial institutions. The research aims to understand:

- The level of understanding and awareness of CI among library managers;
- The identification and analysis of the library's key competitors;
- The extent to which CI informs strategic decision-making within the library;
- The methods employed for collecting and analysing CI within the library.

3. Research Methodology

Table 1 presents a summary of the research methodology, which includes the research paradigm, research approach, the time frame of data collection, research method, methods of data collection, sample method and participants.

Table 1: Summary of the research methodology

Research paradigm	The study was placed in interpretivist paradigm, which is particularly suited for exploring the subjective meanings and interpretations of competitive intelligence (CI) practices within an academic library setting.
Research approach	The study followed a qualitative research approach
Research methods	A case study design was chosen for this research to facilitate an in-depth exploration of CI practices within a specific South African academic library (Pickard, 2017).
Time taken to collect data	Data collection took place between November 2023 until April 2024.
Data collection instruments	Data was collected through semi-structured interviews conducted. Twelve (12) interviews were held remotely via Zoom and Google Meet to accommodate participants' time constraints and preferences.

Sampling methods and participants	The study's participants include a library director, deputy directors, and librarians, totalling twelve individuals engaged in activities related to CI. Participants were selected using convenience sampling,
Ethical clearance and Consent	Ethical clearance was obtained from the University of Pretoria, where the researchers are registered, and from another South African university (name omitted for confidentiality) where data collection took place. Informed consent was obtained from all participants, who voluntarily agreed to participate and be recorded, with pseudonyms used to ensure confidentiality and anonymity in all reporting (Kandeh et al., 2018).

Thematic analysis was used to analyse the interview transcripts, identifying key themes in CI practices and perceptions (Given, 2008). Guided by the adapted CI cycle and Porter's five forces model, the analysis structured insights on CI collection, analysis, and the library's competitive landscape.

4. Models and Theoretical Frameworks Underpinning the Study

Conceptually, the study is informed by two theoretical frameworks. The adapted competitive intelligence cycle, as outlined by Muller (2002), Botha and Boon (2008), and Bose (2008), guided the exploration of CI processes, including the collection, analysis, and application of intelligence. Porter's five forces model, as interpreted by Grundy (2006), offered a framework for examining the competitive dynamics influencing the academic library sector. These frameworks ensured that the data analysis remained aligned with the study's objectives and provided a comprehensive understanding of CI practices.

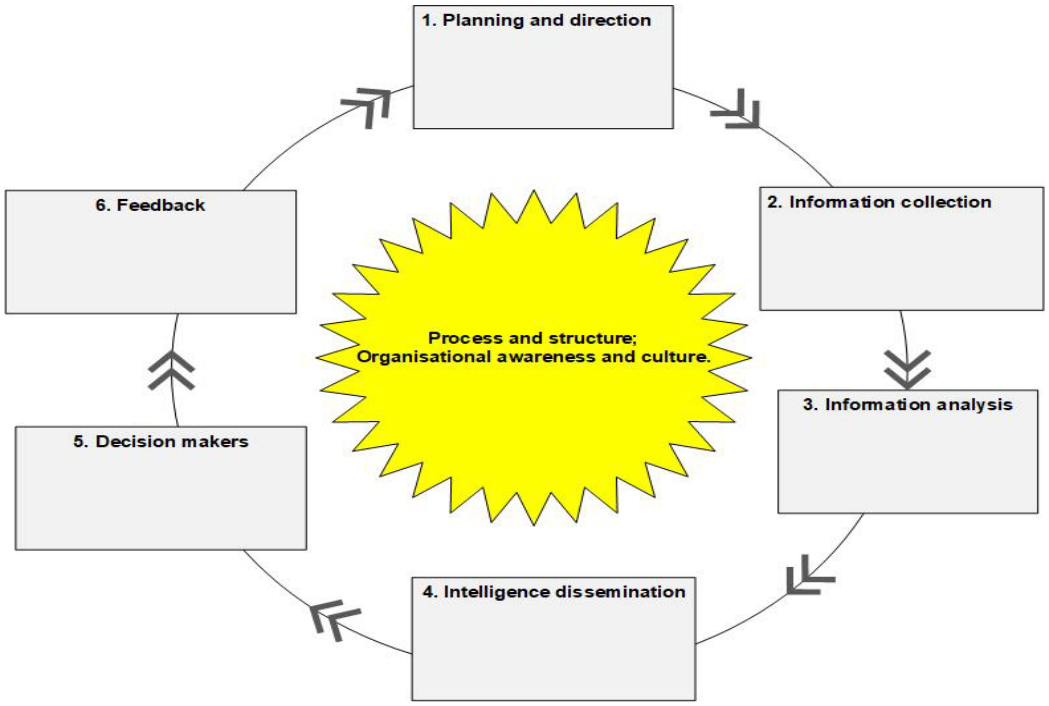


Figure 1: CI cycle adapted from Muller (2002), Boon & Botha, (2008), Bose, (2008)

4.1 Participant Roles and Professional Context

Although demographic data such as age, gender, and years of experience were not collected, as they were not expected to influence the outcomes of the study, participants were asked to describe their professional roles within the academic library. This provided essential contextual insights relevant to the study's objectives. The sample comprised 12 librarians occupying a variety of leadership and specialist roles. These included:

- Director of Library Services, responsible for strategic oversight and alignment with institutional goals
- Deputy Directors, who led key domains such as Collection Development, Teaching and Learning, and Digital Scholarship
- Faculty Librarians, who support academic departments by aligning library services with teaching and research

- Research Librarians, who provide specialised research support to students and faculty
- Information Librarians, who promote information literacy and ensure effective access to library resources

By capturing the responsibilities and functions of each role, the study ensured a well-rounded understanding of competitive intelligence practices within the operational structure of academic libraries.

4.2 Overview of Emergent Themes

The study was guided by 14 semi-structured interview questions, which yielded a rich and diverse set of responses. Through thematic analysis, a wide range of themes and sub-themes emerged, reflecting the complex landscape of CI practices within academic libraries. These included, among others, themes such as leadership roles, navigating competitive environments, maintaining relevance, technological integration, strategic decision-making, benchmarking, ethical considerations, and stakeholder communication.

Given the breadth of data and the exploratory nature of this research, only a selection of the most prominent and relevant themes has been included in this article. The following themes were identified as particularly significant to the study's objectives and are discussed in detail:

- Understanding and Awareness of Competitive Intelligence
- Identification of Competitors
- Extent of CI Use in Strategic Decision-Making
- Methods of CI Collection and Analysis

These themes were selected for their centrality to the research questions and their recurring emphasis across participant responses.

5. Findings From the Interviews

5.1 Understanding and Awareness of Competitive Intelligence

The study revealed a spectrum of understanding and awareness of CI among library managers. While some managers demonstrated a clear grasp of CI's potential, others expressed the need for further education on the subject. From the study, participants generally hold a positive view of CI but often engage in CI activities without explicitly recognising them as such. For instance, Fredricks, the Deputy Director for Teaching and Learning, emphasised the use of "disruptive innovation" over formal CI, indicating a preference for proactive adaptation of emerging trends. Similarly, Vusani, the Director of the Library, expressed a desire to learn more about CI, highlighting opportunities for targeted training to enhance CI understanding and application.

5.2 Identification of Competitors

Participants identified a range of competitors, primarily other academic libraries and higher education institutions within South Africa. Bonga and Dakalo pointed to other academic libraries as their main competitors, while Fredricks specified "top leading universities in the country" as benchmarks. Interestingly, some participants, such as Vusani and Siyabonga, reframed competition in terms of collaboration, viewing other institutions as "colleagues" rather than competitors. This dual perspective of competition and collaboration suggests a nuanced understanding of the competitive landscape within the academic library sector.

5.3 Extent of CI Use in Strategic Decision-Making

CI plays a crucial role in informing strategic decisions within the library. Fredricks highlighted its importance in aligning services with strategic goals and user needs, stating that CI aids in "decision-making, budgeting, and forecasting for new technologies and human resources." Vusani emphasised CI's role in identifying service gaps to create a "seamless experience" for users, while Dakalo noted its value in prioritising tasks amidst digital developments. These insights demonstrate the multifaceted value of CI in supporting innovation, relevance, and efficiency in library operations.

5.4 Methods of CI Collection and Analysis

The library employs a diverse range of methods for CI collection, blending formal and informal approaches. Networking and professional engagement are key strategies, with librarians actively participating in professional associations and conferences to stay informed about industry trends. User surveys, such as first-year experience surveys, are utilised to gather feedback and understand evolving user needs. Benchmarking and collaboration with other institutions are also prevalent, as evidenced by Vusani's and Dakalo's emphasis on international

benchmarking and collaborative projects. Engagement with suppliers further provides valuable insights into new products and solutions.

5.4.1 Frequency of information collection

Information collection occurs on a continuous basis, with specific methods varying in frequency. Dakalo described ongoing engagement in digital scholarship trends, while Fredricks noted plans for more frequent user surveys. Bonga emphasised an opportunistic approach, always seeking innovative practices. This flexible approach to information collection allows the library to balance continuous awareness with resource constraints.

5.4.2 Adherence to ethical principles

Participants consistently emphasised a commitment to ethical principles in CI activities. Ethical clearance is obtained for formal research, and confidentiality is respected in all interactions. Fredricks and Vusani highlighted the role of the university's Ethics Committee in ensuring compliance, while Dakalo and Bonga described transparent communication and permission-seeking processes. This strong ethical foundation ensures responsible information gathering and use.

5.4.3 Analysis

CI data is analysed using a variety of tools and methods. Vusani mentioned the use of software tools like NVivo and SPSS, complemented by manual analysis for contextual relevance. Dakalo described pragmatic use of Excel and OpenRefine, while Bonga focused on comparative analysis without specific software reliance. These diverse approaches reflect adaptability in extracting meaningful insights from CI data.

5.4.4 Challenges impacting CI practice

Several challenges impact the practice of CI within the library. While information sharing is generally positive, accessing sensitive competitor information remains difficult. Lesedi noted that "competitors always protect their sensitive information," posing a barrier to comprehensive CI. Dakalo highlighted the challenge of ensuring data relevance and comparability, emphasising the need for strategic selection of benchmarking partners. Despite these challenges, the library remains committed to ethical conduct and continuous improvement in CI practices.

6. Discussion of the Main FinDINGS

6.1 Understanding and Awareness of Competitive Intelligence

Library managers' understanding of CI presents both opportunities and challenges for strategic development. While some recognise its potential for innovation and alignment, the lack of formal CI frameworks highlights the need for targeted training. This aligns with research emphasising CI skills for informed decision-making (Iwu-James *et al*., 2019). Fredricks' preference for "disruptive innovation" over traditional CI suggests that proactive adaptation is key in today's evolving landscape. A structured CI approach could enhance this mindset by offering systematic insights into competition and user needs.

The study reveals that while participants engaged in CI-related activities like benchmarking and technology adoption, they rarely used the term "Competitive Intelligence." This suggests an implicit understanding, supporting Nenzhelele's (2012) view that awareness is essential for CI adoption. However, this contrasts with Moyane *et al*. (2020), who found higher explicit CI awareness among South African library directors—possibly due to differences in sample populations or question specificity.

Findings highlight a gap between intuitive CI practice and formal knowledge, presenting an opportunity for professional development. By integrating structured CI methodologies, libraries can strengthen strategic planning. Positive attitudes toward CI and engagement in related practices indicate a receptive environment for cultivating a CI culture. However, diverse interpretations of CI (Adenekan *et al*., 2024; Nenzhelele, 2013) underscore the need for standardised terminology to enhance communication and strategic growth in the field.

6.2 Competitors and Collaborative Perspectives

Academic libraries face competitive pressures from other institutions, particularly well-funded universities. This aligns with Haliso and Aina (2012), who highlight intense competition between public and private university libraries. Study participants emphasised benchmarking against top universities to maintain competitiveness.

Beyond academic libraries, participants identified private information providers, including internet and telecom companies, e-resource platforms like EBSCOhost, and open-access search engines like Google, as key competitors. These alternatives challenge the perceived value of traditional libraries (Madukoma *et al*., 2015; Moyane *et al*., 2020). Additionally, publishers bypassing libraries to sell directly to students and researchers further intensify competition (Iwu-James *et al*., 2020; Adegbite, 2020). To remain relevant, libraries must enhance service quality, resource attractiveness, and operational efficiency.

Interestingly, internal competition within institutions was not mentioned, though literature suggests it affects funding and resource allocation (Iwu-James *et al*., 2020). Despite competitive pressures, some participants, like Vusani, noted a growing collaborative approach. Collaboration enables resource sharing and problem-solving, especially in resource-limited environments (Chawinga & Selemani, 2017). Arsanti *et al*. (2024) argue that collaboration enhances knowledge absorption, supporting this shift.

The study suggests a dual approach where competition and collaboration coexist, challenging traditional views. This balance allows libraries to adapt to the evolving information landscape while maintaining strategic relevance.

6.3 Strategic Application of Competitive Intelligence

Competitive Intelligence (CI) plays a crucial role in academic libraries, guiding budgeting, technology adoption, and service improvements to enhance user satisfaction. CI enables libraries to anticipate trends and align services with institutional goals (Maluleka & Chummun, 2023), fostering a user-centric model.Library directors leverage CI data to align decisions with institutional strategies, including the Sustainable Development Goals (SDGs), ensuring services remain relevant in a rapidly evolving digital landscape. CI also supports evidence-based budgeting, helping libraries allocate resources effectively to support research and innovation. Studies highlight the risks of uninformed decision-making (Ambali *et al*., 2012; Olayemi *et al*., 2022), while Moyane *et al*. (2020) show South African libraries using CI for service innovation, though with varying formality. This study provides concrete examples of CI applications in resource allocation and strategic planning. It also reveals a rigorous evaluation process, incorporating performance management frameworks, user surveys, and usage statistics to assess and refine strategies based on empirical data. By integrating CI into decision-making, libraries can enhance efficiency, remain competitive, and better serve their communities.

6.4 Methods of CI Collection and Analysis

The library remains responsive to the evolving information landscape through diverse competitive intelligence (CI) collection and analysis methods, including networking, surveys, and benchmarking. This strategic mix of formal and informal approaches enhances adaptability. However, reliance on manual analysis and limited use of advanced analytical tools highlight areas for improvement. Integrating sophisticated data analytics could refine insights and align with data-driven decision-making trends (Botha & Boon, 2008).

Participants employ various CI collection methods, such as attending conferences (e.g., IFLA, LIASA), conducting user surveys, benchmarking, and collaborating with libraries and suppliers. These practices align with Yaya *et al*.'s (2014) CI collection techniques and Moyane *et al*.'s (2020) emphasis on digitisation and web-based services. Ethical considerations are integral, with participants stressing adherence to data privacy regulations (e.g., POPIA) and ethical clearance for formal research.

The library utilises tools like NVivo, SPSS, Excel, and OpenRefine alongside manual methods for CI analysis. While these tools support qualitative and quantitative insights, further investment in advanced analytics and staff training could enhance efficiency. Additionally, structured annual reviews and dedicated quality assurance personnel ensure proactive CI collection, contributing to strategic decision-making and continuous improvement.

6.5 Challenges and Ethical Considerations

Accessing sensitive competitor information and ensuring data relevance remain persistent challenges in competitive intelligence (CI) practices within academic libraries. These obstacles align with broader CI literature, which highlights the difficulty of obtaining high-quality, comprehensive data for strategic decision-making (Heppes & Du Toit, 2009). Despite these challenges, the library demonstrates a strong ethical commitment to information gathering, ensuring responsible CI practices that maintain trust with stakeholders and align with best practices in library management (Kandeh *et al*., 2018).

The study presents a nuanced view of CI challenges. Some participants reported minimal difficulty in gathering competitor intelligence, suggesting positive inter-institutional collaboration and a willingness to share information among academic libraries. However, others identified significant challenges, particularly in accessing sensitive competitor data, highlighting the tension between obtaining strategic insights and respecting confidentiality. Additionally, participants noted the difficulty of engaging with the right institutions for benchmarking, as transparency levels and information-sharing policies vary across organisations.

Internal coordination with faculty and aligning CI efforts with institutional priorities emerged as another challenge. While existing literature primarily focuses on external CI barriers, such as budget constraints, lack of skilled personnel, and poor ICT infrastructure (Haliso & Aina, 2012; Madukoma *et al*., 2015; Unobe, 2019; Adegbite, 2020; Moyane *et al*., 2020; Adetayo *et al*., 2021), this study highlights internal organisational challenges that can impact CI effectiveness. Interestingly, while the literature often cites a reluctance to share strategic information, participants in this study generally reported positive experiences with inter-library collaboration, suggesting a potential shift towards greater cooperation within the academic sector.

The findings suggest that while some traditional CI challenges persist, the evolving information landscape presents opportunities for improved practices. Addressing both external and internal barriers, through targeted training, enhanced internal coordination, and investment in analytical tools, can further strengthen CI effectiveness, ensuring that academic libraries remain competitive and responsive to emerging trends.

6.6 Implications for Practice

The findings of this study have significant implications for academic library practices and future research in competitive intelligence (CI).

6.7 Practical Implications

The study highlights the need to formalize CI practices in academic libraries, bridging the gap between intuitive CI use and structured frameworks. Establishing formal CI methodologies will enhance strategic planning and decision-making while fostering a culture of intelligence aligned with institutional goals. To achieve this, targeted training and professional development are essential, equipping librarians with CI skills and proficiency in advanced analytical tools.

The study also emphasizes the dual role of competition and collaboration in the library sector. Libraries can enhance resource sharing and problem-solving by fostering partnerships with other institutions and information providers. Such collaborative strategies are particularly valuable in resource-limited environments. Ethical considerations remain a key component of CI practice. Libraries must ensure responsible information gathering, maintain transparency, and obtain ethical clearance when necessary. Strengthening ethical guidelines will uphold stakeholder trust and compliance with data privacy standards. To reduce reliance on manual analysis, libraries should invest in advanced analytical tools and train staff in data-driven decision-making. This will improve the depth and accuracy of CI insights.

6.8 Research Implications and Future Research

Future studies should explore factors influencing CI awareness and adoption across diverse institutions. Research could also examine the impact of collaborative CI practices on library performance and user satisfaction. Additionally, evaluating CI training programs can identify best practices for integrating intelligence methodologies effectively. Further investigation into ethical challenges, particularly concerning data privacy, would help develop comprehensive CI guidelines.

With increasing reliance on technology, future research should assess the role of artificial intelligence, machine learning, and big data analytics in CI. Understanding these technologies' impact will provide insights into emerging trends and opportunities. By addressing these implications, academic libraries can strengthen their strategic capabilities, enhance service quality, and navigate an evolving information landscape more effectively.

7. Recommendations and Conclusion

Based on the study's findings, several recommendations can enhance CI practices in academic libraries.

7.1 Formalizing CI Practices

Libraries should develop structured CI frameworks, integrating them systematically into strategic planning. Establishing clear protocols and guidelines ensures alignment with institutional goals. To support this, targeted training and professional development programs should be implemented, building both theoretical knowledge

and practical skills. Training should focus on advanced analytical tools and techniques, equipping staff to apply CI effectively and foster a culture of innovation.

7.2 Collaboration and Ethical Considerations

Libraries should actively pursue partnerships with other institutions and information providers to facilitate resource sharing and collective problem-solving. Enhanced inter-library cooperation can strengthen competitive positioning and improve service delivery. Ethical considerations must remain central, ensuring CI practices respect data privacy and confidentiality. Establishing clear ethical guidelines and securing necessary clearances will help maintain trust with stakeholders and uphold integrity.

7.3 Investment in Analytical Tools

Reducing reliance on manual analysis is crucial. Libraries should invest in advanced analytical tools and provide staff training to enhance data analysis capabilities, leading to more informed strategic decisions.

7.4 Conclusion and Future Research

In conclusion, this study highlights the critical role of CI in enhancing the strategic capabilities of academic libraries. The findings reveal a nuanced understanding of CI among library managers, characterised by both intuitive application and a need for formalised frameworks. By formalising CI practices and investing in targeted training, libraries can effectively integrate CI into their strategic planning processes, driving innovation and improving decision-making. The study also underscores the importance of collaboration in navigating the competitive landscape. By fostering partnerships and sharing resources, libraries can enhance their service offerings and better meet the needs of their communities. Ethical considerations remain paramount, with libraries needing to ensure responsible information gathering that respects confidentiality and maintains stakeholder trust. Future research should continue to explore the factors influencing CI awareness and adoption, as well as the impact of collaborative CI practices on library performance. As libraries increasingly embrace technology-driven approaches, further investigation into the role of emerging technologies in CI practices will provide valuable insights into future trends and opportunities. Overall, this study contributes to the growing body of literature on CI in academic libraries, offering practical recommendations and highlighting areas for future exploration. By addressing the challenges and opportunities identified, libraries can enhance their strategic capabilities and better navigate the evolving information landscape.

Ethical Considerations: Ethical considerations were prioritised throughout the research process. Ethical clearance was obtained from the University of Pretoria Faculty of Engineering, Built Environment, and IT Faculty Committee for Research Ethics and Integrity, as well as the participating institution.

AI Declaration: This is to declare that this work is based on Master's study conducted by Dzhavhelo Tshidaho (The University of Pretoria), the article was not generated using AI tools.

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Futures Thinking: Unlocked Possibilities for Business Model Innovation in VUCA World

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Abstract: The Futures are elusive and intangible. This constrains companies' capabilities to successfully plan and implement Future proof business models. In the process of making future projections, organizations often adopt forecasting and decision-making merely based on historical performance data or short-sighted future outlooks. Previous research on business model innovation has created a wide understanding of this complicated topic from different viewpoints, yet there is still room for academic discussion on the possibilities in combining futures thinking and corporate foresight within these innovation processes. Using qualitative research design, with 24 interviews and co-creational Futures workshop with 15 participants, this study examines how Hospitality Field companies are using Futures Thinking in their Business Model Innovation activities. Central research question in this study is: How Futures Thinking can support Hospitality Field companies in designing future proof Business Models? Practitioners in managerial positions encounter numerous challenges in decision-making in VUCA environment. Findings indicate two main barriers to adaptation of Futures Thinking. A primary barrier is lack of general understanding of this topic and its possibilities. Furthermore, the financial resources needed to support the costs associated with Futures Thinking platforms, materials, and professional orchestration and facilitation remain undefined. Based on the findings, a Futures Thinking and Business Model Innovation process model was designed to explain how these may be combined. This process model illustrates the action movement that is critical to enhance future business innovation. There are five business development stages: 1) environmental scanning, 2) vision formulation, 3) knowledge alignment, 4) innovation implementation and 5) feedback and iteration. This paper shows that in a volatile, uncertain, complex, and ambiguous VUCA business environment, envisioning plausible, probable, possible and/or preferred Futures is a necessity. To overcome organizational inertia and to engage in Futures Thinking initiatives, companies must effectively leverage qualities such as open-mindedness, strategic agility, and commitment to continuous learning and knowledge creation and sharing.

Keywords: Futures thinking, Business model innovation, Foresight, VUCA, Knowledge management

1. Introduction

In 1989 Ulrich and Wiersema saw the coming decade to be “like playing basketball with a moving basket”. This scenario has changed only a little, today's outlook is the same. The only difference is that there are a number of moving baskets on the basketball court. As they declared, when the environment is undergoing dramatic and/or continuous change, flexibility in adjusting to changing competitive conditions and implementing decisions under conditions of uncertainty becomes crucial. Bennett and Lemoine (2014) describe VUCA acronym in business environment by Volatility: change is frequent and sometimes unpredictable, Uncertainty: a lack of knowledge regarding future, Complexity: multiform and convoluted network of information and procedures and Ambiguity: cause and effect are not understood and there is no precedent for making predictions as to what to expect. Today VUCA business environment may be seen as an outcome of disruptive innovation or as a driver of it. Also, it is often used as an excuse to avoid planning and action (Millar, Groth and Mahon, 2018).

Bennett and Lemoine (2014) discussed the importance of leadership in VUCA world. They highlight leaders' importance in preserving and enhancing organizational performance with scarce resources in different VUCA situations. There are several perspectives to consider when dealing with organizational level enquiry. For example, Ramus, Vaccaro and Brusoni (2017) explored how internal tensions triggered by environmental

turbulence may be managed in organizations. Their findings showed for example that possible disagreements may be tackled by collaboration in which different logics can better explain their own viewpoints. They highlight the progressive, sensitizing approach of institutional theory to provide solid foundation to discussion about managerial actions in different kinds of empirical settings.

Fergnani (2022) introduces corporate foresight to be important for research in strategy and management. It adds a future-focused ability to the dynamic capabilities framework with new possibilities for research. Corporate foresight can improve learning, creativity, innovation, and performance by offering a new way to gain competitive advantage.

2. Theoretical Background

2.1 Futures Thinking and Corporate Foresight Changing Business Model Innovation

Previous research on business model innovation has created a wide understanding of this complicated topic, yet there is still room for academic discussion on the possibilities in combining futures thinking and corporate foresight with these innovation processes. As focus on business model innovation has become one of the important priorities of leading companies trying to keep a certain balance of value creation and value capture (Zott, Amit and Massa, 2011) and business models together with innovation have become prominent topics in micromanagement discussion over last few decades (Foss and Saebi, 2017), also SME´s are allocating more resources to pro-active business model innovation in order to create competitive advantage in turbulent environment. Business model innovations have opened the door for new business opportunities far beyond product and process innovations (Freiling, 2015).

As the business environment is undergoing continual and even dramatic changes, the basic assumptions underlying strategic decision making must be reframed to incorporate new perspective on business enhancement (Ulrich and Wiersema, 1989). This does not come without challenges. Latifi, Nikou and Bouwman (2021) advise owners/managers of SMEs to concentrate either on growth or on profit to fully benefit from their BMI-related efforts after carefully assessing their specific situation. To increase velocity of change, firms may need to modularise their business model for reconfiguration and co-optation (Loon and Xiaohong, 2021). Flexibility to adjust to changing competitive conditions and the ability to assess a situation quickly and implement decisions under conditions of uncertainty become crucial success factors (Ulrich and Wiersema, 1989).

In turbulent times, the responsibility of management is to make sure the company holds the capacity for survival. Adaptation of sudden change and availing new opportunities is of importance, as Drucker highlighted already in 1980. Shifting a business model to another is often a demanding challenge that is based on dynamic capabilities (Teece, 2007), according to Foss and Saebi (2015) not all firms succeed in adapting their business model to new market demands or competitive threats. Chesbrough (2010) stated the barriers to changing the business model to be real, and tools such as maps would be helpful, but not enough. Companies must adopt an effectual attitude toward business model experimentation and organizational processes must also change. Attaining alignment with the environment is the main motivation of business model adaptation. Considering the importance of the mediating role played by organizational capabilities, it is important for managers, as well as the people advising them, to create an open, dynamic and entrepreneurial culture (Latifi, Nikou and Bouwman, 2021).

Academic research has provided insights into the necessity of corporate foresight systems (Rohrbeck and Gemünden, 2011). Rohrbeck and Kum (2018) performed a long-term study and discovered solid empirical proof that foresight enhances future preparedness and ultimately drives superior firm performance. On the other hand, corporate foresight has undergone continuous development over time (Rohrbeck et al., 2015). Taken together, foresight is seen as a proactive approach that focuses not on predicting or forecasting the future but on helping individuals explore various possible future scenarios states (Vecchiato, 2012). Fergnani (2022) explains corporate foresight to be a dynamic, firm-level capability that allows firms to evaluate future scenarios of the business environment, including systematic doomsday situated in the broader epistemological underpinnings of futures studies, theoretically inscribed in the dynamic capabilities' framework, distinguished from related constructs, and deconstructed collapses. It is defined, in its main components.

Organisational foresight can be seen to emerge as a critical product of collective knowledge creation. To understand emergence of collective foresight, understanding the social action and context of the collective is needed (Schwandt and Gorman 2004). A belief is that applying futures thinking and related tools enhances decision-making quality. Research in future studies supports this notion, providing evidence that utilizing futures thinking improves decision-making and impacts on organizations activities. (Hines, 2002.) Feuls et al. (2024) define far futures as future matters that are beyond organizations' general planning horizons and represent departure from futures that are typically addressed through organizations' future making practices. Whereas regular planning or future making activities involve repeated processes using strategic plans that may consider an event that is quantitatively different from the present.

2.2 Sensing, Seizing and Transforming: Dynamic Capabilities

Teece (1997) describes dynamic capability as "the firm's ability to integrate, build and reconfigure internal and external competences to address rapidly changing environments". The essence of dynamic capabilities is a firm's behavioral orientation in the adaptation, renewal, reconfiguration and re-creation of resources, capabilities and core capabilities responding to external changes. The futures orientation and futures thinking can be linked to

the dynamic capabilities' theory. In this way, "Seizing" refers to Dynamic Capabilities Theory developed by Teece, Pisano, and Shuen (1997). The theory proposes that organizations need the ability to sense opportunities and change resources to integrate to progress. Futures thinking can be seen as part of the "seizing" process, where strategic options for the future are evaluated. Empirical and conceptual studies of adaptive, absorptive, and innovative capability are long-standing. Recently researchers have related each of these capabilities to a firm's dynamic capabilities but have not thus far clearly identified them as the component factors of dynamic capabilities (Wang and Ahmed, 2007).

Dynamic capabilities are necessary as those enable the firm to integrate, build, and reconfigure internal and external resources to address and shape rapidly changing business environments. Ordinary capabilities are described to be about doing things right, dynamic capabilities on the other hand are about doing the right things (Teece and Leih, 2016). What is required for sustained profitability is that the business enterprise be built to respond to the unexpected by establishing and maintaining flexible systems, which are hallmarks of strong dynamic capabilities (Teece and Leih, 2016).

High-order dynamic capabilities guide second-order dynamic capabilities. in which management, supported by organizational processes, senses likely avenues for the future, devises business models to seize new or changed opportunities, and determines the best configuration for the organization based on its existing form and the new future plans. Highest-order capabilities - sensing, seizing, and transforming competencies – are the most relevant for innovation and selection of business models that address the problems the company is endeavouring to solve/exploit (Teece, 2018).

2.3 Knowledge Management

Theories help us to understand how organizations learn and create knowledge (e.g., organizational learning—Argyris (2005); managing organizational knowledge—Nonaka (1994), how they are structured, and how managers organize their work in them. Theories can help us to gain a competitive advantage and evaluate degree of success. Knowledge-Based Theory of the Firm focuses on resources and organizational capabilities as the principal sources of competitive advantage and the foundation for strategy conceptualisation. Theories of the firm are models of business enterprises which explain their structure and behaviours. The knowledge-based view of the firm (KBV) is different from other theories where the issues are the organizational factors in the production of competitive advantage. KBV focuses on internal organization, and the firm is in the theory of complex organization encompassing multiple individuals (Grant 1996).

A knowledge-based approach offers a theoretical basis for understanding several recent organizational innovations and trends. These include empowerment and the development of new organizational forms for the firm. The primary task of management is finding the coordination necessary for this knowledge integration. Coordination is the main implication, especially when tacit knowledge is involved (Grant, 1996).

While existing knowledge-based theory (Grant, 1996) focuses on the efficiency of hierarchy in economizing on knowledge exchange, this contribution of Nickerson and Zenger (2004) develops a theory of the firm that focuses on the efficiency of alternative organizational forms in generating knowledge or capability. The authors of the paper (Nickerson and Zenger, 2004) shows that they develop a knowledge-based theory of the firm that addresses these shortcomings. They explain how a firm's prospective objectives for knowledge formation dictate the choice of how to organize. Here the question is not whether knowledge should be owned or acquired in the market or how the exchange of knowledge should be facilitated, but rather how a manager should organize individuals to generate knowledge that the firm seeks.

Argyris (2005) proposes a double loop learning theory which communicates learning to change underlying values and assumptions. The focus of the theory is on solving problems that are complex, and which change as problem-solving advances. An example of single-loop learning would be to correct an error in an existing strategy without altering the underlying governing variables of strategy. Double-loop learning occurs if, to correct errors, it is necessary to change the underlying assumptions and values that govern the actions of the strategy. A thermostat is a single-loop learner. It is programmed to turn the heat up or down depending on the temperature. A thermostat would be a double-loop learner if it questioned the existing program that should measure heat (Argyris 2005). Double-loop learning recognizes that the way a problem is defined and solved can be a source of the problem. This type of learning can be useful in organizational learning since it can drive creativity and innovation, going beyond adapting to change to anticipating or being ahead of change.

Nonaka (1994) defines that an organization's competitiveness for innovation is based on its capability to create and share knowledge. This process occurs through interaction between individuals and groups, especially by

combining tacit (personal, experience-based) and explicit (formal) knowledge. Knowledge creation is not just a technical process but also a human and social reality that requires shared context and purpose. Foresight renders tacit knowledge about changes in the environment explicitly, helping organizational members to realize that there are more choices than previously thought (Vecchiato, 2015).

3. Data and Methods

To gain in-depth understanding of the practices of developing future proof business models, we employed a qualitative research design. A combination of data collection methods was employed, including themed interviews and co-creation Futures workshops. This multimethod approach was chosen to gain a holistic view of the business model development in Hospitality Field companies, by including reflective real-time dynamics. In the first phase, in 2023-2024 total of 24 interviews (table 1) were executed in Finland focusing on understanding generally the viewpoints of interviewees to business model innovation practices, to futures thinking and to sustainability linked to these topics. The primary group of interest was executive level Hospitality Field practitioners. One interview was conducted by telephone, 15 face to face and 8 by Teams online system. Discussions lasted between 50 minutes to 1 hour and 25 minutes. A themed interview model was chosen to cover the framework of themes using a structured interview guide with pre-formulated open questions: 1) Business Model Innovation: How turbulent business environment has changed business model innovation practices in your company?, 2) Futures Thinking: Is Futures Thinking (and related tools) actively used in your company and how?, 3) Sustainability: What role sustainability has in business enhancement activities in your company?.

According to Hirsjärvi and Hurme (2022) benefit of a themed interview is that it does not restrict the depth of the interview. Instead of very specific questioning, it allows discussion to flow freely, keeping with the themes set beforehand. Construction of questions along the interview taking place may differ in different interviews according to interviewee's responses.

Table 1: List of interviews

interviewee	business field	interviewee position	interview duration in minutes	interview channel
a	hotel	Front Office Manager	60	face-to-face
b	restaurant and catering	Sales Executive	55	face-to-face
c	hotel	Financial Director	65	Teams
d	hotel	Sales Manager	75	face-to-face
e	travel agency	Sales Manager	60	Teams
f	restaurant and catering	Team Leader	58	face-to-face
g	restaurant and catering	Sales Executive	50	Teams
h	events	Customer Manager	70	face-to-face
i	events	Head of Customer Success	50	face-to-face
j	hotel, events	Team Leader	70	face-to-face
k	restaurant and catering	Entrepreneur	85	face-to-face
l	events	Technical Lead	60	Teams
m	travel agency	Sales Executive	60	Teams
n	restaurant and catering	Head of Catering	64	face-to-face
o	restaurant and catering	HR Director	54	phone
p	events	Head of Production	70	Teams
q	events	Manager	60	face-to-face
r	events	Customer Experience Lead	55	Teams
s	hotel	Head of Marketing	78	face-to-face
t	restaurant and catering	Sales Team Leader	55	face-to-face
u	hotel	HR Manager	59	Teams
v	restaurant and catering	Sales Executive	57	face-to-face
x	hotel	Team Leader	60	face-to-face
y	events	Financial Controller	60	face-to-face

To analyse collected data (table 1), an inductive thematic content analysis was performed. Insight from the interviews was used as a starting point for planning the second phase of the research. Patterns in uncertainty as a common theme in understanding the meaning of Futures Thinking for Business Model Innovation emerged at this point, and these findings were later confirmed by the second phase of the study.

In the second phase, in spring 2025, co-creational Futures workshop was organized with Hospitality field professionals in Espoo (Finland). Twenty Hospitality Field professionals were invited to participate through previous contacts in the field. 15 accepted the invitation to work together on futures canvas work and discussions. During the 2,5-hour long workshop, participants were divided into 4 teams in which they worked on two Futures Canvases ("Getting to grips with a trend" and "Foresight Zoo") by Finnish innovation fund Sitra. Preliminary findings on phase 1 were confirmed, as this group also shared similar experiences, both in challenges and opportunities in combining Futures Thinking to Business Model Innovation activities.

4. Findings

4.1 Decision-Making in VUCA Environment in Hospitality Sector

The central research question in the beginning of the study was: How Futures Thinking can support Hospitality Field companies in designing future proof Business Models? Examples from the Hospitality field and VUCA relevance to decision-making (table 2) show that practitioners in managerial positions encounter numerous challenges in decision-making in VUCA environment.

Table 2: VUCA in Hospitality sector decision-making (composed by authors following Bennett and Lemoine, 2014)

	Definition of the Acronym by Bennett and Lemoine (2014)	Effects of VUCA, insights from Hospitality Field Business Model Innovation (BMI)	Manifest in decision-making within Hospitality sector management
Volatility	"Relatively unstable change; information is available and the situation is understandable, but change is frequent and sometimes unpredictable."	COVID-19: new kind of hazard, BMI processes were disturbed. Pressure of quickly changing national and regional guidelines for sustaining and creating business opportunities makes long-term planning unpossible.	**Agility:** Exponential growth in agility of decision-making. Best practices have remained in post-pandemic market, such as decentralized decision-making -> local managers have been authorized to make decisions that "before" were made in regional headquarters. This enables faster modifications to excisting Business Models. Activating Futures Thinking as a means of preparing supports decision-making in challenging times.
Uncertainty	"A lack of knowledge as to whether an event will have meaningful ramifications; cause and effect are understood, but it is unknown if an event will create significant change."	War and violence in different forms around the world has brought upon dramatical changes, such as in customer segments creates new challenge to BMI.	**Information:** Knowledge creation and transfer challenged. Possibility to make judgement based on bias or uncomplete information. This may render long-running challenges. Onboarding new, digital platforms for knowledge transfer is a necessity in supporting BMI decision-making.
Complexity	"Many interconnected parts forming an elaborate network of information and procedures; often multiform and convoluted, but not necessarily involving change."	Value creation strengthened by new forms of co-operation and partnerships shape BMI: such as hybrid events in partnership with conference hotels, local producers in co-operation with restaurants and grocery stores.	**Restructuring** of internal resources and capabilities opens possibilities for decision-making towards finding new, additional co-creational opportunities. Operating in silos in a VUCA world limits benefits occurring in Business Ecosystem Thinking.
Ambiguity	"A lack of knowledge as to 'the basic rules of the game'; cause and effect are not understood and there is no precedent for making predictions as to what to expect."	Digitalization: Meeting and exceeding customer expectations via use of robots in restaurant services (line of visibility, both in backstage and frontstage operations), Artificial Intelligenge (AI) and automation must be regocnised in BMI.	**Experimentation** is a key to success, this brings new challenges to decision-making. Polarisation of discussion in-house may lead to "stand still". Inertia must be overcome and this craves for new kind of managerial qualities such as open-mindedness, curiosity and tolerance to failure which may be seen as a threat to advancing business.

Insights from the Hospitality Field express examples of real-life effects and manifest to decision-making (table 2). *Volatility*, quick and unpredictable changes challenge agility of decision-making. Ideally managers are to seek out possible solutions beforehand, to prepare possible future business challenges arising from the ever-changing environment. This challenges established routines and thinking. Decision-making chains must be realigned, and empowerment of more localised decision-making is to be enhanced. Experiences from the interviewees highlighted good experiences from COVID-19 in such changes. *Uncertainty* and need for speedy decision-making is another hurdle. Knowledge creation and transfer inside and outside of the company in various forms must be done in more efficient way. Interviewees highlighted the pressure of decision-making with limited access and understanding of the current situation. Digitalization, especially new platforms support knowledge transfer. *Complexity* has awakened managers to utilize power of multi-level relationships. Rather than working in silos, systems may create possibilities for new Business Model Innovation avenues. Trust is a key factor in these

endeavours. Change is not automatic; it requires a lot of time and trust between multiple stakeholders. *Ambiguity* may embrace inertia, which may become a barrier to Business Model Innovation decision-making. In VUCA world, managers are expected to hold new qualities such as open-mindedness, curiosity and tolerance to failures in fast experimentation.

4.2 Barriers in Using Futures Thinking

Findings from the interviews and co-creational Futures workshop created understanding of the topic from the point of view of Hospitality Field practitioners. In general, participants of this study were open-minded to the possibilities of combining Futures Thinking and Business Model Innovation processes and activities even though many had little experience in applying it at their workplace.

> *"The future is interesting, but it is difficult to think 40 years ahead. The business environment may change radically even within a year." - interviewee "k"*

> *"As far as I know, the future is not studied in any way, but assessments of the state of the economy and its weakening and recovery are monitored, because it directly affects the consumer's everyday life and thus consumption." - interviewee "p"*

Several participants highlighted Futures Thinking to be intangible and difficult to understand, as companies are still tied to short-term projections with limited resources at hand to widen their perspective to distant Futures. Uncertainty may give a feeling of "storytelling", Futures Thinking and Corporate Foresight are still something managers need professional guiding and training in.

Furthermore, the second barrier are the financial resources needed to support the costs associated with platforms, materials, and professional orchestration and facilitation. To fully be supported by highest level of company executives, the gains must be presented when new investments are presented, as for example programs and professional training to Futures Thinking. Still, the challenge is that examining the Futures is not a short-term win approach, but it may prove to be well justified investment in the long run as companies are looking for competitive advantage.

4.3 Futures Thinking and Business Model Innovation process model

Findings of this research show that foresighting the future is an essential action in the business world. For that reason, managers must create new ways to build opportunities for using foresight methods beginning from the early stage of the business model innovation process. The following model illustrates how future thinking and business model innovation process can be linked. It introduces two phases: A) strategic and B) tactical. Companies must have a big picture of the future-oriented planning and also the practical implementation guidelines. In this process model there are five business development stages: 1) environmental scanning, 2) vision formulation, 3) knowledge alignment, 4) innovation implementation and 5) feedback and iteration (figure 1).

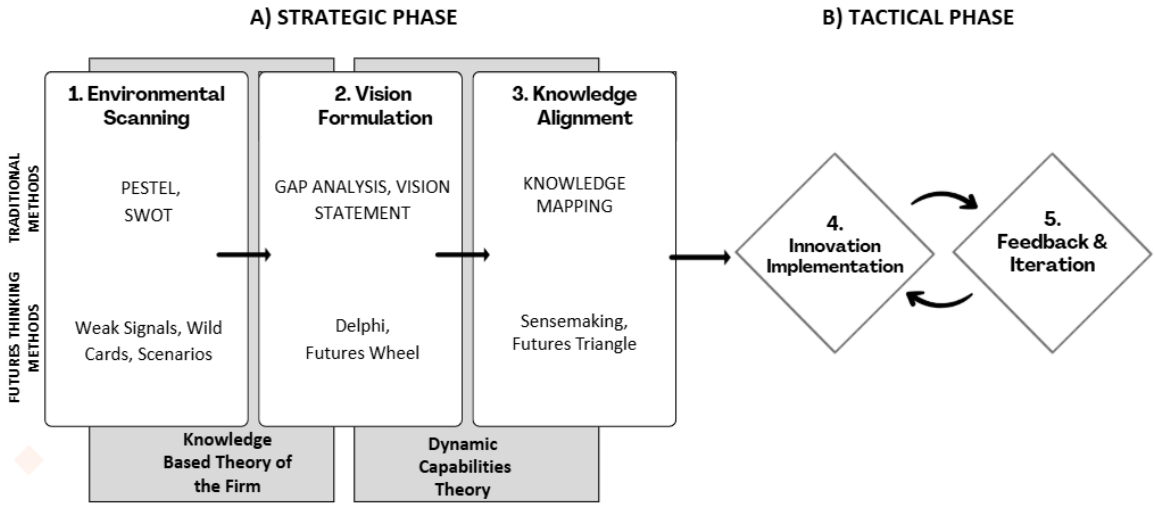


Figure 1: Futures Thinking and Business Model Innovation process model (Vähänikkilä and Vakkuri 2025)

The future thinking and business model innovation process model (figure 1) illustrates the action movement that is critical to enhance future business innovation. Futures Thinking and Business Model Innovation process model

is grounded on theoretical support of knowledge based theory of the firm (Grant, 1996) and dynamic capabilities theory (Teece at all, 1997).

4.3.1 Strategic phase, stages 1-3

This part consists of three essential stages that guides a company toward future-oriented decision-making. 1) Environmental Scanning in systematically observing and analysing external trends, drivers, and uncertainties that may affect the business. 2) Vision Formulation is creating a future vision based on insights from the environment. 3) Knowledge Alignment is about internal knowledge, competencies, and resources to support the strategic vision.

Business developing methods and tools for proceedings at strategic phase (A) has been divided to two sections, to traditional methods and future thinking methods. In this phase there are mentioned selected illustrative future thinking methods for each stage of the process. Traditional methods are more of management and market analysis approach to data gathering. Future thinking tools, on the other hand, are more oriented toward exploring uncertainties, envisioning alternative futures, and supporting strategic foresight. Companies use both traditional method tools like PESTEL analysis and future thinking tools like wild cards because they serve different but complementary purposes in strategic planning and foresight. Together, they help companies build resilient and agile strategies that consider both likely developments and surprising disruptions.

The ability to use a future-oriented vision to understand and critically discuss potential scenarios is a key strategic competence in today's business environment (Moritz, 2005).

4.3.2 Tactical phase, stages 4-5

The tactical phase (B) translates strategic intent into action and learning. It includes two key stages: 4) Innovation Implementation, which focuses on executing the innovation strategy by developing and launching new solutions, services, or processes within the organization. After implementation last stage is 5) Feedback and Iteration, where outcomes are monitored and evaluated. Feedback is used to refine, adapt, or scale the innovation, ensuring continuous improvement and responsiveness to change. This process is not usually a step-by-step process. Instead, it often involves going back and forth between stages, with overlaps along the way. In many cases, innovation becomes connected in everyday service practices, rather than being a separate or isolated activity.

5. Conclusion

Our research findings support earlier work by scholars such as Millar, Groth and Mahon (2018) in their findings of VUCA environment of being difficult to grasp and therefore action taking being difficult. Midst all the turbulence, collaboration and leadership are key factors in-organisation strategy building and business model innovation as stated by Ramus, Vaccaro and Brusoni (2017) and Bennett and Lemoine (2014). Fergnani (2022) explains corporate foresight to be a dynamic, firm-level capability and its importance should be spread across the organization – it is not on the agenda only for the top management. Several Futures Thinking and Foresight actions can be supported by staff members at all levels, such as Weak Signal spotting as an example. Our study highlighted two main barriers to adaptation of Futures Thinking. Based on the findings, Futures Thinking and Business Model Innovation process model was created. It adds new view to the ongoing academic discussion of Futures Thinking and Business Model Innovation by combining these two. This novel viewpoint also combines previously well examined theoretical base of dynamic capabilities and knowledge-based theory of the firm together with Futures Thinking and Business Model Innovation. A new process model with five stages is aimed at both scholars and practitioners introduces both "traditional" and modern Futures Thinking methods which can be of use in different phases of the process. Limitation of this study is a narrow research setting, focusing on solely to Hospitality Field companies. To further examine the possibilities for adapting the newly built model outside of the Hospitality Field, further research is to be carried out in economic sectors beyond hospitality. Also, empirical testing of the model needs to take place.

Ethics declaration: Ethical clearance was not required for the research.

AI declaration: Authors of this article used Microsoft 365 Copilot to structure the article contents they had written into coherent storyline. The tool was used to provide suggestions for improvements to text flow. The output from this tool was checked and modified by both authors, no direct text/content was used in the final article.

Acknowledgements

Authors wish to thank double-blind reviewer for insightful recommendations and constructive advice.

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Intellectual Capital Disclosure in Portuguese Listed Companies: A Longitudinal Approach

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Abstract: The demand for greater disclosure, including Intellectual Capital Disclosure (ICD), has significantly increased among users of accounting information. The European Union has already recognized the relevance of non-financial disclosure through different Directives. In Portugal, the implementation of Decree-Law No. 89/2017 strengthened this requirement. This study aims to determine the extent and quality of ICD disclosures of Portuguese companies listed on the Lisbon Stock Exchange (PSI) between 2016 and 2020, as well as the evolution of such disclosures, considering the impact of the implementation of Decree-Law No. 89/2017 and the effects of the COVID-19 pandemic crisis. It also aims to assess the effect of certain factors on the ICD quality index, specifically company size, the number of board members, the proportion of women on the Board of Directors, and financial performance. A content analysis of 60 Sustainability and Integrated Reports from 15 PSI-listed companies was conducted over a five-year period. Based on this analysis, extent and quality indices for ICD were developed. Subsequently, a multiple linear regression model was applied to verify the effect of the mentioned factors on the quality of IC disclosure. The results show that PSI-listed companies exhibit a satisfactory level of IC disclosure in terms of extent. However, the quality of the disclosed information remains below the extent index. Additionally, a gradual, albeit not sharp, increase was observed in both extent and quality indices over the five years analyzed. Regarding the factors influencing ICD quality, the results showed that the proportion of women on the board of directors does not significantly impact disclosure quality. This study contributes to understanding the evolution of ICDs after the implementation of Decree-Law No. 89/2017 in Portugal. It also facilitates a deeper understanding of the factors that motivate Portuguese-listed companies to disclose IC in their reports. The results indicate that challenges remain in improving ICD quality. The practical implications of this study are relevant for managers, investors, and regulators as they provide insights into the factors affecting IC disclosure and encourage the development of more effective reporting practices. Factors such as company size and the number of board members can significantly influence the quality of ICDs.

Keywords: Intellectual Capital, Disclosure, PSI, Quality, Extent

1. Introduction

In the current Knowledge Era, intellectual work is considered the primary driver of competitive advantage, rather than physical work. Intellectual Capital (IC) is now considered an organization's primary resource, enabling it to create sustainable value. IC can be defined as intangible resources which, although not present in companies' financial statements, correspond to all knowledge that generates added value and competitive advantage (Hoa et al., 2018). Nowadays, most authors defend an IC taxonomy composed of three interrelated dimensions: Human Capital (HC), Structural Capital (SC), and Relational Capital (RC) (Li et al., 2008; Cabrita & Bontis, 2008; De Luca et al., 2020).

Various authors (e.g. De Luca et al., 2020; Li et al., 2008) identified several gaps in the literature related to non-financial information disclosure, and specifically to intellectual capital disclosure. The shift to a knowledge-based economy highlighted the inadequacy of traditional financial statements in providing a comprehensive picture of a company's value (Lopes, 2010). Accordingly, an effective decision-making process should not be based solely on financial statements. The demand for more disclosure, including Intellectual Capital Disclosure (ICD), has been growing significantly among users of accounting information. ICD allows an organization's stakeholders to assess its performance and value-creation processes more effectively (An et al., 2011). Furthermore, IC information can help organizations be more transparent (Vanini and Rieg, 2019). Another important gap in the literature was identified by Abdallah et al. (2025), who suggested the need for more longitudinal studies.

The importance of non-financial disclosure was already recognized by the European Union, which, in 2004, issued Directive 2014/95/EU, aiming to improve organizational transparency across all European Union states (Badia et al., 2022). This directive took effect in 2018, becoming mandatory for certain companies, primarily

listed ones. Regulatory efforts, such as the European Directives and Portugal's Decree-Law No. 89/2017, have reinforced the need for improved non-financial reporting.

This study examines the extent and quality of ICD among Portuguese companies listed on the Lisbon Stock Exchange (PSI) between 2016 and 2020, analyzing the impact of regulatory changes and the Covid-19 crisis. The longitudinal perspective enabled us to examine whether Decree-Law nº89/2017 led to increased information disclosure. This study also aimed to assess the effect of certain factors on the disclosure quality index, more specifically: the company's size, the number of members of the board of directors, the proportion of women on the board of directors, and the financial performance.

To develop the extent and quality indices, a content analysis of sustainability and integrated reports was conducted, followed by a subsequent quantitative analysis. A multiple linear regression model was employed to test the effects. Data was collected from the companies' sustainability reports or integrated reports. The final sample consisted of 60 reports, distributed across 15 companies and spanning 5 years.

The results show a good level of IC disclosure regarding its extent. However, the quality of such information is still below the extent index. Furthermore, the multiple linear regression results indicate that the number of board members, total turnover, and total number of employees have a positive and significant impact on the quality of information disclosed on the IC. However, while the proportion of women on the board of directors also has a positive impact, this effect is not considered significant.

2. Conceptual Background

2.1 Intellectual Capital Disclosure

The interest in IC is supported by its essential competitive factor, as evidenced by companies that achieve different results when employing similar resources (Reboredo and Sowaity, 2021). IC is associated with recent economic, administrative, technological, and sociological developments, albeit in a manner that is little known and often overlooked by some (Guthrie, 2001). The most widely recognized IC taxonomy comprises three different components: human capital (HC), structural capital (SC), and relational capital (RC) (Widiatmoko et al., 2020; De Luca et al., 2020; Dumay et al., 2019; Li et al., 2008). HC refers to human resources within organizations and includes general characteristics such as education, knowledge and work-related skills, motivation, creativity, or training (Duff, 2018; Bozzolan et al., 2003). SC is the supplementary infrastructure that enables the organization to function in a repeatable and extensible manner, encompassing organizational philosophy, techniques, procedures, programs, data, systems, and related elements (De Luca et al., 2020). RC is based on the idea that companies are not considered as isolated systems but as systems that depend on their relationships with their environment, namely with the different external players, such as customers (Bozzolan et al., 2003).

The current nature of the knowledge-based economy has changed not only the way organizations create value but how it is disclosed (Haji and Ghazali, 2012). Academics and practitioners agree that financial statements do not provide a comprehensive view of a company's value. They only show a partial picture (Pablos, 2003). Non-financial information, such as the one about IC, reduces information asymmetry, improves analysts' assessments, and lowers the cost of capital (Vanini and Rieg, 2019). Several studies focus on assessing the extent and quality of ICD. ICD extent refers to the frequency or volume of disclosed IC items. It can be defined as the number of IC elements present in companies' reports. The disclosure quality can be conceptualized as the accuracy, completeness, and reliability or as the level of intensity and comprehensiveness of the information (Onuoha et al., 2020). An increase in ICD over time may suggest that companies have invested more in IC and, consequently, in its disclosure (Crossley et al., 2020). Proper disclosure of this information, combined with effective management and independent supervision, can significantly increase the perceived value of companies in the market (Wardoyo and Utami, 2024).

Considering that, among other goals, ICD aims to create financial value, it is not surprising that most studies about ICD focus on listed companies (Cuozzo et al., 2017). Several examples of studies adopting this specific type of company can be found such as the ones of Bozzolan et al. (2006), Yi and Davey (2010) or Haji and Ghazali (2012). The latter examined the trend of ICD in the annual reports of Malaysian-listed companies between 2008 and 2010. On another stance, Abeysekera and Guthrie (2005) assessed the level of ICD of the top 30 listed companies in Sri Lanka, finding that the disclosed information mainly focuses on RC and HC and that the level of ICD increased between 1998 and 2000. Regarding the relative importance of each IC component, some authors, such as Ferreira et al. (2012), emphasize the role of external capital (i.e., relational capital) in ICD, while others, such as Branco et al. (2011), stress the importance of human capital.

Following Directive 2014/95/EU, and to ensure the quality and consistency of information, since 2018, certain entities have been required to include non-financial and diversity information in their annual reports or in a separate filing. This fact had an impact on the years prior to and following its publication. For example, a significant impact on the disclosure of non-financial information was observed in the two years preceding and following the implementation of the Directive in Italian-listed companies (Agostini et al., 2022). In Portugal, Decree-Law No. 89/2017 aimed to transpose the Directive 2014/95/EU principles into Portuguese law, reinforcing the importance of transparency and consistency in non-financial information disclosed by organizations. This decree aims to strengthen the transparency of organizations in terms of sustainability, human resources, environment, social responsibility, and, in this study, IC. The Decree-Law makes it compulsory for a specific group of entities (namely listed companies) to present a non-financial statement every year, including it in the integrated management report or a separate report. While the Directive 2014/95/EU had a great impact on the ICD of Portuguese stock market companies in 2018, pressuring them to innovate due to globalization, changing technologies and increased competition, the Covid-19 pandemic crisis prompted the acceleration of these market changes in organizations in 2022 (Agostini and Nosella, 2022).

2.2 Hypotheses Development

Previous studies have found that specific company characteristics (e.g., size, profitability, leverage, industry type, or age) are determinants of ICD (see, for example, Astuti et al., 2020; Branco et al., 2011). Dimension has been identified as one important factor influencing ICD. Larger companies tend to disclose more non-financial information since they have greater visibility and are more scrutinized by their stakeholders than smaller ones. For this reason, larger companies are expected to report more information on IC to build and maintain a good reputation. Also, they are more likely to have greater financial, organizational, and human resources to support voluntary disclosure (Oliveira et al., 2010). Branco et al. (2011) claim that a significant relationship exists between size and ICD and that the larger the company size, the higher the ICD index. Similarly, Duff (2018) argues that ICD positively relates to firm size, stating that smaller firms use ICD to disclose information regarding RC, while larger firms tend to disclose more information about HC proportionally. In this context, the following hypothesis can be developed.

H1: *Firm size has a positive influence on the quality of ICD.*

Over the years, several authors have analyzed the impact of the board of directors on corporate social responsibility, considering characteristics that make up the board, such as the mandates and the size of the board, as well as its diversity, gender, age, ethnicity, nationality or educational background (Cucari et al., 2017). The same authors state that larger boards' greater control and monitoring capacity is expected to encourage the quality of IC disclosure in integrated reporting.

Likewise, Vitolla et al. (2020) suggest that board size is conducive to better disclosure quality of IC information.

H2: *Board size has a positive influence on the quality of ICD.*

The composition of the board of directors is an emerging issue and one of the most discussed topics in modern organizations, specifically gender diversity (Rao and Tilt, 2015). The presence of women on company boards enhances management control and increases the independence of company boards, thereby improving the transparency and quality of company disclosures (Arayssi et al., 2016). Arayssi et al. (2016) further suggest that the higher the proportion of female board members, the greater the ability to disclose non-financial information. Additionally, the greater the representation of female elements on a company's board of directors, the more likely the company is to form alliances with sustainability themes (Cucari et al., 2017).

H3: *The proportion of women on the board of directors has a positive influence on the quality of ICD.*

Finally, several approaches have been followed to understand the relationship between ICD and corporate performance (Duff, 2018). On the one hand, a positive relationship between ICD and corporate financial performance can be found, which suggests that companies tend to disclose more often when they obtain favorable earnings, i.e., financial performance can influence the disclosure level (see Oliveira et al., 2006; Clarke et al., 2011). Additionally, Oliveira et al. (2006) suggest that companies with better financial performance disclose IC information about their intangible assets in greater detail to justify their profit levels. On the other hand, and conversely, information quality can influence stakeholders' decisions, who may prefer to work with more transparent companies, resulting in increased turnover and improved financial performance (Salvi et al., 2020).

H4: *Financial performance has a positive influence on the quality of ICD.*

3. Methodology

This study aims to create extent and quality ICD indexes for the companies pertaining to the Portuguese PSI stock exchange for the 2016-2020 period, and to assess the effect of the company's size, the number of members of the board of directors, the proportion of women on the board of directors, and financial performance on the quality index.

3.1 Sample Selection and Data Collection

This paper considers a five-year period encompassing two important dates: the coming into effect, in 2018, of Directive 2014/95/EU transposed into Portuguese Law through Decree-Law No. 89/2017, and the COVID-19 crisis. First, 17 companies listed in the PSI index, a regulated market of *Euronext Lisbon*, were considered for the study between 2016 and 2020. Then, two companies were removed: "Pharol" for being considered an outlier, and "EDP Renewables", which, being a subsidiary of the "EDP company", has its information jointly disclosed with the parent company. Finally, since the data for the sample were collected through sustainability or integrated reports, only 12 companies presented these reports over the analyzed period. Therefore, the final sample comprises 60 reports.

3.2 Data Analysis

A content analysis was conducted to assess the extent and quality of disclosure of IC for the final sample. Based on Yi and Davey (2010) and Liao et al. (2013), the following indicators were adopted: Management Philosophy, Research and development, Information Systems and Technologies and Financial Relationships, to measure SC; Goodwill, Brand Recognition and Reputation, Market Share and Partnerships, to measure RC, and Employee satisfaction, Employee profile, Work-related knowledge, and Education and Training, to measure HC. To develop an Extent Index (EI), a score of 1 was given if an indicator was disclosed and 0 if not. To assess the disclosure quality, i.e. to calculate a Quality Index (QI), a four-point scale (from 0 to 3) adapted from Liao et al.' (2013) study was adopted (see Table 1).

Table 1: Scoring scale

Quality Measure	Description	Content
0	The company does not disclose information	The report provides no information about the indicator
1	Information is presented in narrative form	There are some descriptive references to the indicator
2	Information is presented in numerical form	Information is based on numerical evidence
3	The company discloses information both quantitatively and qualitatively	The report provides detailed information on the indicator and presents numerical support.

Since it was verified that a monetary value cannot be attributed to the indicator "Management philosophy", we followed an extent orientation, i.e., it was assigned a value of 0 or 3. The QI for each company was calculated by adding the scores for each item and then dividing the total by the maximum possible score, i.e., 36. The Quality Index per year is the mean of the companies' disclosure quality. Thus, the overall quality index is the mean of the annual QIs over the years.

Finally, a multiple linear regression model was used to test the relationship between the dependent and independent variables. Additionally, we had to consider whether the following assumptions regarding the residuals were met: homoscedasticity (constant variance of the errors), autocorrelation (absence of correlation between the residuals), normality (the residuals follow a normal distribution), and multicollinearity (validation of whether the independent variables are highly correlated).

4. Results and Discussion

4.1 Descriptive Statistics

The IC disclosure extent refers to the frequency of disclosure of the indicators that comprise IC and, consequently, each of its three dimensions. The results suggest an extent index of 76.39%, which can be considered good. Regarding the extent of disclosure for each IC dimension, HC and RC are deemed strong, in contrast to the disclosure index of SC, which can be considered reasonable (see Table 2).

Table 2: Annual IC Extent Indices between 2016 and 2020

Year	Extent Index			
	IC	HC	SC	RC
2016	70%	83%	45%	83%
2017	73%	85%	44%	90%
2018	78%	88%	50%	96%
2019	78%	79%	60%	94%
2020	82%	88%	65%	94%

Our results align with those of Abeysekera and Guthrie (2005), who, in their study, found similar results, namely that HC and RC were the IC dimensions most disclosed from an extent perspective. Furthermore, while authors such as Branco et al. (2011) suggest that the most disclosed dimension of IC is HC, our results follow Ferreira et al.'s (2012) study, in which RC presents the highest ICD extent index. Also, although Haji and Ghazali (2012) showed, in their study, that HC was the only dimension that significantly increased in disclosure over time, our results suggest an increase in all IC dimensions, namely SC. In fact, SC is the only IC dimension that, considering the years analyzed, does not present the highest level of disclosure in 2020 but rather in 2018.

The ICD quality index, when compared with the extent index, is not so good, considering an overall five-year index of 53.98%. While HC and RC have a five-year disclosure index that can be considered reasonable, at 65.56% and 59.72%, respectively, the disclosure quality of the SC dimension is poor, at 36.67%. These results align with the literature to the extent that authors such as Abeysekera and Guthrie (2005) reinforce the importance of disclosing indicators associated with the HC and RC. Furthermore, the results suggest an increase in the quality of IC disclosure over the years, which varies according to the analyzed dimension (see Table 3).

Table 3: Annual IC Quality Indices between 2016 and 2020

Year	Quality Index			
	IC	HC	SC	RC
2016	50%	67%	32%	53%
2017	50%	62%	28%	58%
2018	56%	71%	35%	63%
2019	54%	60%	40%	61%
2020	59%	69%	48%	62%

It is also important to stress that, regarding all IC dimensions, the disclosure quality was higher in 2018 and 2020, contrary to Agostini et al.'s (2022) study, which shows that there is a significant impact on the disclosure of non-financial information in the years before and after the implementation of the Directive 2014/95/EU, in 2018. Our findings suggest that, prior to 2018, the disclosure indexes, both in terms of extent and quality, were lower than those presented in 2018.

It should also be emphasized that HC and SC disclosure do not exhibit a significant difference in their extent and quality, unlike RC, which presents an excellent extent index (91.67%) but only a reasonable quality index (59.72%). Additionally, the results indicate that the implementation of Directive 2014/95/EU in 2018 had no significant impact on the extent and quality of IC. Regarding the impact of the COVID-19 pandemic crisis on the ICD, it is evident that COVID-19, which emerged in 2020, did not significantly affect the ICD of PSI companies, as the results indicate a minimal increase in disclosure between 2019 and 2020.

4.2 Multiple Linear Regression Model

To test the hypotheses developed above, we employed the multiple linear regression model (MRLM), which examines the existing relationship between the dependent variables and the ICD quality index. The following linear regression model was developed:

$IQ_ICD = \beta 0 + \beta 1DIM + \beta 2MB + \beta 3WB + \beta 4PERF$

In which:

IQ_ICD - ICD Quality Index;

DIM - Size of the company, represented by the total number of employees;

MB - Total number of members of the Board of Directors;

WB - The Proportion of women on the Board of Directors, calculated by the quotient between the total number of women on the Board and the total number of members;

PERF - Company *performance*, represented by total turnover.

The values associated with turnover were rounded to the nearest million to facilitate understanding. Given that the companies are listed on the PSI, the largest Portuguese stock market index, the number of employees and turnover are expected to be relatively high, as they represent the largest companies in Portugal.

First, the ANOVA (Analysis of Variance) test was performed to validate whether there is a difference in the distribution of a measure between three or more groups. We concluded that there are significant mean differences between at least one of the independent variables, with a *p-value* < 0.001 (see Table 4). Thus, we can proceed with analyzing and interpreting the proposed multiple linear regression model. Considering the *p-value* of approximately 0, we reject the null hypothesis.

Table 4: Analysis of variance (ANOVA Table)

ANOVA[a]					
	Sum of Squares	df	Mean Square	Z	Sig.
Regression	4.328	4	1.082	9.123	<0.001 [b]
Residual	6.524	55	0.119		
Total	10.852	59			

(a) Dependent Variable: IQ_DCI
(b) Predictors (Constant). Number of employees, Number of members of the Board of Directors, Proportion of women on the Board of Directors, Turnover

The adjusted coefficient of determination R^2 is 0.355. This means that the regression model explains 35.5% of the dependent variable, already adjusted for the number of observations and variables. If we consider the unadjusted value, that is, the R^2, the model explains 39.9% of the dependent variable.

Through the results of the multiple linear regression (see Table 5), we can infer the impact of the independent variables on the quality index of ICD. First, we can observe that all VIF are between 1 and 1.2. Hence, we can consider that there is a moderate correlation, but not enough to invalidate the estimation of the model.

Table 5: Regression analysis

	Unstandardized beta	**Standard Error**	**ß**	**t**	**p-value**	**VIF**
Constant	1.066	0.152		7.034	<0.001	
DIM	2.656E-6	0.000	0.186	1.715	0.092***	1.073
MB	0.026	0.009	0.289	2.731	0.008*	1.026
WB	0.313	0.401	0.083	0.782	0.438	1.024
PERF	2.903E-10	0.000	0.632	5.731	<0.001*	1.114

* *p-value* < 0.01; ** *p-value* < 0.05; *** *p-value* < 0.1

The results suggest that, regarding the independent variable DIM, there is a positive and significant impact on the ICD QI with a *p-value* < 0.1. The larger companies, in this case with a higher number of employees, tend to increase the quality index by 18.6%, represented by ß. This premise is in line with the literature advocated by several authors, such as Duff (2018), who argue that company size is positively related to ICD, The positive relationship between size and ICD may be explained by the desire of companies to build and maintain their good reputation with information stakeholders, since it is assumed that the larger the company size, the greater its external exposure due to stakeholders' pressure and, therefore, they disclose more non-financial information (Oliveira et al., 2010). Regarding the variable MB, i.e. the number of elements that make up the board of directors, we can see that there is a positive and significant impact on the disclosure index, for a *p-value*< 0.1, which gives rise to an increase of 28.9% in the disclosure quality index, Vitolla et al. (2020) show that the size of the board of directors is conducive to better disclosure of information about the IC, Also Cucari et al. (2017) reinforce the same idea stating that it is expected that larger boards encourage a higher quality of disclosure of information about the IC.

Regarding the proportion of women on the board (WB), a positive effect was found, although not a significant one. In other words, although the presence of women is related to an improvement in the quality of the DCI, statistically, this effect was not robust in the studied context. That suggests that, in the Portuguese companies listed on the PSI, gender diversity on the board has not yet been strongly reflected in CI disclosure practices.

Finally, concerning the analysis of the independent variable PERF, represented by the company's total turnover, we perceived that *performance* has a positive and significant impact on the quality of information disclosed about the IC for a *p-value* < 0.001. The companies that comprise the sample with a higher turnover increase the quality of the disclosure index is 63.2%, Our results are thus in line with authors such as Oliveira et al. (2006) or Clarke et al. (2011) who suggest that companies tend to disclose more frequently and in greater detail when they obtain favorable returns. Companies with better performance have more incentives to disclose transparently and strengthen their image in the market. The results are summarized in Table 6.

Table 6: Results summary

Hypothesis	Result
H1: Firm size has a positive influence on the quality of ICD.	Confirmed
H2: Board size has a positive influence on the quality of ICD	Confirmed
H3: The proportion of women on the board of directors has a positive influence on the quality of ICD	Not confirmed
H4: Financial performance has a positive influence on the quality of ICD	Confirmed

5. Concluding Remarks

This study aimed to assess the extent and quality of ICD in stock market companies listed in the PSI, as well as to analyze the effect of certain variables on the quality index. Regarding the first aim, we obtained 76.39% and 53.98%, respectively. This discrepancy between the extent and quality suggests that companies may be disclosing a significant amount of information, but the quality of this information varies widely, with SC consistently showing the lowest disclosure quality compared to HC and RC. It was also found that there are no significant differences in the ICD of the PSI companies. Finally, we can also conclude that there is an increase, although not pronounced, in the extent and quality indexes at five years, as evidenced by increases of 12% and 9%, respectively. Regarding the second objective, certain variables were analyzed to understand their impact on the quality of information disclosed about the IC. We concluded that the number of board of directors' members, total turnover, and total number of employees have a positive and significant impact on the quality of information disclosed on the IC. In turn, although the proportion of women on the board of directors has a positive impact on the quality of the ICD, it is not considered statistically significant.

The present paper contributes to enriching the literature about ICD. Theoretically, this study enables us to conclude that there is a high level of disclosure in PSI-listed companies. However, the quality of the information disclosure is still below the extent index. Additionally, there were no significant changes in IC disclosure related to the 2018 implementation of Directive 2014/95/EU, suggesting that other factors may have a more profound impact on disclosure practices. This means that the Decree-Law can be seen as a catalyst but not a guarantee of more robust and consistent ICD practices. Although this decree obliges more non-financial information to be disclosed, it has not been enough to guarantee a high disclosure quality. Furthermore, analyzing the linear regression results, we conclude that the contribution of women on the boards of directors in Portuguese-listed companies to improving disclosure quality is insignificant.

Regarding the limitations encountered, the study focuses on companies listed on the PSI stock exchange index, which may not fully represent the broader market. Another limitation was the small sample size, which was a result of the characteristics of the Portuguese capital market. Finally, the analysis spans a five-year period (2016-2020), but the dynamics of IC disclosure may evolve in response to changes in market conditions or regulatory frameworks in the future.

For future research, analyzing other sources of information beyond sustainability or similar reports, such as news or institutional website disclosures, should be considered. Another suggestion would be to extend the research to include a wider range of companies, both listed and non-listed, to assess whether the findings are held across different market segments. Future studies could also investigate whether IC disclosure practices vary by industry, considering that some industries may be more reliant on certain IC dimensions (e.g., human capital in technology companies).

Ethics declaration: Ethical clearance was not required for the research.

AI declaration: Grammarly was used to refine the English language.

Acknowledgements

This work is financed by Portuguese national funds through FCT - Fundação para a Ciência e Tecnologia, under the project UID/05422: Centro de Estudos Organizacionais e Sociais do Politécnico do Porto

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KTP Associates: Facilitators and Hindrances of Knowledge Transfer for University and Industry Collaboration Projects?

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Abstract: In University-industry collaborations, boundary spanners play a key role in knowledge transfer between different individuals. Management Knowledge Transfer Partnerships (mKTPs) are significant university-industry collaborations in the UK, however, limited scholarly attention has been given to their boundary spanners. This paper aims to explore this role in knowledge transfer in university-industry collaborations. Thirty respondents from four groups of KTP actors involved in mKTPs were interviewed: eleven academics, nine business supervisors, seven KTP associates and three KTP advisors. Using Gouldner's framework of Locals and Cosmopolitans, this study identifies four distinct boundary spanner roles that KTP associates play in knowledge transfer: the dedicated facilitator, true bureaucrat (change controller), empire (career) builder and outsider. The dedicated KTP associates recognise the knowledge and individuals within the host organisations, perceiving themselves as essential boundary spanners in knowledge transfer between universities and businesses. In contrast, some KTP associates describe themselves as outsider, isolated from host companies, thereby disengaging in knowledge transfer. The true bureaucrat (change controller) and empire builder present contingent boundary-spanning roles, with their engagement in knowledge transfer being context-dependent. When provided with sufficient support from academic and business supervisors, such as leadership and opportunities for individual career growth, KTP associates are committed to the current boundary-spanning roles of mKTPs, thereby engaging in knowledge transfer, similar to the dedicated facilitator (a positive dynamic). Conversely, in the absence of such support, they will disengage or selectively transfer knowledge, gradually becoming outsiders of mKTPs, obstructing knowledge transfer (a negative dynamic). The identified four roles and their dynamics have demonstrated different influences on knowledge transfer: facilitation, hindrance or contingent context-dependency. Based on these findings, this paper develops a conceptual framework that offers novel insights into boundary spanners by revealing a multifaceted, dynamic, context-dependent nature in knowledge transfer. The paper offers important implications for research on boundary spanners and university-industry collaborations.

Keywords: KTP associates, Boundary spanner, University-industry collaborations, KTPs, Knowledge transfer (KT)

1. Introduction

In University-industry collaboration (UIC), boundary spanners play a key role in knowledge transfer (KT) (Rossi *et al.,* 2022; Pattinson and Dawson, 2024). They act as intermediaries, bridging people in different contexts to enhance KT (De Wit-de Vries et al., 2019; Hakami, Pradhan and Mastio, 2022). However, KT in UICs is not always successful due to the differing priorities of people in varying contexts (De Wit-de Vries et al., 2019; Rossi *et al.,* 2022). For instance, academics pursue theories whereas industry partners seek profit-driven knowledge (De Wit-de Vries et al., 2019; Tootell *et al.,* 2021; Rossi *et al.,* 2022). These differences can create conflicts between partners and put pressure on boundary spanners (Goodrich *et al.,* 2020). Moreover, a lack of recognition and power imbalance can cause the social isolation of boundary spanners (Goodrich *et al.,* 2020; Tootell *et al.,* 2021). Such challenges reduce their motivation to facilitate KT between academic and industry partners (Tootell *et al.,* 2021; Hakami, Pradhan and Mastio, 2022).

Existing research on boundary spanners in inter-organisational collaboration falls into two main streams. The first one views boundary spanning as organisational-level practices or processes, such as KT, as it is affected by organisational or contextual factors (Schotter *et al.* 2017; Rossi *et al.,* 2022). The second draws on individuals, examining their abilities, characteristics and network roles (Dolmans *et al.,* 2022; Pattinson and Dawson, 2024; Zobel, Falcke, and Comello, 2024). Ryan and O'Malley (2016) proposed a more detailed division from a knowledge exchange perspective: network builders, mediators and entrepreneurs. In a recent study, Zobel, Falcke, and Comello (2024) also suggest that effective KT requires boundary spanners to adapt their engagement dynamics based on the context, rather than applying a one-size-fits-all approach. Despite this, most studies treat boundary spanners as a one-size-fits-all and static role with dual responsibilities of internal and external engagement for KT (Ryan and O'Malley, 2016; Zobel, Falcke, and Comello, 2024). Various contexts give rise to a need for different profiles of boundary spanners; thus, no single form meets the varying needs and social realities of differing contexts (van Meerkerk and Edelenbos, 2018). Therefore, Fragundes and Gasparetto (2023)

suggest that further research still needs to study different boundary-spanner individuals' behaviours and their influences on the performance of inter-organisational partnerships, such as KT or innovation.

Knowledge Transfer Partnerships (KTPs) or management KTPs (mKTPs) are significant UICs in the UK, driving innovation in products, services and business functions (Rossi, Rosli and Yip, 2017; Ates *et al.*, 2024). Each partnership consists of a core team: an academic, a business supervisor, a KTP associate, and a KTP advisor who is a government representative monitoring the project (White *et al.,* 2019). The KTP associate acts as the boundary spanner, bridging the academic and supervisors by facilitating KT, managing relationships and project operations (White *et al.,* 2019; Ates *et al.*, 2024). Yet, extant research on KTPs or mKTPs has focused on the enablers, barriers and impacts on knowledge creation, offering limited insights into the specific role of KTP associates (De Wit-de Vries *et al.,* 2019; White *et al*., 2019; Ates *et al.,* 2024). Conceptualising KTP associate as a one-size-fits-all role overlooks how their actions shape and are shaped by the complex dynamics of KT in practice. Therefore, this study aims to explore the roles of KTP associates and their influences on KT within mKTP projects.

To guide the aim of this study, we raise the following research questions:

RQ1: *What roles do KTP associates play in KT within mKTPs?*

RQ2: *Why do they have these roles?*

RQ3*: How do they influence KT?*

2. Literature Review

2.1 Boundary Spanners in Inter-Organisational Partnerships

The concept of boundary spanner is well established in organisational studies but lacks a single agreed definition. How this concept is understood often depends on the differing functions emphasised (Fragundes and Gasparetto, 2023). Boundary spanner emerged in early organisational sociology to describe individuals who work between an organisation and its external environment (Gouldner, 1957; 1958). Gouldner (1957) introduced this idea as 'cosmopolitans' and 'locals' within organisations, where cosmopolitan professionals were more loyal to their profession and locals were more committed to their organisations. Tushman and Scanlan (1981) further explained this idea by identifying two main tasks: gathering external information and sharing it internally. They argued that KT can only happen effectively when individuals are well-connected both inside and outside the organisation. Their work has influenced later research into inter-organisational collaboration and UIC.

William (2002) defined boundary spanners as a dedicated role to support collaboration between diverse agencies and interests. He identified two important boundary-spanner roles in inter-organisational relationships: network managers who build relationships, and policy entrepreneurs who connect problems to solutions. In his later study, William (2012) argued that boundary spanners can take many forms, including dedicated, leaders, managers and frontline professionals, and each appreciates the many different purposes of their roles. Ryan and O'Malley (2016) further outlined three important roles: 1) *network builder* who maintains relationships across organisational boundaries, creating communication channels; 2) *entrepreneur* in charge of identifying opportunities for innovation; 3) *facilitator/mediator* responsible for managing and addressing conflicts and ensuring cultural and objective alignment. Their findings highlight the relational and dynamic nature of boundary spanners in KT and innovation along with processes of ongoing problem-solving and relationship development.

Boundary spanners also encounter various challenges. Working in a complex environment involving different rules, structures and stakeholders can create tension and ambiguity (William, 2012; Tootell *et al.,* 2021). In such cases, boundary spanners may retreat to their own organisation's interests, withdraw support for collaboration or even remove dedicated boundary-spanning posts, thereby these actions can hamper KT and collaborative projects (William, 2012). These issues are also observed in UIC, where universities act as key external sources of knowledge for innovation in organisations (Goodrich *et al*., 2020; Mattin and Ibbotson, 2021; Pattinson and Dawson, 2024). Goodrich *et al*., (2020) identified key attributes of boundary spanners in UIC, including communication skills, relationship-building abilities and cultural awareness. Despite their important role, boundary spanners in UICs often lack formal recognition and clear career paths, which can affect their motivation and engagement in KT (De Wit-de Vries *et al.,* 2019; Goodrich *et al.,* 2020; Tootell *et al.,* 2021).

Mattin and Ibbotson (2021) use the concept of identity work to explore how university staff act as boundary spanners by adapting to internal and external requirements through interaction and learning. Similarly, Pattinson and Dawson (2024) revealed that individual and collective boundary spanners connect people across organisational and disciplinary boundaries, which is essential for encouraging collaborations and supporting KT within science-based SMEs. These findings emphasise that boundary spanners facilitate KT from external organisations (e.g. universities) to local organisations (Goodrich *et al*., 2020; Pattinson and Dawson, 2024), which reflects Gouldner's (1957) idea of cosmopolitan (externally focused) and local (internally focused). Because of this, several researchers revisit this early discussion to explore boundary spanners in KT. For instance, Dahlander, O'Mahony and Gann (2016) discovered that people who rely on internal networks (locals) can be as innovative as those who explore widely outside (cosmopolitans), but only when the latter truly engage with their external contacts. This suggests that successful KT is driven not only by many outside connections but also by how people spend time and attention internally. Although some recent studies do not use the terms 'locals' and 'cosmopolitans', they also explore boundary spanners through a similar discussion—internal and external engagement for KT (Zobel, Falcke, and Comello, 2024). Zobel, Falcke, and Comello (2024) conclude that frequent switching between internal and external engagements helps transfer clear knowledge but makes it harder to process complex and specialist knowledge. Less frequent switching appears better for transferring hard-to-share knowledge. This demonstrates that boundary spanners need to adapt their engagement dynamics for KT based on the contexts, rather than applying a one-size-fits-all approach. Nevertheless, while many studies focus on the internal-external (local-cosmopolitan) divide, this binary view may not fully explain multiple boundary-spanner roles in KT and why they behave as they do. Gouldner (1958) expanded the local-cosmopolitan framework by examining six types of social roles, offering a more detailed approach to understanding how professionals commit to and engage with different tasks and people. Hence, using the full local-cosmopolitan framework could provide more exploratory possibilities of the roles of boundary spanners in KT for this study.

2.2 Local-Cosmopolitan Framework and six Latent Social Roles

Gouldner's (1958) local-cosmopolitan framework offers a valuable lens for understanding individuals' professional roles, identities and engagement in varied organisational activities. 'Local' roles include the dedicated, true bureaucrat, home guard and the elders, characterised by internal relationships and organisations (van Meerkerk and Edelenbos, 2018; Stephens, van Steden and Schoonmade, 2024). Specifically, *the dedicated* identifies with organisational values, emphasising collective goals over personal preferences (William, 2012). *True bureaucrat* advocates for changes to address external pressures, often prioritising control over others (Petchey *et al.,* 2007). *Home Guard* has the lowest level of professional commitment but remains individually loyal to the organisation and existing relationships, because of their past experiences. *The elders* are typically the most experienced and long-standing members, deeply committed to the organisational relationships (Gouldner 1958).

'Cosmopolitans', which include *outsiders* and *empirical builders*, focus on self-interests and external career possibilities (Fuller et al., 2009). *Outsiders* view themselves as separate from organisational relationships and therefore unwilling to engage with individuals within organisations, while *empire builders* pursue better career opportunities from external, leading them to explore possibilities elsewhere (William, 2012). Both prioritise personal goals, resulting in less emphasis on engaging in organisational internal activities (Fuller *et al*., 2009).

Prior studies on inter-organisational collaboration describe boundary spanners in two roles: locals and cosmopolitan: 'cosmopolitans' who acquire knowledge externally and 'locals' who rely on internal knowledge (Dahlander, O'Mahony and Gann*,* 2016; Zobel, Falcke and Comello, 2024). This distinction highlights where boundary spanners access knowledge, which is relevant to UICs, where KTP associates undertake acquiring and transferring knowledge between university and business partners. It evidences that knowledge boundaries are viewed as organisational divisions separating universities from organisations (Goodrich *et al.,* 2020; Mattin and Ibbotson, 2021). However, from a sociological perspective, boundaries are not just structural, but they depend on whether individuals identify with the organisations or not (Schotter *et al.* 2017). UICs are collaborative partnerships where different stakeholders work together to co-create knowledge for common goals (De Wit-de Vries *et al*., 2019; Tootell *et al.,* 2021). So, the boundary between university and business becomes blurred. In this context, successful collaboration depends not only on KT but also on how boundary spanners identify with the project and engage with other actors (Goodrich *et al*., 2020; Pattinson and Dawson, 2024). Gouldner's (1958) six roles contribute to explaining different types of identification (commitment) and engagement that individuals bring to the collaborations.

Additionally, Gouldner's (1985) framework is useful for analysing individual behaviours in environments where internal tensions and conflicts exist, such as within KTPs or mKTPs (De Wit-de Vries *et al.,* 2019). KTP associates often have to navigate between collective goals and self-preservation, their commitment may be influenced by how others perceive their role, whether as cosmopolitans or locals (Fuller *et al.,* 2009). When encountering unfairness or power imbalances, they may prioritise self-interests, which can hinder their engagement in KT (De Wit-de Vries *et al.,* 2019; Tootell *et al.,* 2021). Moreover, individuals mainly driven by financial rewards tend to show lower commitment to boundary-spanning roles (Keller and Holland, 1975). Hence, in this context, this framework is helpful for this study, as it supports deeper insights into how different individuals commit to and engage in KT within complex, project-based environments, like KTPs or mKTPs.

3. Research Approach

This paper employs an inductive qualitative approach to explore the experience of individuals involved in mKTPs, focusing on KTP associates' roles in KT within such collaborations. While the research mainly focuses on KTP associates, considering the nature of this role in interacting with other actors, such as academics, business supervisors and KTP advisors should be included (White *et al.*, 2019). Participants were initially selected through purposeful sampling, based on their participation in mKTPs. Afterwards, we asked the participants to recommend others for subsequent interviews, which followed a snowball strategy. It guarantees a holistic view of the research (Creswell 2013; Easterby-Smith, Thorpe and Jackson 2021). Using snowball sampling, the data collection and participant selection co-occurred, and this process lasted fifteen months (May 2022 – August 2023). In total. Thirty participants from four distinctive groups were interviewed (see Table 1). All the participants are referred to by pseudonyms.

Table 1: Summary of the demographic profile of the participants

Name (code)	mKTP code	Gender	Role	Duration in mKTPs	Project stage	Sector located
Robert	Project 1	Male	KTP associate	3 years	Late stage	Construction
Juliet	Project 1	Female	KTP manager	4-5 years	all stages	Various
Alice	Project 2	Female	KTP associate	1.5 years	Late stage	Construction
Luke	Project 3	Male	KTP associate	1.5 years	Late stage	Energy
Andrew	Project 3	Male	Business supervisor	5 years	Late stage	Energy
Rach	Project 4	Female	KTP associate	1.5 years	Middle stage	Housing
Angela	Project 4	Female	Academic	1.5 years	Middle stage	Housing
Christina	project 5,6,7	Female	KTP advisor	5 years	all stages	Consultation
Peter	project 1,2,3,4,10,11,12, 13,14	Male	KTP advisor	5 years	all stages	Consultation
William	project 8,9	Male	KTP advisor	5 years	all stages	Consultation
Emily	Project 4	Female	Academic	1.5 years	Middle stage	Housing
Samantha	Project 5	Female	Business supervisor	2 years	Middle stage	warehouse technology
John	Project 4	Male	Business supervisor	1.5 years	Late stage	Housing
Adan	Project 1	Male	Business supervisor	2 years	Late stage	Construction
Steve	Project 2,5,6,7	Male	Lead academic	4.5 years	all stages	Various
Carrie	Project 1	Female	Academic	6 months	Completed	Construction
Mark	Project 6	Male	Academic	4 years	Completed	Consultation
James	Project 1,3,4,8,9,11,12	Male	Lead academic	4.5 years	all stages	Various
George	Project 7	Male	Academic	3 years	Completed	Social enterprise digital marketing
Joseph	Project 8	Male	Academic	1 year	Completed	
Miranda	Project 9	Female	KTP associate	2 months	Early-stage	Biotech
Jennie	Project 9	Female	KTP associate	5 months	Early-stage	Biotech
Daniel	Project 10	Male	KTP associate	3 months	Early-stage	manufacturing
Sarah	Project 11	Female	Academic	3 years	Completed	manufacturing
Romeo	Project 12	Male	Academic	1 year	Middle stage	Housing
Lily	Project 10	Female	Business supervisor	2 years	Early-stage	manufacturing
Bob	Project 9	Male	Business supervisor	1.5-2 years	Early-stage	Biotech
Simon	Project 10	Male	Business supervisor	1.5 years	Middle stage	Legal service
Rose	Project 13	Female	Business supervisor	1.5 years	Middle stage	Not-for-profit enterprise
Jack	Project 14	Male	Business supervisor	8 months	Middle stage	digital marketing

A semi-structured interview protocol was developed from the extensive literature review, which aimed at participants' roles and their experiences in enabling and hindering mKTPs. Each interview lasted 30-100 minutes and was recorded via Microsoft Teams. After the interviews, the transcripts were reviewed verbatim by two researchers (the interviewer and an experienced professor). We sent them to participants for verification. Once participants returned the transcripts with their comments, the updated versions were used for further analysis.

The data used in this paper stemmed from the entire dataset based on novel stories identified during the analysis. Thematic analysis with an inductive approach was used for data analysis (Creswell 2013), which was completed by two researchers. In stage 1, we used open coding to create a list of codes based on the words used by participants, ensuring the accuracy and consistency of the data. After comparing the open codes, we grouped similar ones together (Braun and Clarke, 2006). In this process, we identified a novel storyline that focuses on the role of KTP associates within mKTPs, which has been limited in current literature. As such, the subsequent analysis drew on this topic. In stage 2, based on the new scopes---KTP associates and their engagement in KT, we initially found four themes: (1) facilitators (2) Change Controllers, (3) Career Builders, and (4) Outsiders. Through a cyclical analysis and refinement, a new theme— the dynamics of the four KTP associates, was discovered. Therefore, apart from the former four themes, we added the new themes as the fifth theme.

4. Main Findings and Discussion

4.1 Facilitators (the Dedicated Facilitators)

The findings reveal the four KTP associate roles that influence their engagement in KT within mKTPs. Foremost, the facilitators are characterised by KTP associates recognising their mKTPs. As Robert, a KTP associate, stated: "*It's useful to make the project my own and take elements from it".* This recognition enables KTP associates to facilitate KT, for example, "bring all of the actors together to have a meeting to keep every onboard (Rach, a KTP associate) or "*having lunch, having a coffee with employees"* (Robert, a KTP associate). Their efforts ensure "*people feel they can be trusted and then can trust others*" (Simon, a business supervisor), enabling KT.

The facilitators in mKTPs align with Ryan and O'Malley's (2016) two boundary spanners roles: network builder and mediator (facilitator). In intra-organisational arrangements, boundary spanners have to translate information for them to ensure their perceptions are aligned (Ryan and O'Malley, 2016). The findings indicate that their engagement in KT stems from their identification with the project. Drawing from Gouldner's (1958) concept of the dedicated, this type of KTP associate can be seen as the dedicated boundary spanners, committed to shared goals and relationships in work environments (William, 2012; Stephens, van Steden and Schoonmade, 2024).

4.2 Change Controller (True Bureaucrat)

The second role, change controller, involves KTP associates managing changes in mKTPs, such as personnel shifts and adjustments in working methods. To facilitate associates, business supervisors "*empower an authority to him (KTP associate) to deliver the project and manage changes*" (Andrew, a business supervisor). Whereby leadership, associates are able to "*organise a project team meeting to manage conflicting perceptions due to changes, with the university and company supervisors altogether"* (Daniel, a KTP associate). In this way, they can help communication and KT between two partners. However, excessive leadership can make associates feel like they *"own the project"* (Rach, a KTP associate), leading to dominance over knowledge resources and ignoring others' valuable knowledge. "*Things are being heard that want to be heard. What the associate doesn't want, they're not heard… She (associate) is trying to give the academics the tasks to do. She's missing the fact that's not what the mKTP is. So, I hold my knowledge back."* (Emily, an academic). Such control can harm academics' commitment to KT Additionally, losing leadership can get associates frustrated*, "as I detect everything happening in the company. I know better than university supervisors"* (Daniel, a KTP associate). This lack of acknowledgement can diminish their engagement in KT.

Change controller, involves KTP associates managing changes within mKTPs and addressing the resulting challenges. Business supervisors empower associates with leadership, enabling them to communicate with different individuals and make them accept changes through control (De Wit-de Vries *et al.*, 2019; White *et al.,* 2019; Ates *et al.,* 2024). KTP associates contribute to KT. However, excessive control by KTP associates can produce a sense of project ownership, leading to restriction of information and control of academics. This obstructs KT from academics (De Wit-de Vries *et al.,* 2019; Tootell *et al.,* 2021; Hakami, Pradhan and Mastio, 2022). According to Gouldner's (1958) concept of the true bureaucrat, who favours control to address external pressures, the study highlights leadership or control as defining traits of a change controller. Despite the control

characteristic, a true bureaucrat values internal organisational groups over external ones (Petchey *et al.,* 2007). In this study, associates embedded within businesses are better positioned to understand business and manage changes, often expecting their knowledge to drive these processes. These behaviours, rooted in goodwill for collective success, aligned with the characteristics of a true bureaucrat.

4.3 Career Builder (Empire builder)

The third role, career builder, describes KTP associates who focus on their career development. When they do not see career benefits, they are less willing to engage in KT. For example, one associate shared: *"I felt like quitting because it's hard to see how this is benefiting my career…that's where it's easier to bring them (academics) into the company at the right time to share knowledge with the right stakeholders, rather than expecting the associate to do all of that"* (Rach). This aligns with Keller and Holland's (1975) findings that individuals motivated by economic rewards are less committed to undertaking boundary-spanning practices. Hence, associates disengaged in KT and even "*left after 12 months and took a job in academia. The project did not go to the end*" (Sarah, an academic). This behaviour can be seen as a self-interest behaviour to seek a better opportunity outside of the current project, jeopardising KT (Tootell *et al.,* 2021).

Nevertheless, if supervisors help associates develop their professional skills in mKTPs, the associates perceive the project as *"a valuable opportunity for personal development"* (Luke, a KTP associate). Consequently, this can strengthen their dedication to KT, similar to the helper role. Based on the concept of empire builders, individuals dissatisfied with careers within organisations may seek possibilities elsewhere (Fuller *et al*., 2009). In this research, whether KTP associates stay or look for new careers, their focus remains on advancing their careers, linking to the characteristics of empire builders. When their career goals are aligned with mKTPs, KTP associates are more engaged in and facilitate KT; otherwise, they may seek a better job in other contexts, which hinders KT within the mKTPs.

4.4 Outsiders

KTP associates perceive themselves as an outsider of the host organisation because "*You're in working in a company, but you're not employed by that company"* (Robert, a KTP associate). As such, when KTP associates attempt to engage with the employees of the host company, they may say "*No, I am busy*" (Peter, a KTP advisor) to reject the request of KTP associates. This results in associates' feelings of disconnection in mKTPs (William, 2012; White *et al.* 2019). Over time, *"there was such a reluctance from the associate to speak to other people even if I tried to get people talking"* (Emily, an academic). Another academic experienced a similar situation. "*My associate was less willing to get involved in the day-to-day running of the company and the employees. He was heavily reliant on emails for KT, rather than conversations, workshops, and discussions. I couldn't keep up with the email thread"* (Sarah). This destroys KT channels between universities and businesses. According to the concept of outsiders, individuals who feel detached from work networks are less willing to engage in activities within the current environment (William, 2012). The outsider-type of KTP associate aligns with this concept and hinders KT in mKTPs.

4.5 Dynamics of KTP Associates

A novel finding reveals the dynamics among the four roles. At first, when supervisors empower them to lead project changes, true-bureaucrat associates may transition into the dedicated facilitators because they believe their knowledge can contribute to the project rather than just personal gain. The leadership allows them to manage changes and support KT in mKTPs. Similarly, when empire-building associates receive professional development, they will align their careers with mKTPs. Thus, they become more willing to facilitate KT, as the facilitators do (William, 2012; Ryan and O'Malley, 2016).

The results highlight the interaction between empire (career) builders and outsiders. When KTP associates view themselves as outsiders, they lose interest in KT and may explore other career opportunities (Tootell *et al.,* 2021). Likewise, if associates do not receive career benefits from mKTPs, over time, they will disengage in communication and KT within mKTPs and become outsiders (William, 2012; Tootell *et al.,* 2021). However, the consequences suggest that support from supervisors, such as helping associates know organisational employees, especially early in the project (De Wit-de Vries *et al.,* 2019), can help them become one part of the mKTPs. Over time, they evolve into the dedicated facilitators.

Lastly, the findings leave some indications about the dedicated facilitators. If KTP associates are excluded from organisational relationships or cannot obtain recognition and support from supervisors (e.g. leadership or skill development), their engagement in KT may erode (William, 2012; White *et al.* 2019; Tootell *et al.,* 2021). Over

time, the dedicated facilitators may transition into other roles: outsiders, true bureaucrats and empire builders. Hence, this indication implies two dynamics--positive and negative. Positive dynamics occur when KTP associates shift toward the facilitators in KT, while negative dynamics refer to the transition toward outsiders or empire builders, disengaging and hindering KT.

According to the above description, a framework is developed to illustrate the dynamics among four KTP associate roles and their influences on KT, as shown in Figure. 1. The core of the framework represents KTP associates, with the four roles in separate quadrants around: The green quadrant depicts the dedicated facilitators who identify with their current boundary spanning role in mKTPs and committed to engaging and facilitating KT between universities and companies; the orange quadrant means that KTP associates view themselves as outsiders from the host company or even the project, thereby disengaging in KT; as both true-bureaucrat and empire-building KTP associates show contingent influences on KT based on varying situations (either facilitate or hinder KT), they are filled in the same yellow colour in the quadrants.

The inner black arrows mean the dynamics among the four roles of KTP associates depending on the different contexts. The outer-above green arrows indicate positive dynamics that enable KT between universities and companies when KTP associates who request leadership (true bureaucrat) or opportunities for personal career growth (empire builder) or perceive themselves as an outsider, transition toward the dedicated boundary spanners; while the outer-below red arrows represent negative dynamics that hinder KT as empire-building and true-bureaucrat KTP associates shift toward outsiders.

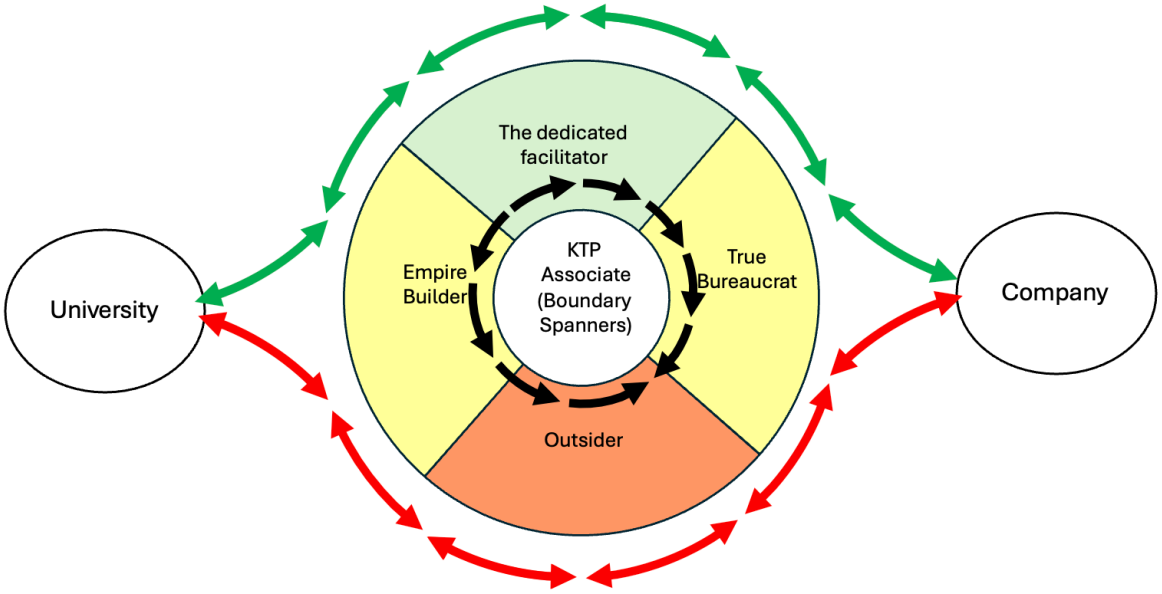


Figure 1: Framework of Four Boundary Spanning Roles in University-Industry Collaboration and Their Dynamics

5. Contributions

Our findings make several contributions to the literature on KT and boundary spanners in UICs by exploring the KTP associates' role in mKTPs. Foremost, exploring the four KTP associate roles and their underlying reasons addresses RQ1 and RQ2**.** Using Gouldner's (1958) framework helps to conceptualise the multifaceted roles of KTP associates based on their engagement in KT in mKTPs. When associates engage internally, they act as the local boundary spanners, such as the dedicated facilitator and change controller. Conversely, when they attempt to engage with opportunities externally or disengage in internal KT, they adopt cosmopolitan roles, such as career builders and outsiders. Prior literature on UICs and KTP/mKTPs on boundary spanners and KTP associates have often regarded it as a one-size-fits-all static role in KT within UICs (e.g. De Wit-de Vries *et al.,* 2019; White *et al.,* 2019; Goodrich et al., 2020; Mattin and Ibbotson, 2021; Ates *et al.,* 2024). Nevertheless, the present study expands this understanding by identifying four roles: the dedicated facilitators true bureaucrats, empire builders and outsiders based on different personal and contextual reasons. Therefore, this paper contributes to emphasising that KTP associates are multifaceted and context-dependent boundary spanners in KT.

Moreover, by exploring these four roles, this study reveals the positive and negative dynamics of KTP associates in mKTPs, which offers a novel insight into the literature on boundary spanners. A framework has been developed to demonstrate these dynamics influencing KT. By large, the dedicated associate is a facilitator of KT, while the outsider is a hindrance. The true bureaucrat and empire builder play a contingent role in this process within UICs. Positive dynamics occur when true bureaucrats, empire builders and outsiders transition toward the dedicated, KT will be enabled. In contrast, negative dynamics emerge when true bureaucrats and empire builders shift toward the outsider, KT will be hindered. These consequences and the framework address RQ3: *How do they influence KT?*

The dynamics of KTP associates in KT challenge the majority of previous research on KTPs and UICs that depicts boundary spanners as a static role with dual responsibilities or functions of internal and external engagement for KT (e.g. De Wit-de Vries *et al.,* 2019; White *et al.,* 2019; Goodrich *et al*., 2020; Mattin and Ibbotson, 2021; Ates *et al.,* 2024). The results regarding positive and negative dynamics reveal the dynamic and context-dependent nature of boundary spanners in UICs, contributing to the literature on boundary spanners and the studies of KT in inter-organisational partnerships and UICs.

This paper also offers practical implications. This study emphasises the importance of KTP associates in KT due to their positioning between university and business. This provides them with more opportunities to communicate with project members, compared to academics and business supervisors (White *et al.,* 2019). If this role fails to engage in KT for both partners, the collaborations may be problematic. Therefore, support from supervisors is essential to help KTP associates become the dedicated facilitators (De Wit-de Vries *et al.,* 2019; White *et al.,* 2019). Supervisors can empower associates through leadership and professional development; thus, associates will bond personal growth with projects and be willing to undertake their duties as the boundary spanner in UICs. Moreover, the presence of outsider roles suggests the importance of supervisors creating a supportive environment, especially early in the project (De Wit-de Vries *et al.,* 2019; Dolmans *et al.,* 2022). An initial lack of trust and unclear objectives can impact associates' engagement in subsequential KT (De Wit-de Vries *et al.,* 2019). Supervisors' support can help KTP associates adapt to organisational life and connect with organisational employees. Over time, they will see themselves as one part of mKTPs, thereby transitioning into the dedicated facilitator.

6. Conclusion, Limitations and Future Research Avenues

The paper employs Grouldner's (1958) local-cosmopolitan framework to explore the role of KTP associates in KT within UICs. It highlights that the contexts in which supervisors provide sufficient support (e.g. leadership, opportunities for career development, etc.) shape how KTP associates perceive their roles in their mKTPs, leading them to engage in KT. The engagement behaviours result in four boundary spanner roles: the dedicated facilitator, true bureaucrat (change controller), empire (career) builder and outsider. Importantly, these roles are dynamic, varying according to specific contexts, and their dynamics have different influences on KT in UICs—either facilitating, hindering or influencing it contingently. The findings underscore the dual engagement behaviours of KTP associates in managing relational dynamics.

This research has several limitations. First, while interviews with thirty respondents from four distinct groups provide valuable insights into individual experiences related to KTP associates in KT (Creswell 2013; Easterby-Smith, Thorpe and Jackson 2021), relying on one data collection approach may overlook the interactive factors between KTP associates and other actors during collaboration process (De Wit-de Vries *et al.,* 2019; White *et al.,* 2019). The cross-sectional data may limit the depth of understanding regarding the dynamics (Easterby-Smith, Thorpe and Jackson 2021). Accordingly, the findings on the dynamics of KTP associate roles in KT remain an illustrative step. A longitudinal study with additional data and alternative methods, such as observation, and focus groups, could provide a more comprehensive understanding of these dynamics over time. Second, the focus on mKTPs may limit the understanding of boundary spanners to a broader context of UICs, such as knowledge spins-off, business consultancy activities, etc. Including other collaborative forms could offer a more nuanced understanding of boundary spanners and their dynamics across diverse contexts in the future.

Ethical declaration: This study was granted ethical approval with reference number: 22/LBR/003. All the research progress followed ethical principles. All the participants were informed about the purpose and research process of this study by reviewing the Participant Information Sheets and then signing the Participant Consent Forms. There were no ethical issues throughout this study.

AI declaration: This paper was completed by the authors without the use of AI tools.

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Some Provocations Concerning the Foundations of IC and KM Research

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Abstract: The overall objective of this paper is to propose and discuss some provocative questions about the foundations of IC and KM research. These provocations primarily, but not exclusively, address issues with respect to the ontologies and epistemologies that underlie these areas of research. The nature of knowledge and its articulation lies at the heart of concerns with the current theories underpinning IC and KM and, indeed IC and KM research generally. Such concerns also raise interesting issues about many existing research studies in IC and KM. Of particular concern are the ways in which the terms 'knowledge' and 'intellectual capital' are defined (or not defined) and explored. It is critical that generally agreed on definitions of key concepts are identified so that firm foundations exist as a basis for empirical investigations. However, it is argued that these definitions are likely to be open-ended and need to recognize that, at least with respect to value, the definition of relevant concepts is radically dependent on context at many different levels. From a definitional perspective IC and KM are intertwined and overlapping. Furthermore, to the extent that one of the dominate objectives of the management of IC and KM is the creation of value the contribution of the components of IC and KM is intimately related to the individual, group, organization and social context within which such management takes place. Although this paper offers provocations with respect to the current state of IC and KM research, it also provides some suggestions as to potentially fruitful extensions of existing research. One stems from a nuanced consideration of knowledge and the interaction of knowledge and IC in generating value. It is suggested that much insight can be gained through a renewed consideration of such disciplines as Economics and Organizational Studies. The paper concludes by proposing that IC and KM researchers refocus both on the intersection between the two research areas and the nature and value of knowledge.

Keywords: Intellectual capital, Knowledge, Knowledge management, Theory, Value

1. Introduction

As researchers working in both IC and KM research, we have had over 50 years of experience of conducting research in the KM and IC domains and other associated fields. Throughout our journey we have been increasingly concerned with the relative lack of detailed discussion of the foundations of IC and KM research. We acknowledge that many of our colleagues have provided valuable insights into these concerns (e.g. Kianto et al. 2020, Vielma, 2007, Viedma and do Rosario-Cabrita, 2023) however we contend that there is a need to reconsider a variety of fundamental issues with respect to the foundation of IC and KM research particularly pertaining to the ontological and epistemological aspects of these research projects. Furthermore, with respect to the fact that IC and knowledge research are studied with a view to how they allow organizations to achieve objectives as creating value (economic and otherwise), achieving resilience or sustainability, there is a need to conduct research that elaborates on the contribution of knowledge and IC to these objectives.

2. Classification and the Development of Theory

In many ways, since the time of Aristotle (2023), classification has been seen to a fundamental precursor to representing and referring to the world and creating the basis for developing theory. Typically, classification results in a taxonomy. Classification involves the identification of referents through their location within a taxonomy. At the most basic level being able to refer to the world and communicate requires the making of distinctions – to distinguish between what is and is not (Spencer-Brown, 2008). Furthermore, the basis for such distinctions will be characteristics of the referent in question. Although this is a precursor stage to the formulation of theory such classification may not be based on an underlying theory or lead to one that links deeper concepts to surface characteristics. However, an appropriate taxonomy may provide the ground for theorising about deeper concepts and their relationships to surface characteristics. It is interesting to note that in the case of Linnaeus fortuitously the surface features he sought to use to develop a taxonomy of living things could later be associated (generally) with genetic theory (Paterlini, 2007).

In addition to identifying basic referents of interest it is typically of interest to identify how such referents are interrelated and related to other higher-level concepts such as outcomes, values etc. Integral to these concerns is how we may go about establishing the existence of such referents, their characteristics and the relationships to other concepts. Thus, both ontology and epistemology are key aspects of theories – thus,

central questions that we must answer in developing the foundations of any theory are: What are the basic referents of the theory and how do we learn about them?

As a starting point for investigating the foundations of IC research it is appropriate to review approaches that have been adopted to develop taxonomies of IC components and investigations as to the characteristics of IC components, their interrelationships and their relationships to higher level concepts such as value, sustainability, resilience and competitive advantage.

3. The Challenge of Developing a Taxonomy for IC?

Expanding on the discussion in the preceding section to provide an adequate foundation for any theoretical study it is necessary to develop an appropriate ontology which initially involves establishing appropriate classification(s) utilizing taxonomy(ies) for what is referred to by the portmanteau concept – IC. The initial impetus to identify IC was the failure or economic theory to adequately provide an explanation for the economic value derived from traditional capital. This led to a distinction being proposed between Tangible Capital and Intangible Capital. There are many closely related definitions of Intangible Capital an example of which is '[i]ntangible capital is generally defined by what it lacks—that is, as productive capital that lacks a physical presence' (Crouzet et al. 2022). In IC research Intellectual Capital (IC) was initially further decomposed into Human Capital, Customer Capital, Social Capital and Structural Capital which itself can be decomposed into Process Capital, Organizational Capital and Innovation Capital (Edvinsson and Malone, 1997). Andriessen (2001, p. 204) notes that, at least at this 'early' stage of development there is probably no generally agreed 'standard' theory of IC whist observing that existing classification schemas (as of 2001) generally "break down the total [intellectual] capital of a company into its contributing parts, the human capital and structural capital" (ibid. p. 205). However, he also notes that "this is a very useful way to define what we are talking about, but at the same time it hampers us in seeing the wood from the trees' (ibid. p. 205).

Fairly early on Bontis (2001) had concerns as to the non-standardization of the definition of IC and its components and subcomponents. In the same volume However, this seems to have had relatively little effect since some years later Roos and Pike (Roos and Pike, 2007, p. 11) opine that 'the devotion of numerous paragraphs or even entire sections [in IC research publications] to a discussion of taxonomy ten years after the two most popular systems were first published seems absurd'.

Marr and Moustaghafir (2005) review a range of published research to explore the concept of IC. It is instructive to note that of the 938 papers selected only 55 provided useful definitions of IC. From their sample they provide 'guidance' with respect to identifying the components of IC namely: employees' skills and know-how, organizational culture, relationships with stakeholders, organizational image and reputation, technological infrastructure, intellectual property rights, and practices and routines. They is relatively little discussion as to the structural relationships of the subcomponents of IC, the characteristics of each of the subcomponents of how they can be utilized to create value.

A later and truly impressive literature review (Pedro et al., 2018) concludes that "[components of IC] formed of human capital, structural capital and relational capital is the [research approach] showing a convergence of the majority of authors analysing empirically the main components of IC". However, it should be noted that many researchers have expanded to overall concept of IC. Thus, additional components have been added such as Green Capital (Chen, 2008). Other researchers have expanded the components of IC considerably to include such components as Technical Capital and Spiritual Capital (Kahn, 2015). In addition, issues relating to the cross-cultural comparison between IC components have been investigated by Inkinen et al. (2017).

In reviewing the direction of in IC research to date at least four distinct issues can be identified. In the first place although it seems that there is some coherence with respect to the subcomponents IC new components are being added without clearly identifying their relationship to existing subcomponents. For example, Chen introduces the concept of Green Capital and decomposes it into green human capital, green structural capital and green relational capital. There is a need to articulate the ontological/conceptual structure of IC even though such a ontological/conceptual structure is likely to be open ended. Without a articulated ontological structure it is difficult to see have a reliable epistemological basis for IC can be established.

In the second place there is a need to articulate the interrelationships between the different subcomponents of IC particularly in the way they jointly relate to the achievement of goals such as the creation and capture of value. In the analysis of the contribution of IC and its subcomponents to the creation of value.

Thirdly, the current approach to developing a conceptual structure for IC leads to assumptions that IC and its subcomponents are distinct entities in so far as they allow organizations to create value. However, this does not allow for the recognition that, at the very least, considering knowledge as a component of IC, the value of IC is radically dependent on context. The recognition that IC can be represented by stocks and flows does not help.

Fourth, although knowledge is often referred to as having 'something to do' with IC and the creation of value the part played by knowledge is rarely investigated in detail apart from observing that one component of IC may be knowledge or that Human Capital includes the knowledge and skills of employees.

To go beyond the superficial, albeit one that has been empirically quite productive, there is a need to further establish how the components and subcomponents of IC lead to the achievement of overall goals such as the economic performance or, more generally, the creation of value.

Many researchers have indicated the interweaving the concepts of IC and KM. Kianto et al. (2020) argue that the two concepts are intimately linked. In the following section the linkages between the concepts of IC and KM are explored by considering extant research conducted by IC and KM researchers.

4. How are IC and KM Related?

In many ways IC and KM research sprang from the same root, at around the same time, and claim common pre-cursors (e.g., Bontis, 1998, 2001; Edvinsson and Malone, 1997; Stewart, 1997). However, in the last quarter century these research disciplines seem to have drawn apart as has been noted by Lambe (2023, p. 202-3).

IC researchers have largely explained IC as a combination of organizational knowledge and knowing capabilities (e.g., processes) that enable organizations to derive value from organizational knowledge (Bontis, 1998; Nahapiet and Ghoshal, 1998). Furthermore, IC may act as basis for the addition of value to the organization, potentially leading to the establishment of competitive advantage (e.g., Bontis, 1998, 2001; Edvinsson and Malone, 1997; Stewart, 1997).

In contrast, the focus of much KM research has been to consider the nature of knowledge. Initially focus was placed on the distinction between tacit and explicit knowledge (Nonaka et al, 1995) and to a somewhat lesser extent, implicit knowledge. Initially, in its early stages KM research was somewhat focused on existing and new digital technologies and the extent to what they facilitated the creation, capture, and dissemination of knowledge.

This second generation of KM research inevitably brought with it deeper considering of the human involvement in KM and the production, management, and utilization of knowledge (McElroy, 2003 McElroy et al., 2006). Thus, the second generation of KM research recognized social and organizational contexts, closely interweaving KM with the IC literature, even if researchers didn't necessarily articulate this connection. This research did not classify all knowledge as inherently valuable but rather tried to explain how organizational knowledge can be turned into valuable knowledge through dynamic capabilities that facilitate the acquisition, combination, and sharing of knowledge to support decisions and processes that create value for the organization. Typically, this value was measured primarily in terms of organizational financial performance.

In addition to insufficient attention being paid to the part that knowledge plays in facilitating the linkage between IC and value there has been insufficient attention paid to the different types of knowledge encountered in organizations and their characteristics.

In similar vein, much recent research into, for example, knowledge hiding has addressed individual, organizational, and social perspectives, which often involve components of IC directly or indirectly (Tokyzhanova and Durst, 2023).

The above discussion suggests the need to explore, with a more critical eye, where and how KM and IC are closely interweaved both in terms of their components and how they organizations combine them to generate value. As observed by McElroy et al. (2006), Kianto et al. (2020), Albertini (2016), Reed (2000) and Reed et al. (2006), components of IC and knowledge are intimately interweaved It is proposed that one starting point is the proposal that KM is focused on the management of knowledge, which is embedded in IC (or articulated through IC) to create value which may be economic value, social value or other value outcomes. This is discussed in the following section.

5. What is the Knowledge?

Kianto et al. (2020) note that "knowledge itself is an extremely complex and problematic concept that has been discussed in a multitude of disciplines, from philosophy to accounting and from information science to anthropology" (p. 2). It can be argued that each discipline brings with it a different definition of knowledge, and taxonomy of knowledge, and identifies different characteristics of knowledge.

Mokyr (2002), an economic historian, introduces the concept if useful knowledge' but does not provide a detailed definition One can probably infer that 'useful' knowledge is that knowledge which enables the creation of human value. It leads to actions that create human value. In this context human value could be considered to refer to economic value, social value or other bases of value.

Mokyr (2002) separates into Omega, O*,* knowledge and Lambda, L knowledge. Broadly speaking Omega, O knowledge not only involves facts and empirically 'validated' regularities but also folk theories, myths, facts, etc. L knowledge is procedural knowledge or knowledge of how to get things done and is based on O knowledge. Mokyr (2002) focuses on knowledge that allows human to intervene in nature and interact to create value. Mokyr alerts us to the need to recognize the different types of knowledge that can be combined to create value and the limited importance of such concepts as truth.

In a further recognition of the richness of the concept in group and organizational settings an individual may acknowledge many different types of knowledge which may well interact when the individual acts (or interacts) with others in a group action situation. Individuals are members of many different "epistemic cultures" (Knorr-Cetina, 1999) which have their own definitions of knowledge and approaches to the 'construction' of knowledge (often unstated). Thus, different knowledge communities may have radically different ontologies and epistemologies, as well as ways of dealing with important aspects of knowledge, such as uncertainty and vagueness in different ways. Furthermore, it is likely that there are many different knowledge communities that a particular individual participates in that have different perspectives on what constitutes knowledge.

Many groups within an organization may need to collaborate to create a product or service which generates value. Different groups or, 'knowledge communities' may well subscribe to different ontologies and epistemologies. As Wittgenstein notes that this may result in different groups having a different 'world view' or a view of what we can know, the limits of our knowledge, and the criteria that are relevant to our claims to know something (discussed extensively in Korber, 2018 and Tsoukas, 2019).

To communicate and coordinate their actions groups must find some way of reconciling their world views. One way that organizations can better deal with or process of reconciling different epistemologies of knowledge is by using 'boundary spanners' who can interpret the knowledge provided by different knowledge communities (see, for example. Stafford et al., 2017). These individuals can, for example, recognize the unexpressed level of uncertainty in one community's knowledge when decisions are processed, or the tentative nature of knowledge provided by one knowledge community versus another. However, in many areas we need to explore how individuals and groups of individuals collaborate with a focus on knowledge and IC. Rather than examining 'knowledge sharing' it is necessary to investigate the types of knowledge that are shared and their characteristics and the process of knowledge sharing. In addition, knowledge sharing is essentially an interaction between individuals which may involve extensive exploration, explanation and negotiation.

6. How does IC Contribute to the Creation of Value and What Part Does Knowledge Play?

As noted above and observed by McElroy et al. (2006), Kianto et al. (2020), Albertini (2016), Reed (2000) and Reed et al. (2006), the components of IC and knowledge are intimately interweaved. Clearly, the simple possession of knowledge does not create value for the organization. It is the articulation of this knowledge that creates, markets and supports products and services that potentially create value for the organization. Thus, knowledge or, more generally IC has value in an organizational setting only to the extent that it leads to action(s) that result in the creation of value. Thus, for example, human capital is valuable since humans are knowledgeable, have the capability and the opportunity of interacting with other humans, and can access and interpret information available in the organization's information system to create products or services, marketing campaigns, business strategies that add value. Furthermore, it is the complex interweaving of IC and knowledge in a rich social context that leads to the creation of value. The rich social context that needs to be

considered embraces not only the context(s) within which the individual operates but also the organizational context(s) and the context(s) within which the organization operates.

For example, a better understanding of the ways in which human capital interacts with other components of IC and other organizational resources to create value can potentially provide a rich range of insights. These insights may provide an indication of ways in which the organization can increase the value it creates through paying close attention to the knowledge that it has/utilizes, and its present IC. On way in which this can be done is using 'thick' studies of organizations. Investigating how individuals manage IC and actively make decisions to utilize IC to engage in actions to add value.

However, alternative approaches to the measurement of value may be utilized as in the case of Responsible Knowledge Management (Durst, 2024). Furthermore, knowledge and IC may have value to the extent that they provide a path to future valuable knowledge and IC.

As noted above, perhaps, the central problem associated with the valuation of knowledge, and the various components of IC is that their value is radically contextual. As indicated above the value of knowledge depends on the knowledge already available to the organization (at all levels, individual, collective and organizational), and the specific components of IC in place in the organization. As indicated above, there has been extensive work on developing approaches to valuing IC (see, for example, Kianto et al. 2020) but typically these approaches are focused on a financial reporting or economic perspective and therefore, essentially providing some measure of economic value. Apart from ignoring issues such as ambiguity and uncertainty which are likely to have a significant impact on value. Furthermore, they are generally focused on the value of IC, as it presently exists in an organization, rather than the value of IC in generating future valuable options (see Kogut and Kulatilaka, 2001). There is clearly a need to investigate how IC and knowledge jointly create value and consider other definitions of value beyond economic value.

7. How are 'Significant' Empirical Results Obtained Based on Fuzzy KM and IC Concepts?

In the case of knowledge, as noted above it likely to be the case that what represents 'knowledge' to one individual in a particular context is not necessarily knowledge to another individual in a different context. A similar point can be made at the collective and organizational level. This should give researchers pause, as one would expect the 'world model' of individuals in radically different industries or domains to be different. Thus, the epistemological support, degree of agreement, or tightness, to use Mokyr's (2002) terminology relating to the of the concept of knowledge may differ between individual, groups, and indeed organizations. In addition, the components of IC may differ significantly. These differences would need to be captured at an individual and collective level. As if this wasn't enough to keep KM theoreticians and empirical investigators up at night, the term knowledge does not necessarily carry the same meaning(s) in different languages or cultures. At a minimum it would be helpful when using terms like 'knowledge' to explore with subjects studied of such behaviours as knowledge sharing and knowledge hiding how they interpret the term knowledge.

However, it is commonly the case that when KM or IC research is replicated in different cultures and industrial domains, the results are often similar, if not identical. How can this be when there is little coherence between either the components of IC or, more fundamentally, the nature of knowledge?

As the beginnings of an explanation of the consistency of empirical results it is possible that in any context individuals interpret the term knowledge as that which contributes to the ability of the individual, collective, or organization to achieve its objectives. This seems to be a relatively unexplored area of research.

8. A Path Forward by Aligning IC and KM Research

It has been noted that there are fundamental challenges both with respect to the ontologies and epistemologies that underpin both IC and KM research. In addition, from the standpoint of the generation of value the context within which knowledge is articulated through IC is rich and multidimensional. Thus, it seems unlikely that concepts that are developed in IC and KM can be limited in their dimensionality. This would seem to be a characteristic of research in the social sciences. At the very least this is likely to mean that explanation and prediction in the sense used in empirical sciences is simply not possible. Perhaps the best that can be done is to specify the nature of the rich contexts that seem to generate the successful creation of value. Such definitions will not be precise but will allow significant flexibility as human actors interact with the knowledge and IC in action.

One observation is that the arbitrary separation of IC research and KM research has reduced the contribution of both research domains and limited the valuable synergies presented. It has been noted that empirical research seems to have confirmed the importance of a variety of factors relating to IC and KM yet establishing the significance of this is contentious, as the definition of terms used in the empirical analysis often have an inherent vagueness or are inadequately articulated. Both IC and KM research could benefit with a deeper level of analysis of the terms that are used and, through this, an appreciation of the interweaving of IC and KM (see, for example, McElroy et al., 2006 and Kianto, et al., 2020) and the rich contextual relevance.

A further concern is that, in paying insufficient attention to the multi-dimensional and contextual nature of the fundamental foundational concepts of IC and KM research agendas have been unnecessarily restricted. For example, the part played by ambiguity and uncertainty in the ability of IC and knowledge has been inadequately explored. Thus, it may be possible to revisit prior research for new insights or more likely to implement new research agendas to explore these issues among others. Furthermore, much extant research in other related disciplines which could have contributed to enriching the IC and KM research agendas has also largely been ignored. It is worth noting that computer science research in general, and AI in particular is replete with relevant and applicable knowledge. Indeed, when reference is made to 'artificial knowledge' in recent KM research (Bratianu and Paiuc, 2025) it seems necessary that work relating to the representation of knowledge in Knowledge Based systems is reviewed. Finally, in developing theory there is a need to pay much more attention to the epistemological and ontological foundations of IC and KM.

Ethics declaration: Ethical clearance was not required for this research.

Artificial intelligence (AI) declaration: No AI tools were used in the idea or content generation, writing, or editing of this paper.

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Understanding the Role of Tacit and Explicit Knowledge Hiding in Organizations

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Abstract: Knowledge hiding (KHi) is the intentional withholding of knowledge from colleagues, often caused by a lack of trust. It takes three forms: rationalized hiding, evasive hiding, and playing dumb, with the latter two fueling ongoing mistrust. To address this, organizations promote sharing both Tacit Knowledge (TK) and Explicit Knowledge (EK), to improve teamwork, problem-solving, and workplace relationships. Recent studies highlight the challenge of distinguishing general knowledge from TK and the difficulty of articulating TK, which adds to its scarcity and value. Examining the intentions and motivations behind KHi and KHo, often driven by fear, provides important insights into organizational knowledge dynamics. This study aimed to identify key factors influencing individuals' decisions to share TK or engage in KHi or KHo behaviors in the workplace. Using an 11-stage Survey Design methodology, data was collected from 285 Knowledge Management (KM) professionals across five countries over 42 days. This comprehensive approach ensured a diverse and representative sample, enhancing the validity and applicability of the findings. Results revealed that participants were aware of and engaged in KHi, KHo, and Knowledge Sharing (KS) behaviors. They recognized that TK holders made deliberate sharing decisions based on trust, sincerity, skillsets, and expertise. This insight underscores the complexity of KM in organizational settings and the need for nuanced approaches to encourage KS. The study highlighted the need for future research to include leadership influences, which significantly impact KHi and KHo behaviors. This finding emphasizes the critical role of leadership in shaping knowledge-sharing cultures within organizations and suggests that effective KM strategies must consider leadership styles and practices. By addressing these complex issues, organizations can develop more effective strategies to promote KS, reduce harmful hiding behaviors, and ultimately enhance their competitive advantage through improved KM practices. The study's findings provide a foundation for future research and practical applications in organizational KM, potentially leading to more efficient and collaborative work environments.

Keywords: Knowledge hiding, Knowledge hoarding, Knowledge sharing, Tacit knowledge, Behavioral intention, Trust

1. Introduction

Knowledge Hiding (KHi) involves intentionally withholding information due to organizational factors like politics, behavior, or workplace treatment. Connelly et al. (2012) define it as deliberate concealment driven by distrust, expressed through rationalized hiding, evasive hiding, or playing dumb.

Rationalized hiding, KHi's least harmful form, withholds information citing sensitivity/confidentiality, breeding distrust (Bari et al., 2020; Connelly et al., 2012; Tian et al., 2021). Evasive hiding shares partial/misleading information (Tian et al., 2021), while playing dumb feigns ignorance (Bari et al., 2020).

Bari et al. (2020) found evasive hiding and playing dumb highly detrimental, fostering mistrust and reduced collaboration. KHi may arise from organizational issues, leadership, or antisocial behaviors (Banagou et al., 2021; Pradhan et al., 2019). Banagou et al. (2021) distinguish KHo-accumulating knowledge without intentional concealment.

Bilginoğlu (2018) describes KHo as deliberately withholding information to retain knowledge and power. Like KHi, KHo reduces Knowledge Sharing (KS) and collaboration, leading to tension and harming both interpersonal and organizational performance (de Garcia, 2020).

Knowledge hiding and KHo are used to retain information when individuals feel threatened or seek protection from uncertainty (Bilginoğlu, 2018; de Garcia, 2020). Hiding conceals requested information, hoarding unrequested. This study examined their interplay in TK sharing.

1.1 Problem Statement

Clear study goals and data collection are essential (Rea & Parker, 2014). A quantitative survey assessed KHo and KHi regarding TK (Peng, 2013), using standardized questions to minimize bias (Brace, 2013) and reveal antecedents like mistreatment and trust (Connelly et al., 2012; Oliveira et al., 2019).

Peng (2013) noted research lacked evidence linking TK as the source of KHi. Unlike EK, TK is personal, difficult to share, and uniquely valuable (Gubbins & Dooley, 2021; Peng, 2013; Singh, 2019). Examining interactions may clarify relationships among TK, trust, and KS (Gubbins & Dooley, 2021).

The study addressed four Research Questions (RQ) on individuals' understanding and motivation for KHo, KHi, and TK sharing. It examined motivations for TK sharing, behavioral traits of KHi, KHo, trust, and TK sharing, and factors promoting both TK and EK sharing.

RQ1: How well do individuals understand the behaviors of knowledge hiding or knowledge hoarding in the workplace?

RQ2: What motivators lead an individual to share tacit knowledge with others in the workplace?

RQ3: Which behavioral characteristics influence an individual's decision to exhibit behaviors of knowledge hiding, knowledge hoarding, or to not share tacit knowledge?

RQ4: Which motivators of trust facilitate tacit knowledge sharing?

The study aimed to identify the characteristics and motivators of KHi and KHo behavior. The literature review helps address the barriers and limitations to KS within organizations.

2. Review of Literature

Individuals recognize KS, KHo, KHi as common workplace problems. A literature review explored KS, KHi, KHo, the role of trust, and the importance of TK.

2.1 Knowledge Sharing

Knowledge sharing is essential for organizational success, reducing rework, fostering innovation, and improving productivity (de Garcia et al., 2020; Oliveira et al., 2021; Pradhan et al., 2019). It also ensures valuable knowledge is captured for future use (de Garcia et al., 2020; Gubbins & Dooley, 2021).

Integrating TK into KS boosts learning and innovation, especially when experienced employees depart (de Garcia et al., 2020; Oliveira et al., 2021). However, despite leadership efforts to promote sharing, individual behaviors like KHo can limit its effectiveness (Oliveira et al., 2021; Pradhan et al., 2019).

2.2 Knowledge Hoarding

Knowledge hoarding is the intentional accumulation of knowledge, often driven by self-interest or fear of losing power (Aljawarneh et al., 2022; Banagou et al., 2021; Khalid et al., 2020). Unlike KHi, which responds to requests, knowledge hoarding is self-motivated (Banagou et al., 2021; Serenko, 2020).

Ostracism increases KHo, while poor kKS processes and organizational silos foster competition and mistrust (Bilginoğlu, 2018; Khalid et al., 2020). Although KHo may seem selfless, it limits KS, erodes trust, and restricts access to valuable knowledge (Bilginoğlu, 2018). Knowledge hiding also restricts knowledge flow and has become a key focus of recent research.

2.3 Knowledge Hiding

Connelly et al. (2012) emphasized the need for greater KHi research compared to KS. Recent studies continue exploring its motivators and behaviors across organizations and academia (Connelly et al., 2012; Koay & Lim, 2022; Wang & Dong, 2022; Wen et al., 2022).

Connelly et al.'s (2012) definition of KHi as intentional knowledge concealment due to distrust remains foundational. The authors insights on workplace competition, communication, leadership, and KHi behaviors are still highly relevant.

Knowledge hiding is a deliberate act by individuals or groups to withhold or obscure knowledge from others, often motivated by assumptions, misinformation, or distrust (Connelly et al., 2012). This behavior is particularly common when the knowledge involved is TK rather than EK.

2.4 Tacit Knowledge

Oliviera et al. (2021) reviewed 50 articles on KHi and KHo, but only six addressed the influence of TK or EK (Feng & Wang, 2019; Hearnus et al., 2018; Peng, 2013; Singh, 2019; Skerlavaj et al., 2018; Wang et al., 2018). These studies primarily examined factors motivating KHi or KHo.

Tacit knowledge is difficult to express because it is experiential, internalized, and "embrained, embodied, and embedded" (Leonard & Sensiper, 1998; Rechberg, 2020). In contrast, EK is easily shared (Gamble, 2020). Organizations often struggle to access TK, especially when its boundaries are unclear (Lanke, 2018).

Poor working conditions and low trust reduce KS and increase KHo and KHi (Rechberg, 2020). Academics often conceal TK for competitive reasons, making trust essential for balancing competition and relationships to enable effective sharing (Gubbins & Dooley, 2021; Hernaus et al., 2019).

2.5 Trust

Trust is generally understood as the willingness to rely on the intentions and actions of others (Kocak, 2023). Within KS contexts, this concept manifests in several distinct forms, including Ability-Based Trust (ABT), Benevolence-Based Trust (BBT), Cognition-Based Trust (CBT), and Competence-Based Trust (CoBT).

Gubbins and Dooley (2021) found that pre-existing relationships favor ABT, while BBT applies more when no prior connection exists; knowledge seeking depends on social identity, trust, and psychological safety. They define ABT as seekers identifying experts by ability and credibility, BBT as holders evaluating the seeker's need and goodwill, and note that CoBT, like ABT, works best in established relationships.

Levin and Cross (2004) emphasize strong relational ties in knowledge transfer, using CoBT as an example. Conversely, Chowdhury (2005) highlights CBT, which relies on evaluating credentials. Both CoBT and CBT ultimately build confidence and encourage KS.

3. Theoretical Background

Knowledge hiding is “an intentional attempt by an individual to withhold or conceal knowledge that has been requested by another individual” (Connelly et al., 2012, p. 2). Unlike KHo, it involves deliberate actions, and is associated with workplace problems like deception, social undermining, and aggression, leading to wider organizational consequences (Connelly et al., 2012).

Bari et al. (2020) found that cultures of KHi and KHo significantly undermine creativity, innovation, performance, and coworker trust. These behaviors erode trust, foster a “climate of silence,” and act as workplace exclusion, especially when combined with bullying. Despite these impacts, the authors research faces several methodological challenges.

Tacit knowledge makes studying KHi and KHo difficult, as participants may struggle to interpret or apply its definition in surveys. This ambiguity, combined with limited follow-up and methodological constraints, can reduce the clarity and depth of research findings.

Small, localized samples and self-reporting introduce bias, while cross-sectional designs limit understanding of KHi in organizations (Banagou et al., 2021; Bari et al., 2020; Yuan et al., 2020). Ongoing debates about KHi boundaries highlight the need for more cross-cultural and longitudinal research.

Furthermore, self-report surveys in sensitive areas like KHi and KHo are prone to recall bias, perceptual inaccuracies, and social desirability effects (Aljawarneh et al., 2022; Banagou et al., 2021; Duan et al., 2022; Ford & Staples). To mitigate these issues, researchers suggest using multiple data sources, open-ended questions, and experimental designs to enhance data quality and causal inference (Connelly et al., 2012; Koay & Lim, 2022; Banagou et al., 2021; Ford et al., 2015; Peng, 2013; Singh, 2019; Tian et al., 2021; Wen et al., 2022).

4. Methodology

This study addressed gaps in KHo, KHi, TK, and trust. An 11-stage Survey Design (Rea & Parker, 2014) ensured unbiased data collection from conceptualization to results.

This research followed Rea and Parker’s (2014) eleven-stage process. Stage 1: The study’s focus and methodology were defined using a quantitative survey with standardized questions to minimize bias. The research was conducted over 42 days, utilizing Qualtrics^{XM} to maximize responses within budget constraints.

Stage 3: A literature review and stakeholder input shaped the survey content, ensuring relevance to KHi, KHo, and knowledge sharing best practices. Stage 4 and 5: The sampling frame focused on IT and KM professionals in the U.S. and Germany, recruited primarily through social media.

Stage 6: Survey items were pre-coded and used a 7-point Likert scale to encourage nuanced, anonymous responses and minimize method bias. Stage 7: The instrument was reviewed by Subject Matter Experts and piloted with 14 IT professionals to enhance clarity and validity.

Stage 8: The survey was self-administered online to accommodate participant diversity and ensure quality and anonymity (Fowler, 2009). Stage 9: The survey was implemented with Qualtrics^{XM}, providing secure, device-agnostic participation and meeting privacy standards (Qualtrics, 2023).

Stage 10: Data were coded automatically for efficient analysis, with closed questions supporting response range and anonymity (Brace, 2013). Stage 11: Analysis commenced after data collection, and findings were prepared for dissemination to stakeholders and publication.

5. Results

Data analysis began with reviewing data collection and cleaning, highlighting the importance of participant demographics. The four RQs and Supporting Survey Questions (SSQ) were analyzed to evaluate survey items related to KHi, KHo, EK, TK, trust behavior, and KS.

5.1 Data Analysis

The data analysis section covers survey development, including validation by two SMEs and a pilot study with 14 experts. The SMEs improved clarity and consistency, while the pilot identified minor grammatical issues and recorded completion times ranging from 6:21 to 37:47.

A Qualtrics^{XM} close-ended survey investigated characteristics and motivators affecting organizational trust and TK sharing. After removing straightlining responses (Reuning & Plutzer, 2020), the sample decreased from 338 to 285 responses.

5.2 Findings

The following sections will detail the seven demographic inquiries. Additionally, a high-level overview of the SSQ that supports the survey's research questions will be discussed.

5.2.1 Demographic data

Participants were almost evenly split between Europe (50.55%) and North America (49.45%), with balanced gender representation (50.35% female, 49.65% male). The majority (61.5%) were aged 34–57, reflecting a fairly even age distribution.

Participants came from 16 industries, mainly Information Technology (28.8%), Office & Administrative (10.5%), Healthcare (10.2%), and Education & Training (10.0%). Most held a college degree, with 74.4% earning a bachelor's or master's.

The majority of participants (73.7%) had over 11 years of work experience. Ethnically, 59% of respondents identified as Caucasian, with the remaining 41% representing a diverse range of ethnicities. This combination of experience and diversity was beneficial in providing valuable feedback on the survey study.

5.2.2 Supporting survey questions

Survey questions were classified as Low Perception (LP) or High Perception (HP) by comparing their mean scores to the weighted average ($\bar{x}$). Scores below the average were LP; those at or above were HP, enabling trend identification without discounting other responses.

The SSQ for RQ1 for Table 1 assessed participants' comprehension of KHi, KHo, and KS. It also explored their perspectives on coworkers' related behaviors with a weighted mean of 3.71.

Table 1: RQ1 SSQ

Question	$\bar{x}$	Decision
1) How familiar are you with the concept of KS in the workplace?	5.87	HP
2) How familiar are you with the concept of KHi in the workplace?	4.66	HP
3) How familiar are you with the concept of KHo in the workplace?	4.84	HP
4) How aware are you of coworkers choosing not to KS?	4.83	HP
5) How aware are you of coworkers choosing to partially KS?	5.09	HP
6) Coworkers may withhold knowledge because they consider you a threat.	4.57	HP
7) Coworkers withhold knowledge from you because of personality differences.	4.44	HP

Question	$\bar{x}$	Decision
8) Coworkers KHo because they don't want you to succeed on a task or project.	3.94	HP
9) Have you ever refrained from KS with a coworker due to personality differences?	2.02	LP
10) When asked a question by a coworker, I respond to suit my needs or outcome.	2.69	LP
11) I keep what I am working on private from coworkers until an appropriate time to KS.	2.84	LP
12) I keep documents and/or resources from coworkers to maintain control of knowledge.	2.91	LP
13) I keep innovative achievements to myself until I can receive recognition.	2.17	LP
14) I choose not to let coworkers know all that I know, even if it could help the coworkers or the organization.	1.94	LP

The SSQ for RQ2 in Table 2 assessed EK and TK comprehension, with most responses indicating a HP for KS upon request. Using the weighted average method, RQ2's SSQ achieved an overall weighted average of 5.22).

Table 2: RQ2 SSQ

Question	$\bar{x}$	Decision
15) I share EK when requested.	6.13	HP
16) I share TK when requested	5.71	HP
17) I share TK with coworkers when it is reciprocated.	5.16	HP
18) I would help coworkers tackle their issues in the workplace using my TK if compensated through rewards, bonuses, or acknowledgments.	4.53	HP
19) Sharing EK will elevate my status within the workplace	4.79	HP
20) Sharing TK will elevate my status within the workplace.	4.92	HP
21) Sharing TK will gain me more acceptance among coworkers.	5.19	HP
22) Sharing EK increases my competitive advantage in the workplace.	4.58	LP
23) Leadership knows I possess TK useful for solving problems.	5.54	LP
24) Coworkers know I possess TK useful for solving problems.	5.66	LP

Table 3 outlines the SSQs on KHi, KHo, and TK withholding reasons. Applying the weighted average method from prior analysis, RQ3's overall average is 3.98.

Table 3: RQ3 SSQ

Question	$\bar{x}$	Decision
25) Time is a factor when choosing not to share TK with coworkers.	4.66	HP
26) A lack of trust in coworkers is a factor when choosing not to share TK.	4.54	LP
27) Understanding the power of knowledge is a factor when choosing not to share TK with coworkers	4.32	HP
28) Individuals who possess TK choose not to KS with coworkers.	3.99	HP
29) Trust of coworkers is a factor when choosing not to share TK.	3.28	LP
30) There is not an advantage in sharing TK with coworkers.	2.97	LP
31) There are no negative consequences for not sharing TK with coworkers.	3.28	LP
32) The decision not to share TK can often be influenced by a feeling of importance or power.	4.79	HP

Table 4 outlines factors motivating trust in TK sharing. Applying the weighted average method from prior analysis, RQ4's overall average is 5.27.

Table 4: RQ4 SSQ

Question	$\bar{x}$	Decision
33) I share relevant TK with coworkers based on their abilities in the workplace.	4.81	LP
34) I share relevant TK with coworkers who are perceived as being credible in the workplace.	5.20	LP
35) I share relevant TK with coworkers who have high standing in the workplace.	4.98	LP
36) I share relevant TK with coworkers who lack knowledge but are sincere in their request.	5.63	LP
37) I show goodwill in sharing relevant TK with coworkers after evaluating their sincerity and potential skill set.	5.36	HP
38) I share relevant TK with coworkers who possess subject matter expertise in the workplace.	5.51	HP
39) I share relevant TK with coworkers who possess exceptional credentials in the workplace.	5.25	LP
40) I share relevant TK with coworkers who are perceived as subject matter experts qualified to share TK.	5.45	HP

6. Discussion

This section discusses the RQs, implications, limitations, and future research from a study of 285 participants. Participants used the Qualtrics^{XM} platform, contributing KM and KS expertise through writing, problem-solving, and reviewing.

6.1 Research Question 1

The primary objective of RQ1 was to assess participants' understanding of KHi and KHo behaviors in the workplace. Through 14 questions, participants reported their familiarity with these behaviors among coworkers. Analysis of SSQs 1–3 in Table 1 showed strong comprehension of KHi, KHo, and KS occurrence.

For SSQ (4-8) revealed HP of coworkers withholding information, often due to personality conflicts or perceived threats. This aligns with KHo behaviors (Bilginoğlu, 2018) and consistent with Psychological Ownership Theory's link to knowledge protection (Ali & Sagsan, 2021).

Participants frequently perceived coworkers KHi and KHo information due to threats or conflicts but reported rarely exhibiting such behaviors themselves. Responses to SSQ (9–14) linked withholding to obstructing others' success, with high coworker awareness despite low self-reported KHi/KHo.

6.2 Research Question 2

For SSQ (15–24) in Table 2 assessed EK and TK understanding, revealing high willingness to share upon request. However, SSQs (17–22) had lower means than the overall average, likely skewed by SSQ 15 and 16's high Likert ratings.

Survey participants reported that reciprocating KS is easier when others share their EK or TK first (15, 16, 17). This supports Social Exchange Theory (SET), which suggests that EK and TK sharing becomes more reciprocal as workplace relationships develop (Singh, 2019).

Many participants viewed sharing EK and TK favorably (19–21), citing financial benefits, status elevation, workplace acceptance, or competitive advantages. Oliveira et al. (2021) further analyzed the KHi and KHo causal relationship.

Participants in SSQs (23 & 24) felt coworkers and leadership recognized their valuable TK. In contrast, SSQs 18 and 22 responses showed low perception of sharing EK driven by rewards, recognition, or competitive advantage.

6.3 Research Question 3

The SSQs (25–32) in Table 3 examined KHi, KHo, and TK withholding reasons. Most participants agreed that tight schedules hinder TK sharing (25), while 28 revealed many withhold TK intentionally.

The SSQs 27 and 32 revealed strong agreement that TK ownership confers power. Tian et al. (2021) assert knowledge inherently grants power, enabling bargaining leverage in organizational decisions, aligning with TK owners' recognition of this dynamic.

The four LP SSQ identified trust, advantage, and consequences as key factors. The results of SSQ 26 and 29 highlighted distrust in coworkers, aligning with Arain et al. (2020) on SET triggered distrust cycles from KHi. Responses to 30 and 31 reflected perceptions of no TK sharing advantage and minimal withholding consequences.

6.4 Research Question 4

The SSQs 33–40 in Table 4 analyzed trust factors in TK sharing, showing split LP and HP responses. In Q33 there was a willingness to share TK regardless of coworkers' abilities, aligning with Gubbins and Dooley's (2021) "in-group" sharing pattern. For SSQ 34 and 35 the LP ratings suggested TK sharing persists regardless of rank if some association exists.

The final LP question (39) assessed whether TK holders share only with coworkers of exceptional ability (Chowdhury, 2005). Results showed a LP, indicating ability is not a strict barrier to receiving TK. However, the mean score of 5.25-close to the weighted average of 5.27-suggests some TK holders may prefer sharing with highly qualified coworkers.

For SSQs 36 and 37 it showed TK sharing willingness via BBT (extended to "out-groups" valuing sincerity), balanced by CBT and CoBT in SSQ 38 and 40. Responses for 36 participants shared TK within "in-groups" (ABT), while SSQ 37 confirmed sharing with skilled coworkers when requests are sincere.

Reponses to SSQ 38 (CBT) and 40 (CoBT) responses showed strong TK sharing willingness with capable SMEs (Levin & Cross, 2004), though exceptional credentials alone were not major factors.

6.5 Implications

Participants recognized KHi, KHo, KS, EK, and TK behaviors. While TK-related withholding was rare (driven by time/trust issues), EK/TK sharing occurred when requested, motivated by status and credibility. Denials of withholding for personal gain accompanied sharing upon recognition and explicit requests.

Trust behaviors significantly influenced TK sharing, with ABT encouraging sharing with skilled coworkers and BBT motivating sharing with sincere, even less knowledgeable, requesters. Participants typically shared TK with recognized SMEs, though some were neutral. Consistent with Chowdhury (2005), strong personal connections (i.e., ABT) could override tendencies of KHo, highlighting trust as a key enabler.

The final implication stresses informing leadership about KHi and KHo's negative effects and how coworker trust impacts KS. Active knowledge withholding was evident, with Andreeva and Zappa (2023) linking collaboration to enhanced trust, communication, and innovation opportunities.

6.6 Theoretical Limitations

The study clarifies differences between KHi and KHo, showing both harm trust, collaboration, and performance. It highlights that TK is especially hard to share, challenging traditional KM models. Findings reveal trust is multi-dimensional (i.e., ABT, BBT, CBT and CoBT) and central to KS, KHi, and KHo.

Motivations like fear, self-protection, and lack of trust drive these behaviors, linking intentions to outcomes. The study suggests KM theories should be refined to address TK's complexity, diverse trust forms, and the interplay of individual, relational, and organizational factors.

6.7 Limitations

Although this study included a diverse sample, its cross-sectional design shares the theoretical limitations discussed earlier, capturing only a single moment and missing leadership's impact on trust and knowledge sharing. Longitudinal research is needed to better understand how leadership influences KHo, KHi, EK, and TK sharing over time.

In-person interaction was limited, but about 18% of participants contacted the principal investigator to share insights. An open-ended survey might have captured richer qualitative data on workplace knowledge dynamics.

6.8 Future Research

Future research should 1) consider using use longitudinal studies and in-person surveys to data over time and offer deeper insights into KM dynamics and leadership influence on TK; 2) utilize one-on-one discussions to enrich the analysis of KHo, KHi, and TK sharing, despite the topic's sensitivity; and 3) concentrate on TK sharing and the KHo and KHi behaviors occurring among employees, supervisors, and organizational leadership.

Ethics declaration: This research required ethical clearance, which was granted by Nova Southeastern University's Institutional Review Board.

AI declaration: The authors confirm no AI tools were used; only Grammarly and Copilot were used for grammar validation.

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Organizational Wisdom Elements: How Does it Work in the Organization?

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Abstract: This article aims to develop a comprehensive compilation of knowledge-related activities recognized in the literature as components of organizational wisdom. Contemporary organizations acknowledge that knowledge is the foundation of their development; however, the extensive theoretical framework concerning knowledge management processes often remains unclear to practitioners. We propose a new perspective on knowledge management processes, presented through the lens of organizational wisdom, understood as a mechanism for transforming employees' knowledge into organizational success. We conducted a systematic literature review using the SCOPUS and WOS databases, selecting papers for analysis describing theoretical and empirical organizational wisdom models. Applying methodological rigor, we analyzed these models and identified 24 elements, which we theoretically and practically defined, indicating specific activities within organizations. Our findings hold significant implications for scientific development. The added value of this study lies in developing a classification of 24 elements that organize and systematize the existing body of knowledge on the components of organizational wisdom. The research results are also relevant to practice, as they enable managers to understand which knowledge processes are essential for fostering organizational wisdom and managing wise organizations.

Keywords: Wisdom, Organizational wisdom, Wisdom model

1. Introduction

In pursuit of value creation, contemporary enterprises increasingly emphasize the growing importance of intangible resources such as knowledge, experience, and organizational wisdom (Czerniachowicz, 2016). Research indicates that organizations that effectively manage intangible assets in the context of dynamic changes in the business environment are more likely to achieve competitive advantage (Bontis, 1998; Nahapiet & Ghoshal, 1998). In a knowledge-based economy, traditional resources give way to an organization's ability to process information and make sound strategic decisions effectively (Pinheiro et al., 2012). Many authors often equate this capability with the concept of organizational wisdom (OW).

Despite the growing interest in this topic, the literature has not yet established a single, universally accepted definition of OW. Existing definitions vary, which complicates the operationalization of the concept. For example, Guo et al. (2017) define wisdom as the highest level in the knowledge hierarchy comprising data, information, knowledge, experience, and wisdom. Ramanauskas and Benevicius (2021) associate OW with specific characteristics of organizations, whereas Rowley (2006) reduces it to the ability to make appropriate decisions.

Given these conceptual divergences, there is a clear need for terminological and conceptual clarification of this phenomenon. Addressing the identified gap concerning organizational wisdom's components is essential for further developing scholarly research and a more comprehensive understanding of the phenomenon in theoretical and practical contexts. This article aims to identify and organize existing knowledge on the constituent elements of organizational wisdom. The following research question was posed to achieve this goal: What are the constituent elements of organizational wisdom models?

Due to the phenomenon's complexity and the multiplicity of its conceptualizations, a systematic literature review (SLR) was selected as the primary method of data analysis. Researchers widely use SLR to synthesize evidence and identify knowledge gaps (Farrukh & Sajjad, 2023). The SLR covered Scopus and Web of Science databases to ensure data heterogeneity. The very limited number of texts describing specific models of organizational wisdom effectively addressed the commonly noted drawback of SLR, its time-consuming nature (Booth, 2016). The synthesis of knowledge extracted through the SLR was conducted using thematic analysis, which allowed for the identification of three key groups of organizational wisdom elements. The undertaken study synthesizes existing knowledge and highlights contemporary key areas in which components of organizational wisdom have been identified.

2. Literature Review

The concept of wisdom is not new. It has long been explored in philosophical discourse (Izak, 2013), within the field of psychology (Sternberg, 1998), and in the management literature (Malan & Kriger, 1998). Pinheiro et al. (2012) argue that wisdom is not merely a philosophical concept but also a psychological phenomenon, allowing for a comprehensive understanding of wisdom as the capacity to make sound judgments and decisions based on knowledge and ethical considerations. To define the components of organizational wisdom models, it is helpful to examine the conceptual background and highlight key wisdom principles rooted in Hellenistic philosophy. These include the timeless principle of passing on wisdom and engagement in the common good, as derived from Socrates. Socrates emphasized the necessity of knowledge, skills, and judgment in governance, all directed toward the common good (Osbeck & Robinson, 2005). Plato introduced the idea of ethical reflection, going beyond mere accumulation of knowledge. He pointed to the harmony among the soul's virtues: reason, spirit, and desire as essential for wisdom. Aristotle further developed the idea of balance in applying wisdom, emphasizing that wisdom is not merely an intellectual exercise but a life experience that shapes ethical decisions and virtuous actions. While rooted in philosophy, this approach offers valuable insights for the study of organizations and management.

In contemporary discourse, wisdom is increasingly considered a key factor for organizational success. Radaelli and Sitton-Kent (2016) argue that wisdom enables individuals to approach problems from a broader perspective, contributing to more effective organizational outcomes. Leadership (i.e., managerial wisdom) is a leader's competence to act virtuously, discern new meanings in knowledge, and interpret it holistically (Malan & Kriger, 1998). Since the seminal study by Bierly et al. (2000), many scholars have viewed organizational wisdom as the application of knowledge rooted both in the Organization and revealed through practical experiences and actions. Nielsen et al. (2007) highlight that team wisdom is essential for resolving conflicts arising from competing priorities among team members and effectively managing their skills and knowledge.

From a process perspective, organizational wisdom includes the collection, transfer, and integration of individual wisdom (knowledge processes), as well as the use of institutional and social processes (e.g., organizational structure, culture, leadership) to support strategic decision-making (Kessler, 2006). This processual approach emphasizes the dynamics of developing and applying wisdom within organizations. It encompasses knowledge sharing, decision-making practices, and integrating ethical dimensions into organizational behavior (Pinheiro et al., 2012; Becker et al., 2017).

The competency-based approach highlights the need for individuals and teams to develop specific skills such as critical thinking, emotional intelligence, and ethical reasoning to foster the emergence of wisdom in organizational settings (Vitari & David, 2017; Vasconcelos, 2021). Both perspectives highlight the crucial role of continuous learning and adaptive capabilities in addressing complex managerial challenges.

However, despite their value, the processual and competence-based approaches fail to clarify how wisdom can be effectively managed and shaped within organizations. They do not provide clearly defined, measurable elements that allow this construct to be practically applied.

The resource-based approach offers valuable insights into which components may constitute organizational wisdom. It assumes that tangible and intangible organizational resources are key in shaping a company's ability to apply wisdom. For instance, integrating local wisdom and cultural values can significantly influence organizational behavior and decision-making processes (Radaelli et al., 2016; Mann et al., 2017).

In identifying the elements of organizational wisdom, one cannot overlook spiritual and ethical dimensions. Rocha et al. (2022) and Kodama (2021) emphasize the role of wisdom in knowledge management, suggesting that organizations must reconcile social, environmental, and economic goals to meet the diverse needs of stakeholders. This view aligns with the notion that wisdom is not purely cognitive but also encompasses ethical and spiritual dimensions that shape decision-making processes and organizational practices (Pierścieniak & Stelmaszczyk, 2020; Spiller et al., 2011).

Empirical studies on Māori organizational culture provide a compelling illustration. They highlight the role of values in managing Māori enterprises (Durie, 2001), integrating economic objectives with broader well-being. The concept of kaitiakitanga (guardianship leadership) introduces two critical contributions: first, it provides an indigenous Māori perspective on management that can help organizations transcend traditional Western paradigms (Bolman & Deal, 1995, p. 39); second, it creates a space for integrating organizational wisdom by bridging indigenous and Western viewpoints.

Another example of value-driven management is the governance model of Islamic Financial Institutions (IFIs), which is grounded in Sharia law. Research on wisdom in Islamic banking emphasizes the importance of the Shari'a Supervisory Board (SSB). Sharia regulations define principles for resource allocation, management, production, consumption, capital market activity, and the distribution of income and assets. The SSB has the right to participate in board meetings to discuss religious aspects of decision-making (Nathan & Ribière, 2007).

A further category that emerges in fragmented studies on wisdom involves the values held by internal and external stakeholders. In a large-scale study of American firms, Kotter and Heskett (1992) found that companies with strong organizational cultures based on shared values achieved significantly better results than those without such cultures. Researchers emphasize values as the foundation for guiding business behavior and decision-making (Hofstede & Hofstede, 2005; Kotter & Heskett, 1992; Senge et al., 2004). Integrating values, including religious and cultural values, can facilitate decision-making that considers social, environmental, and economic well-being, thus embodying wisdom in the organizational context.

3. Research Methodology

To address the research problem and answer the research questions posed, the method of systematic literature review was chosen. This approach enabled a reliable analysis of the current state of knowledge (Czakon, 2015). The systematic analysis of the components of various OW models was based on scholarly articles indexed in the prestigious Scopus and Web of Science (WOS) databases. The selection of these two databases was justified by their international reputation, broad temporal scope, and the richness of publications in the fields of business, management, and economics, which ensured the high quality and credibility of the data collected.

The same search strategy was applied to both databases, encompassing predefined publication selection criteria. These included database sources, time range, language, publication type, and thematic areas. The detailed selection criteria and the search strategy are presented in Table 1.

Table 1: Search strategy

Position	Scopus	WoS
Key Words	"Organizational wisdom" OR "wisdom of an organization" OR "wisdom in an organization" OR "wisdom of organization" OR "wisdom in organization"	
The 1 level of inclusion criteria	Publication year: All years Document type: Article Language: English	
The 2 level of inclusion criteria	Scopus – Subject area: All - (nS=36) Web of Science – Categories: All – (nWob=32)	
The 3 level of exclusion criteria	Files cleaning (17 duplicate records removed) Abstract analysis (40 files deleted)	
The 4 level of exclusion criteria	Full text analysis (3 Files deleted)	
Final sample	N=(36+32)-(17+40+3)=8	

As a result of the adopted criteria, 36 records were retrieved from the Scopus database and 32 from the Web of Science. Among the 68 scientific articles, 17 duplicates were identified and removed. In addition, publication abstracts were analyzed to assess their relevance to the research objectives, and 40 more articles were excluded. The key exclusion criterion in this case was the absence of any reference to an OW model or its components.

Following the abstract analysis, 11 papers were selected for full-text analysis. Ultimately, 8 papers were retained for the study as they contained content describing OW elements. Of these, three articles were published more than a decade ago, while the remaining were published in 2019 (two articles), 2021 (two articles), and 2022 (one article). Regardless of whether they focused explicitly on OW models, the number of studies on wisdom in organizations appears to be increasing.

Content analysis of the selected articles began with identifying and extracting all elements of OW models mentioned by the authors. In total, 56 elements were identified, each assigned a definition or source description from the analyzed texts. Excel software was used to organize the collected material (functions and pivot tables). The initial analysis revealed inconsistencies in terminology and varying levels of generality among the elements.

Therefore, the researchers applied qualitative thematic analysis to analyze and identify common patterns among the reviewed OW models. This method was chosen for its flexibility and suitability for identifying patterns within and across data sets in relation to experiences, perspectives, behaviors, and practices (Clarke & Braun, 2016). It allows the analysis of various sources (e.g., theoretical and empirical research), providing a systematic and accessible procedure for generating codes and themes from qualitative data.

The first step of the procedure involved generating preliminary codes, brief, descriptive labels closely linked to the content of the OW model descriptions. These codes helped organize the data into meaningful units but were not yet complete themes, which are broader and may encompass several codes (Riger & Sigurvinsdottir, 2016).

After identifying the codes, they were grouped into potential themes. Theme organization may vary. The literature suggests hierarchical structures with main themes, subthemes, or networks of interrelated ideas (Attride-Stirling, 2001). This study selected themes related to the examined domain, representing concepts from knowledge management, organizational management, and human capital.

The essence of this stage was to create logical groups of codes according to a defined key or schema. After identifying potential themes, a review was conducted to ensure they accurately reflected the data content. The themes were refined, clearly explained, and then redefined and named. These actions led to the development of a final catalog of 24 OW elements, ensuring the consistency of the entire research process.

4. Findings

As a result of the research, a final list of 24 elements appearing in the examined models was obtained. These were then organized into three categories: knowledge management, organizational management, and human capital management. The first and largest group of elements identified in OW models relate to knowledge management (Table 2). These include knowledge absorption processes: acquisition and accumulation, adaptation and assimilation, transformation and utilization. Also included are learning and knowledge-sharing processes that concern the development of employees' skills and competencies and knowledge resources that serve as a foundation for the processes mentioned above. Including knowledge absorption, learning and sharing processes, and knowledge resources within the knowledge management (KM) category creates a logical structure of elements associated with this domain.

Table 2: Elements of Organizational Wisdom Models in the Area of Knowledge Management

OW Element and Organizational Action	Source
KM1. Acquisition and Accumulation The ability to identify and collect external knowledge such as customer feedback and market insights to update and guide organizational activities.	(Bierly et al., 2000; Pinheiro et al., 2012; Scott-Kennel & Von Batenburg, 2012; Stelamszyk et al., 2021)
KM2. Adaptation and Assimilation Integrating and applying new knowledge through smooth information flow integration with experience supports decisions and creates knowledge-based synergy.	(Akgün et al., 2019; Bierly et al., 2000; Pinheiro et al., 2012; Scott-Kennel & Von Batenburg, 2012; Stelamszyk et al., 2021)
KM3. Knowledge Transformation A process of analyzing and structuring new knowledge to convert it into a usable form within the Organization.	(Scott-Kennel & Von Batenburg, 2012; Stelamszyk et al., 2021)
KM4. Knowledge Utilization The use of knowledge to support prototyping, experimentation, and continuous improvement of methods and technologies.	(Bierly et al., 2000; Scott-Kennel & Von Batenburg, 2012; Ahmadi et al., 2021; Stelamszyk et al., 2021)
KM5. Knowledge A key resource exists in various forms and enhances the company's ability to respond to change and make decisions.	(Pinheiro et al., 2012; Scott-Kennel & Von Batenburg, 2012; Ahmadi et al., 2021; Vasconcelos, 2022)
KM6. Knowledge Infrastructure Dynamic knowledge management mechanism that supports structuring and using information, measured by the ability to store, transfer, codify, and replicate knowledge.	(Pinheiro et al., 2012; Scott-Kennel & Von Batenburg, 2012)
KM7. Knowledge Configuration	(Cortez & Johnston, 2019)

OW Element and Organizational Action	Source
The balance of different knowledge types is essential for ensuring continuous development and innovation.	
KM8. Learning Processes Processes of developing employee competencies through learning and innovation, supporting adaptation to changing market conditions.	(Bierly et al., 2000; Pinheiro et al., 2012; Scott-Kennel & Von Batenburg, 2012; Cortez & Johnston, 2019; Ahmadi et al., 2021; Stelamszyk et al., 2021)
KM9. Knowledge Sharing Coordinated knowledge-sharing processes that support cross-level transfer and foster understanding and collaboration across departments.	(Pinheiro et al., 2012; Scott-Kennel & Von Batenburg, 2012; Akgün et al., 2019; Cortez & Johnston, 2019; Stelamszyk et al., 2021)

Effective knowledge management within an organization is based on integrated processes of acquiring, processing, structuring, and utilizing knowledge, both internal and external.

This facilitates a seamless flow of information, integrating new knowledge with experience and informed decision-making. Coordinated activities, such as interdepartmental knowledge transfer or the incorporation of customer feedback, support innovation, developing employee competencies, and the Organization's adaptive capacity. A balance between different types of knowledge and a robust knowledge management infrastructure enhances flexibility, encourages experimentation, and enables continuous improvement of operational methods, which translates into long-term competitive advantage.

The second group of identified elements in OW models comprise those related to the organizational management process (Table 3). The organizational management (M) category includes relational capital, which encompasses interactions with stakeholders (such as customers, suppliers, and employees), organizational culture and values, i.e., how employees perceive values and behaviors within the Organization as well as the cultural and historical context, which also plays a significant role in shaping organizational strategies. The management category encompasses organizational processes, structure, decision-making, strategic management, and market and customer orientation. Relational capital, organizational culture, cultural context, organizational structure, and strategy are inextricably linked and collectively influence the effectiveness of organizational performance.

Table 3: Elements of Organizational Wisdom Models in the Area of Management

OW Element and Organizational Action	Source
M1. Relational capital Collaboration with customers enables understanding the market, adapting products to client needs, and acquiring location-specific knowledge. Key elements are intermediaries between external clients and the company's internal knowledge resources.	(Pinheiro et al., 2012; Scott-Kennel & Von Batenburg, 2012; Vasconcelos, 2022)
M2. Organizational Culture and Values A system of shared meanings, norms, and beliefs that shape members' attitudes, behaviors, and values. Crucial to this is the alignment between the values held by employees and management.	(Akgün et al., 2019; Bierly et al., 2000; Pinheiro et al., 2012; Ahmadi et al., 2021)
M3. Cultural and Historical Context The ability to reflectively draw on traditions and wisdom from a cultural-historical perspective.	(Akgün et al., 2019)
M4. Decision-Making and Flexibility Contextual decision-making shaped by intuition, emotions, and sensory judgment rather than fixed rules.	(Akgün et al., 2019; Pinheiro et al., 2012; Ahmadi et al., 2021; Vasconcelos, 2022)
M5. Organizational Processes and Structure A structured system of activities built on operational regularity, including specialization, hierarchy, control span, centralization, and formalization.	(Bierly et al., 2000; Pinheiro et al., 2012)
M6. Strategic Management A long-term approach to organizational leadership based on vision, mission, and stakeholder trust, focused on improvement, market adaptation, and innovation.	(Pinheiro et al., 2012; Vasconcelos, 2022; Cortez & Johnston, 2019; Bierly et al., 2000)
M7. Market and Customer Orientation The ability to swiftly and effectively meet customer needs, solve problems, and adapt to market and competitive changes.	(Pinheiro et al., 2012)

Management processes within organizational wisdom models represent a combination of a strong organizational culture, a flexible decision-making structure, and close collaboration with customers.

A system of shared values, norms, and beliefs shapes employee attitudes, supports learning, communication, and shared responsibility, and its alignment with managerial actions strengthens internal engagement. Decisions are made contextually, incorporating intuition and emotions, enhancing actions' appropriateness in complex situations. A well-organized operational structure and strategic management guided by vision and mission enable rapid response to change and the implementation of innovations. Customer relations also play a pivotal role. A notable example is the role of sales representatives as intermediaries of market and local knowledge, allowing for better adaptation of offerings to individual needs and effective responses to competition.

Human capital management is the last identified element category (Table 4). Within this category, we aggregated the competencies of organizational members, including social, professional, personal, ethical, cognitive, strategic, and leadership competencies, as well as employee attitudes. Additionally, this category includes elements related to people management processes, such as organizational motivators, employee relations, and the resolution of workforce-related issues.

Table 4: Elements of Organizational Wisdom Models in the Area of Human Capital Management

OW Element and Organizational Action	Source
HRM1. Social and Professional Competencies The ability to communicate effectively, sensitivity to the needs of others, and the capacity to acquire new knowledge through social interactions. Strong domain knowledge regarding the Organization's operations and the ability to act effectively.	(Scott-Kennel & Von Batenburg, 2012; Ahmadi et al., 2021; Akgün et al., 2019)
HRM2. Personal and Ethical Competencies The ability to apply universal ethical principles in complex and ambiguous professional situations. Awareness of the importance of ethics and the capacity for sound ethical judgment.	(Ahmadi et al., 2021; Akgün et al., 2019)
HRM3. Cognitive and Strategic Competencies The ability to effectively absorb, identify, evaluate, and transfer knowledge relevant to the Organization.	(Scott-Kennel & Von Batenburg, 2012; Ahmadi et al., 2021)
HRM4. Employee Attitudes Employees' ability to independently assess what is good and beneficial for themselves and the Organization. Includes behaviors, collaboration, engagement, and self-confidence.	(Pinheiro et al., 2012; Ahmadi et al., 2021; Akgün et al., 2019)
HRM5. Leadership Competencies The ability to communicate expectations and articulate goals simply and understandably. An effective leader inspires through message clarity, action consistency, and the ability to give shared efforts meaning.	(Bierly et al., 2000)
HRM6. Organizational Motivators Elements that encourage employees to use their industry knowledge and information. Support for employee development, talent retention, and consideration of employee needs.	(Pinheiro et al., 2012; Bierly et al., 2000; Stelamszyk et al., 2021; Ahmadi et al., 2021)
HRM7. Employee Relations The quality of interactions between management and staff. Characterized by honest communication, individualized attention to employees, and the display of personal care.	(Pinheiro et al., 2012; Bierly et al., 2000)
HRM8. Resolving Employee Issues The Organization's ability to identify employees' personal difficulties and provide support in overcoming them.	(Pinheiro et al., 2012)

5. Discussion and Conclusions

Models of organizational wisdom are grounded in elements whose origins can be traced to the domains of knowledge management, organizational management, and human resource management. The analysis conducted identifies these three areas as key sources of organizational wisdom. This finding reinforces the widely held belief that people, their human capital, are the true drivers of organizational success (Doong et al., 2010). The study results also emphasize the importance of principles and rules identified within the field of organizational management.

The elements identified in organizational wisdom (OW) models include process-related components, such as knowledge processes, learning, and organizational processes, and those connected to people management. They also encompass competency-based and resource-based components. Thus, organizational wisdom emerges as a multidimensional research area integrating cognitive, organizational, and social issues. The identified elements vary in type (resources, competencies, processes) and origin (knowledge, Organization, people). These elements and their appropriate configuration become the source of synergy in the Organization's accumulated knowledge. This phenomenon aligns with the resource-based view (Sajdak, 2010) and with definitions of strategic resources (Barney, 1991). Such an approach offers a novel perspective for studying organizational effectiveness and performance, where it is not the quantity of individual components but their optimal configuration that determines the actual value of wisdom. Knowledge, its application, organizational functioning, and human capital, including the attitudes individuals bring, constitute a set of intangible assets that build organizational wisdom. Therefore, further research on intangible organizational resources, particularly attitudes, is warranted as the foundation of organizational and decision-making processes.

In summary, this study contributes to theory by being among the first to structure and synthesize previously fragmented knowledge on the elements of organizational wisdom. The synthesis has allowed for identifying key organizational domains that, in prior conceptualizations, have been highlighted as sources of wisdom components. The main findings relate to identifying two dimensions: (1) the key organizational domains and (2) the nature/identity of the components of organizational wisdom. It was established that organizational wisdom is not a set of homogeneous elements; rather, it constitutes a complex organizational capability. Its components, processes, competencies, and resources enable organizations to succeed. They originate from human resource management, knowledge management, and organizational management.

The issue under analysis also carries significant practical implications, extending beyond theoretical considerations. Studying the structures of organizational wisdom in terms of their application value can support enterprises in achieving sustainable competitive advantage and long-term development. Based on the research, organizations receive clear guidance on which elements constitute OW and, thus, which should be prioritized for development. The research most frequently highlighted the importance of knowledge acquisition, adaptation, and learning processes where organizations should focus their initial efforts.

Additionally, effective knowledge management requires the creation of an infrastructure that facilitates rapid information flow, using local knowledge (e.g., from sales representatives) and integrating data with experience and intuition. Strengthening employee and leadership competencies in substantive knowledge and communication, ethics, and leadership domains is crucial. The work environment should foster engagement, individualized approaches, and identifying and resolving personal challenges. Strategic decisions should be contextually grounded and made flexibly, which enhances the Organization's ability to respond to market changes and build a lasting competitive advantage.

Continued research on organizational wisdom models is particularly important today, where enterprises operate under constant flux driven by shifting goals and ecological, social, and economic challenges. Such a dynamic business environment demands that organizations be capable of responding swiftly and appropriately to change. Future research directions may include:

- The relationship between the configuration of OW model elements and organizational outcomes.
- The role of employee well-being in shaping organizational wisdom.
- Organizational wisdom in the context of hybrid and distributed teams.

Ethics Declaration: This research did not involve human participants; therefore, ethical clearance was not required.

AI Declaration: AI tools were not used during the preparation of this paper.

This research was funded in whole by National Science Centre, Poland; Grant number: 2023/49/B/HS4/01481. For the purpose of Open Access, the authors have applied a CC-BY public copyright license to any Author Accepted Manuscript (AAM) version arising from this submission.

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The Impacts of Generative AI Application on Employees' Creativity: The Mediating Role of Knowledge Management Activities

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Abstract: As generative artificial intelligence applications, such as ChatGPT, DeepSeek are widely used, the impacts of generative artificial intelligence on employees' creativity remains unknown. This study aims to investigate the relationship between generative artificial intelligence applications and employees' creativity as well as the role of knowledge management activities - namely knowledge acquisition, knowledge sharing, and knowledge application - in this relationship. Based on 350 employees' valid responses in China, the structural equation modelling was used to test the hypotheses and we find that generative artificial intelligence applications positively impact employees' creativity. Additionally, knowledge management activities mediate the relationship between generative artificial intelligence applications and employees' creativity. This study provides insights into the linkage between generative artificial intelligence and employees' creativity. This study enriches current knowledge by demonstrating how knowledge management activities mediate the relationship between generative artificial intelligence applications and employees' creativity—an underexplored area in prior research. It also assists us in understanding how generative artificial intelligence applications influence employees' creativity, thereby informing strategic decisions for organizations to utilize artificial intelligence while developing a creative workforce.

Keywords: Generative artificial intelligence, Employees' creativity, Knowledge management activities

1. Introduction

It is a wide belief that knowledge management (KM) technologies applications benefit organizational performance (Liu, Kianto, et al., 2023), which means that employees can use KM technologies to enhance organizational performance. With the rise of digital technologies, particularly generative artificial intelligence (GenAI), there is growing interest in whether GenAI can enhance employees' creativity. Employees' creativity is a vital driver of organizational innovation and growth, involving the generation of original and applicable ideas that lead to new products, services, or methods (Luu, 2022). GenAI, which produces novel content by learning from existing data (Brynjolfsson et al., 2025), offers immediate, human-like responses, potentially transforming creative processes. Unlike traditional digital tools that automate routine tasks, GenAI is seen as a catalyst for creative ideation. However, its long-term effects on creativity remain unclear.

Creative process theory suggests that GenAI may enhance absorptive capacity - the ability to identify and apply external knowledge (Zahra & George, 2002) - thereby fostering divergent thinking and creativity. Conversely, over-reliance on GenAI could reduce cognitive deepening, the in-depth analysis of information (Krämer, 2013), which is linked to convergent thinking and may hinder creativity. Employees with strong interpersonal skills may mitigate this by engaging in reflective discussions, enriching GenAI outputs, and preserving deep thinking.

Existing literature presents conflicting views. While GenAI can improve knowledge management (KM) by automating acquisition, sharing, and application (Nonaka, 1994), its effectiveness depends on human oversight to ensure critical evaluation and avoid passive acceptance (Haefner et al., 2020). KM activities thus mediate GenAI's impact, balancing automation with human agency to maximize creativity (Nonaka and Takeuchi, 1997).

This study explores the dual effects of GenAI on creativity, emphasizing the mediating role of KM. It provides theoretical insights and practical guidance for organizations to leverage GenAI effectively while fostering innovation.

2. Literature Review

Recent research highlights GenAI's role in enhancing workplace creativity by providing original ideas, automating repetitive tasks, and enabling strategic thinking (Rahman and Watanobe, 2023). Tools like ChatGPT assist in brainstorming and information synthesis, acting as catalysts for creative output (Liu et al., 2023). However, the direct impact of GenAI on creativity remains debated, with concerns about overreliance potentially stifling human innovation (Bahrini et al., 2023). Studies suggest GenAI can reduce cognitive load and offer new perspectives, yet its effectiveness depends on mediating factors like KM activities - knowledge acquisition (KA), knowledge sharing (KS), and knowledge application (KAP) (Jarrahi et al., 2022).

GenAI enhances KA by providing instant access to information and personalized learning (Sallam, 2023), which fosters engagement and creativity (Martin and Bolliger, 2018). For KS, GenAI facilitates real-time collaboration and multilingual communication, though its success hinges on organizational trust in GenAI outputs (Al-Emran et al., 2023). In KAP, GenAI supports problem-solving through tailored recommendations, but algorithmic biases may limit its effectiveness (Zhai, 2024).

The expectation-confirmation model (ECM) explains how continuous GenAI usage strengthens KM activities, ultimately boosting creativity (Bhattacherjee, 2001). Hypotheses propose (See Figure 1):

H1-H3: GenAI continuous usage positively affects KA, KS, and KAP. (Jarrahi et al., 2022).

H4-H6: KA, KS, and KAP each enhance creativity by exposing employees to diverse ideas and enabling practical implementation (Bolisani and Bratianu, 2017).

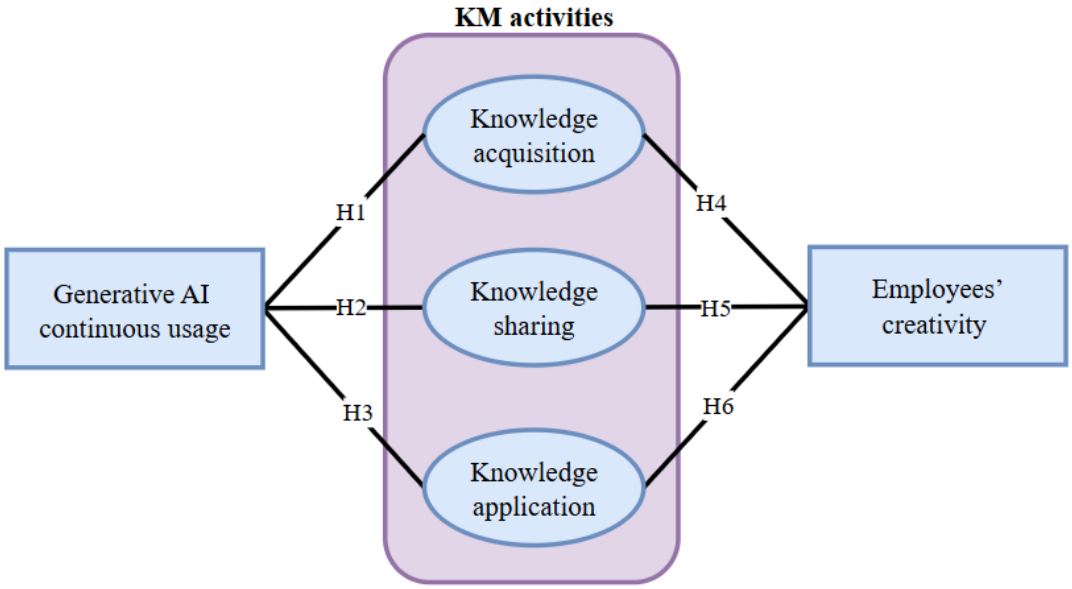


Figure 1: Theoretical model and hypotheses

3. Methods

3.1 Data Collection

A cross-sectional survey was conducted via the Credamo platform, collecting 397 responses. After removing 47 incomplete responses, the final sample included 350 employees with GenAI experience across various industries and company sizes. The sample distribution shows in Table 1:

Table 1: Demographic characteristics statistics

Question	Option	Frequency	Percentage
Number of employees	Less than 10	88	25.1
	10-100	93	26.6
	100-300	86	24.6
	More than 300	83	23.7
Whether it is a multinational company	Yes	180	51.4
	No	170	48.6

Data quality was ensured through attention-check questions and minimum response time requirements. Ethical considerations included informed consent and anonymity.

3.2 Measurement of Variable

The questionnaire measured five key constructs using validated multi-item scales adapted from prior research (see Table 2):

GCU: Measured intention to continuous using GenAI (3 items) (Wolf and Maier, 2024)

KA: Assessed AI' s role in facilitating knowledge gain (5 items) (Jarrahi et al., 2022)

KS: Evaluated AI-enabled knowledge exchange (5 items) (Sundaresan and Zhang, 2021)

KAP: Examined practical use of AI-derived knowledge (4 items) (Jarrahi et al., 2022)

Creativity: Captured innovative behaviors (3 items) (Sarooghi et al., 2015)

Table 2: Questionnaire scale item content

Scale	Item	Content	Source
GenAI continuous usage (GCU)	GCU1	You intend to continuously use GenAI in the future.	Adapted from (Ngo et al., 2024)
	GCU2	You intend to continuously use GenAI tools over other options.	
	GCU3	If you could, you would like to continuously use GenAI tools.	
Knowledge acquisition (KA)	KA1	GenAI application facilitates the process of KA from the working documents.	
	KA2	GenAI application facilitates the process of KA through discussions.	
	KA3	GenAI application allows you to generate a new knowledge based on your current knowledge.	
	KA4	GenAI application enables you to access to knowledge through various resources.	
	KA5	GenAI application helps you to gain the knowledge that suits your needs.	
Knowledge sharing (KS)	KS1	GenAI application permits you to share knowledge with your supervisors and colleagues.	
	KS2	GenAI application supports various types of discussions.	
	KS3	GenAI application facilitates the process of KS at any time anywhere settings.	
	KS4	GenAI application enables me to share different types of resources with your supervisors and colleagues.	
	KS5	GenAI application facilitates the collaborative learning process.	
Knowledge application (KAP)	KAP1	GenAI application provides you with immediate access to different types of knowledge.	
	KAP2	GenAI application allows you to apply your knowledge while working.	
	KAP3	GenAI application permits you to combine various types of knowledge.	
	KAP4	GenAI application can assist us in better handling of working documents within the company.	
Creativity	C1	You have the experience of trying or using new methods at work (methods not previously available in the company) to achieve work goals.	
	C2	You would actively express your ideas to your colleagues.	
	C3	You would be willing to take risks for innovative approaches at work.	

3.3 Data Analysis Method

The study employed a rigorous analytical approach to examine relationships between GenAI usage, KM activities (KA, KS, KAP), and employees' creativity. Descriptive statistics and normality tests (skewness < 3, kurtosis < 10) confirmed data quality. Reliability was strong (Cronbach's $\alpha > 0.7$).

EFA revealed a five-factor structure (71.34% variance explained, loadings > 0.7), and CFA validated the model with good fit indices. SEM with bootstrapping (5000 samples) confirmed KM activities as significant mediators between GenAI usage and creativity. This robust analysis supported all hypotheses.

4. Result

The study employed SEM for analysis. Before validation, descriptive statistics were conducted to assess sample characteristics and variable distributions using SPSS.

4.1 Descriptive Analysis

Descriptive statistics for all variables (N=350) confirmed normal distribution, with skewness (<3) and kurtosis (<10) within acceptable thresholds (Table 3). Mean scores ranged from 2.73 (KAP4) to 2.88 (C1), indicating consistent response patterns.

Table 3: Data quality test

	Minimum	Maximum	Mean	Standard Deviation	Skewness	Kurtosis
GCU1	1	4	2.7914	0.7374	-0.123	-0.339
GCU2	1	4	2.8086	0.73818	-0.196	-0.24
GCU3	1	4	2.8086	0.72644	-0.096	-0.365
KA1	1	5	2.8029	0.76341	0.039	-0.505
KA2	1	4	2.7543	0.76242	-0.099	-0.419
KA3	1	5	2.7886	0.71887	-0.033	-0.152
KA4	1	4	2.7971	0.71536	-0.058	-0.373
KA5	1	5	2.76	0.75671	-0.008	-0.318
KS1	1	4	2.76	0.6976	0.162	-0.607
KS2	1	4	2.7686	0.73834	0.01	-0.513
KS3	1	4	2.78	0.70215	-0.064	-0.298
KS4	1	4	2.7857	0.71602	0.012	-0.473
KS5	1	4	2.7771	0.70734	-0.093	-0.267
KAP1	1	5	2.7886	0.69866	0.062	-0.214
KAP2	1	4	2.7457	0.70684	-0.083	-0.253
KAP3	1	4	2.7543	0.71189	-0.083	-0.275
KAP4	1	5	2.7343	0.75756	0.008	-0.303
C1	1	4	2.8829	0.69422	0.006	-0.574
C2	1	5	2.8114	0.70111	-0.022	-0.119
C3	1	4	2.8086	0.69829	-0.075	-0.3

4.2 Reliability Analysis

All constructs showed high internal consistency (Cronbach's α > 0.7; corrected item-total correlations (CITC) > 0.5) (Table 2).

Table 4: Questionnaire reliability analysis table

Variable Name	Measurement Index	Corrected Item - Total Correlation	Cronbach's α after Deleting Item	Cronbach's α
GenAI continuous usage (GCU)	GCU1	0.682	0.813	0.845
	GCU2	0.719	0.778	
	GCU3	0.735	0.762	
Knowledge acquisition (KA)	KA1	0.732	0.872	0.894
	KA2	0.762	0.866	
	KA3	0.728	0.873	
	KA4	0.743	0.87	
	KA5	0.732	0.872	
Knowledge sharing (KS)	KS1	0.723	0.86	0.885
	KS2	0.725	0.86	
	KS3	0.712	0.863	

Variable Name	Measurement Index	Corrected Item - Total Correlation	Cronbach's α after Deleting Item	Cronbach's α
	KS4	0.711	0.863	
	KS5	0.741	0.856	
Knowledge application (KAP)	KAP1	0.672	0.821	0.853
	KAP2	0.661	0.826	
	KAP3	0.722	0.801	
	KAP4	0.72	0.801	
Creativity	C1	0.651	0.763	0.816
	C2	0.67	0.744	
	C3	0.68	0.733	
Total Scale		——	——	0.914

4.3 Validity Analysis

The exploratory factor analysis (EFA) revealed a 5-factor structure (71.34% variance explained; loadings > 0.7). The confirmatory factor analysis (CFA) confirmed excellent fit (χ^2/df = 1.03; the root mean square error of approximation (RMSEA) = 0.009; CFI = 0.999) and convergent validity (AVE > 0.5, CR > 0.7) (see Table 5).

Table 5:Convergent validity

Scale	Item	Standardized Factor Loading	AVE	CR	VIF
GenAI continuous usage (GCU)	GCU1	0.76	0.6474	0.8462	2.364
	GCU2	0.832			3.247
	GCU3	0.82			3.058
Knowledge acquisition (KA)	KA1	0.776	0.6275	0.8938	2.519
	KA2	0.819			3.04
	KA3	0.777			2.525
	KA4	0.8			2.786
	KA5	0.788			2.646
Knowledge sharing (KS)	KS1	0.772	0.6065	0.8851	2.475
	KS2	0.785			2.604
	KS3	0.764			2.404
	KS4	0.763			2.392
	KS5	0.809			2.89
Knowledge application (KAP)	KAP1	0.741	0.5928	0.8532	2.217
	KAP2	0.733			2.16
	KAP3	0.8			2.786
	KAP4	0.803			2.817
Creativity	C1	0.761	0.5962	0.8158	2.375
	C2	0.764			2.398
	C3	0.791			2.674

4.4 Hypotheses Testing

Following CFA, AMOS 26.0 was used to construct the SEM. Through statistical estimation, path coefficients and significance levels between latent variables were calculated to test the proposed hypotheses. The model's path diagram is showed in Figure 2.

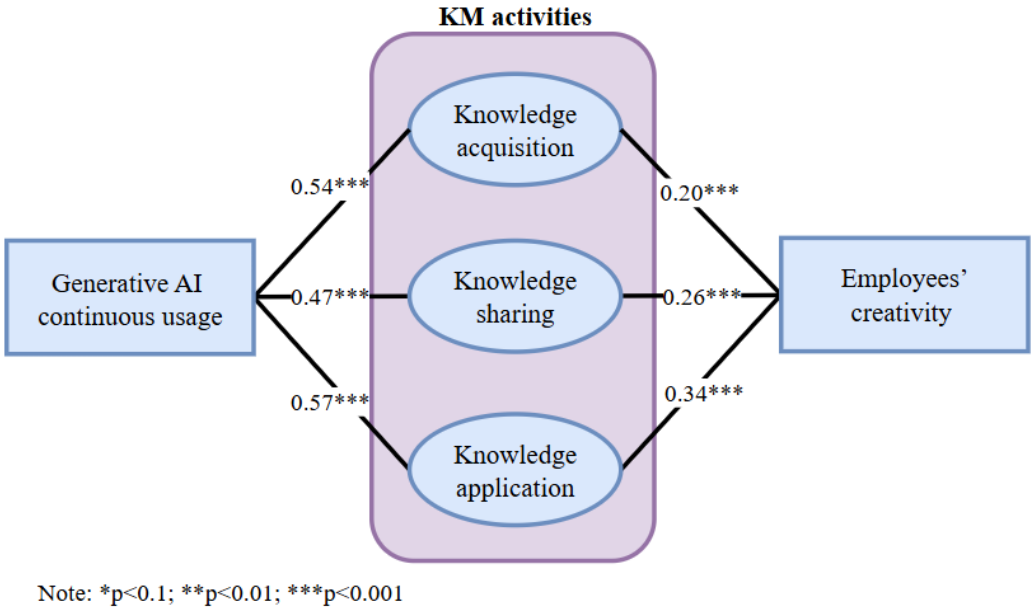


Figure 2: Test of structural model

The SEM results revealed significant direct effects of GenAI continuous usage on all three KM activities: KA (β = 0.541, p < 0.001), KS (β = 0.475, p < 0.001), and KAP (β = 0.565, p < 0.001). Furthermore, each KM activity positively influenced employees' creativity, with KAP showing the strongest effect (β = 0.344, p < 0.01), followed by KS (β = 0.256, p < 0.01) and KA (β = 0.202, p < 0.05). Crucially, bootstrap mediation analysis (5000 samples) confirmed that all three KM activities fully mediated the relationship between GCU and creativity, with KAP demonstrating the largest mediating effect (0.195, p < 0.001, 95% CI [0.115, 0.286]), followed by KS (0.122, p < 0.05, 95% CI [0.055, 0.197]) and KA (0.109, p < 0.05, 95% CI [0.036, 0.193]). These findings indicate that while GenAI usage significantly enhances all aspects of KM, its ultimate impact on creativity is most strongly realized through the practical application of knowledge in work tasks.

Table 6: Standardized coefficients and standard deviations of the path model

Path			Unstandardized Path Coefficient	Standardized Path Coefficient	S.E.	C.R.	P
GCU	→	KA	0.581	0.541	0.069	8.413	***
GCU	→	KS	0.463	0.475	0.062	7.428	***
GCU	→	KAP	0.524	0.565	0.063	8.38	***
KA	→	Creativity	0.174	0.202	0.052	3.327	***
KS	→	Creativity	0.243	0.256	0.058	4.2	***
KAP	→	Creativity	0.344	0.344	0.065	5.265	***

Note: Model fit indices: $\chi^2/df = 1.469$, RMSEA = 0.037, CFI = 0.979.

5. Discussion

This study provides important insights into how GenAI enhances employees' creativity through KM activities. The findings demonstrate that GenAI's continuous usage positively impacts creativity primarily by transforming three key KM activities: KA, KS, and KAP. As an intelligent knowledge infrastructure, GenAI fundamentally reshapes organizational workflows by efficiently synthesizing complex information (facilitating KA), enabling seamless collaboration (promoting KS), and providing context-aware support for practical implementation (enhancing KAP). Importantly, these KM activities mediate GenAI's effect on creativity through distinct mechanisms. While KA exposes employees to diverse information sources that stimulate divergent thinking, and KS integrates cross-functional perspectives to generate novel ideas, KAP emerges as the most influential factor by translating abstract knowledge into concrete innovations. This hierarchy of effects (KAP > KS > KA) aligns with absorptive capacity theory, emphasizing that applied knowledge generates the highest creative value. The study

confirms that KM activities fully mediate GenAI's impact on creativity, with particularly strong mediation through KAP, suggesting that GenAI's ultimate value lies in how organizations operationalize the knowledge it provides. These findings support Nonaka's knowledge creation theory (1994), highlighting that true innovation emerges from the dynamic interplay between knowledge exploration (through KA and KS) and knowledge exploitation (through KAP). For organizations, this means that while GenAI serves as a powerful enabler of knowledge activities, its creative potential is maximized when combined with structured approaches to KAP and knowledge implementation. The robust structural model validates these relationships, offering practical guidance for leveraging GenAI to foster workplace innovation while avoiding potential pitfalls of overreliance that might hinder deep cognitive engagement.

6. Conclusion

This study provides compelling evidence that GenAI significantly enhances employees' creativity through its transformative effects on KM activities. The findings demonstrate that GenAI's impact is fully mediated by three key KM activities - KA, KS, and KAP - with KAP emerging as the most influential pathway. This hierarchy of effects (KAP>KS>KA) offers important theoretical contributions by validating absorptive capacity theory in AI-augmented contexts and resolving previous contradictions in the literature. The research positions GenAI not merely as a tool but as a comprehensive knowledge infrastructure that reshapes organizational learning by simultaneously supporting knowledge exploration (through KA and KS) and exploitation (through KAP). A particularly valuable insight is the dual-path model showing that GenAI can either enable creativity through enhanced self-efficacy when properly implemented, or inhibit it through over-dependence when human oversight is lacking. For organizations, these findings suggest that simply adopting GenAI is insufficient - the greatest creative benefits come from building integrated human-AI systems that emphasize critical application of AI-generated knowledge. Practical recommendations include developing targeted training programs focused on KAP, creating collaborative platforms that combine GenAI capabilities with human expertise, and establishing organizational practices that balance GenAI assistance with independent thinking. While the study provides robust evidence for these relationships, future research should address limitations by employing longitudinal designs, examining additional KM activities beyond KA, KS, and, KAP, and developing more nuanced measures to distinguish human from GenAI contributions to creative outputs. Future studies may also examine the role of KM practices, such as KM leadership (Liu et al., 2018), KM strategies (Liu, Tsui, et al., 2023), and strategic KM (Liu et al., 2020), etc., in affecting the relationship between GenAI and employees' performance.

Acknowledgements

The authors appreciate the support from the Guangdong University Engineering Technology Research Center for Precision Components of Intelligent Terminal of Transportation Tools (No.2021GCZX002).

Ethics declaration: This study followed the ethical norms of academic study. The data used in this study were collected within a legal and ethical framework.

AI declaration: The AI tool was used for assistance in proof reading in this paper.

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Extending Institutional Isomorphism: Adaptive and Dynamic Dimensions in Green Policy Strategies in Knowledge Management Fields

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Abstract: Although DiMaggio and Powell's (1983) theory of organisational isomorphism suggests that organisations develop structural similarities under external pressures (coercion, mimetic and normative pressures), it is clear that this model cannot capture the dynamics shaped by digitalisation and ecological crises. To fill this theoretical gap, this study offers a new perspective by exploring the concepts of "adaptive isomorphism" and "dynamic isomorphism" in the context of green politics and knowledge management. Adaptive isomorphism stands for the ability of organisations to react flexibly to environmental regulations, market fluctuations and technological breakthroughs in the short to medium term. In this process, knowledge management systems form the backbone of organisational adaptation through concrete steps such as energy transition, resource optimisation and circular economy practises. Dynamic isomorphism represents a more radical transformation: It requires the reconfiguration of strategic vision and core business models in line with environmental sustainability goals. This approach is embodied by the continuous learning and evolution of organisations. The study extends DiMaggio and Powell's model by highlighting the integration of green strategies with knowledge management and the central role of both types of isomorphism in the processes by which organisations adapt to changing conditions, develop innovative strategies and achieve competitive advantage. Beyond the theoretical contributions, it offers a roadmap for organisations by providing concrete practical recommendations for sustainable transformation.

Keywords: Institutional isomorphism, Adaptive isomorphism, Dynamic isomorphism, Green policy strategies, Knowledge management

1. Introduction

The environmental and sustainability challenges in today's globalized world economic order are prompting businesses to re-blend within traditional structures and strategies, and to think in new ways and paradigms (Bansal & Roth, 2000). DiMaggio and Powell's (1983) model of institutional isomorphism explains how similar structures form between organisations through coercive, mimetic and normative pressure. However, today's rapidly changing environmental and technological dynamics show that aspects of this model that focus only on conformity to existing norms are inadequate and this idea cannot fully explain the rapid changes in the field of sustainability and is therefore criticised (Hoffman, 2001; Wijen, 2014). In particular, the complexity of environmental policy and the importance of appropriate information management (Nonaka, 1994) show that it is not enough for organisations to adapt only in the short term (adaptive isomorphism). They also need long-term, fundamental changes (dynamic isomorphism) (Teece, 2007).

This article takes DiMaggio and Powell's model one step further and add the concepts of 'adaptive' and 'dynamic' isomorphism. In this way, sustainability strategies are better linked to institutional theory. The main research question is: 'Why does the traditional isomorphism model fail to meet the diverse demands of green transformation and how can this gap be bridged by adaptive-dynamic integration?'

The literature shows that organisational convergence is limited to static norms (Scott, 2014), while sustainability-oriented transformations require dynamic capabilities (Teece, 2007) and knowledge-based learning processes (Argote & Miron-Spektor, 2011). Hart's (1995) "resource-based view" theory, for example, emphasises the integration of environmental strategies with an organisation's core competencies. However, it is not yet fully understood how this integration is shaped by mechanisms of organisational isomorphism.

This paper analyses the synergy of green policies with knowledge management (Grant, 1996) and institutional flexibility (Shrivastava, 1995) by distinguishing between adaptive isomorphism (short-term operational adjustment) and dynamic isomorphism (long-term strategic development). The proposed extended framework shows that instead of resisting homogenisation pressures (Oliver, 1991), organisations develop innovative heterogeneity (Padgett & Powell, 2012) to achieve environmental sustainability goals.

2. Theoretical Framework

Institutional isomorphism is a central concept of institutional theory for explaining the homogeneity of organisations in a field (DiMaggio and Powell, 1983). Coercive isomorphism arises from the formal and informal pressures exerted on organisations by other organisations with which they must work, as well as the influence of societal and cultural expectations on the organisation. This pressure causes organisations to come to terms with the status quo through persuasion, coercion or suggestion (Oliver, 1991). Uncertainty is one of the most important factors leading to imitation or mimicry in particular. The inadequacy of the technologies used by the organisation, the uncertainty of the objectives or the uncertainty created by the environment itself lead organisations to model themselves on other organisations. Mimetic behaviour is seen as an advantage for organisations and the economy of action is emphasised. Organisations fall back on existing experience when they are confronted with problems whose causes they do not fully understand or when the solutions become complex. This leads to the imitation of other organisations (Haveman, 1993). A third source of isomorphic change is normative and arises primarily from professionalisation. Professionalisation is defined as the framework that enables each individual practising a profession to control, through collective effort, the characteristics, methods and production processes of work and of all (Dacin, et al., 2002). This classification of isomorphism is based on a purely analytical framework and the boundaries between them are not strictly drawn.

Nowadays, however, rapidly changing environmental pressures, technological innovations and sustainability requirements limit the explanatory power of the traditional isomorphism model. Especially in the field of knowledge management, digital transformation and the importance of environmental strategies challenge the assumption that organisations only become similar due to coercive, imitation and normative pressure (Nonaka & Takeuchi, 1995; Drucker, 1999). Castells (2011) and Acemoglu & Robinson (2012) argue that the structural changes in the modern economy have deepened the strategic transformation processes of organisations and require new approaches to sustainability goals. Hobsbawm (1990) and Anderson (2006) have also emphasised the importance of flexible and innovative strategies beyond traditional institutional structures in the transformation of nation states and global systems.

In this context, the limitations of the current model are that it is unable to respond adequately to the pressure to innovate created by ecological and technological dynamics and the adaptive demands of knowledge management (Christensen, 1997). Adaptive isomorphism is the process by which organisations gradually and incrementally adapt to environmental regulations and market demands in the short and medium term while maintaining their current structure. This is the process of adaptation to external factors on the basis of optimisation (Teece, 2007). Dynamic isomorphism, on the other hand, is a process of long-term strategic change, radical innovation and the complete redesign of organisational structures. This process requires fundamental change. For green policies and knowledge management practises to increase their effectiveness, it is important to think together. Organisations may need to change in order to meet environmental and economic challenges in the short, medium and long term. In some ways, it may be necessary to combine the two dimensions at the intellectual level to take a broader and more flexible approach to green policy and knowledge management (Nonaka & Takeuchi, 1995).

3. Adaptive Isomorphism: Environmental and Strategic Adaptation

3.1 Definition and Conceptualisation

It is the process by which institutions gradually and incrementally adapt to environmental regulations and short- to medium-term market demands while maintaining their current structure in response to environmental, technological and economic dynamics (Child, 1997; Lawrence & Lorsch, 1967). This approach, which goes beyond the framework of DiMaggio and Powell's (1983) institutional isomorphism and focuses on structural optimisation, is about continuous interaction with the environment (Scott, 2008). While traditional isomorphism explains the tendency of organisations to have rather static and uniform structures, adaptive isomorphism assumes dynamic and living organisational units that can react quickly to the ever-changing environmental pressures (Weick, 1995). This adaptation process requires an active rather than a passive strategy. This ability can give organisations a flexible and sustainable competitive advantage in the face of environmental uncertainty.

Theoretically, adaptive isomorphism is a dynamic process of individual beliefs based on Nonaka and Takeuchi's (1995) concepts of continuous learning and innovation in the process of knowledge creation (Argyris & Schön, 1996). This perspective highlights the need for organisations to continuously adapt their structures to the fast-

moving knowledge and technology spiral and to invest in their continuous development beyond adapting to current environmental regulations (Teece, Pisano, & Shuen, 1997). Adaptation processes are also consistent with Porter and van der Linde's (1995b) hypothesis of 'competitive advantage through environmental adaptation'. According to them, environmental pressures pave the way for the development of innovative strategies and lead to improvements in resource utilisation, energy efficiency and operating costs (Hart, 1995). This process (environmental regulation) paves the way for triggered innovation and competitiveness, not coercion.

The basis of adaptive isomorphism is that a proactive rather than a reactive attitude towards environmental stress requires competence (Miles & Snow, 1978). This proactive attitude is, in a sense, the process and ability to develop an adaptation to the environment. This process defines a process in which organisations not only refuse to comply with normative and legal frameworks, but also use and adapt their internal dynamics and knowledge base (Wernerfelt, 1984). The process involves the development of short- to medium-term flexible structures as well as long-term strategies (Senge, 1990). In this environment of uncertainty, organisations are forced to focus on their survival and development.

Adaptive isomorphism refers to the continuous improvement of existing structures and processes in response to the environmental, economic and technological pressures to which today's business world is constantly exposed (Elkington, 1997). The concept not only targets these external factors, but also requires the development of internal resources and knowledge management processes (Grant, 1996). This approach offers companies the opportunity to gain an advantage in sustainable competition.

3.2 Applications in Knowledge Management

Adaptive isomorphism and sustainable knowledge management are beneficial for organisations as they are flexible in achieving sustainability goals and can adapt to environmental regulations. This approach refers to knowledge management processes that require continuous updating and the ability to adapt to changing technological and environmental conditions as quickly as possible. Nonaka and Takeuchi (1995), for example, argue that organisations can only remain agile in an environment where knowledge is generated dynamically and in a healthy environment where innovative solutions are developed. In this context, green technologies that are integrated into the digital transformation - e.g. energy-efficient data centres, sustainable waste management systems - can be seen as concrete examples of adaptive isomorphism. Such short- to medium-term dynamic responses that enable companies to optimise resource consumption - one of their biggest challenges - cannot only enable them to tackle the optimisation problem, but also provide a strong response to environmental pressures (Drucker, 1999).

In addition, green certification schemes, international environmental standards and local regulatory authorities are some of the factors that challenge or even provoke firms' adaptive mechanisms to take action (Porter & van der Linde, 1995a). This provocation or driving force can lead companies not only to developing environmentally friendly strategies in information management, but also to optimise their corporate structures. Examples such as reducing the energy consumption of data centres, which are now leaders in electricity consumption, increasing efficiency and the use of renewable energy sources, and sustainable waste management are expressions of adaptive isomorphism at the corporate level.

In short, this concept can be defined as the rapid and gradual response and adaptation of organisations to environmental and technological constraints in the implementation of green knowledge management strategies. As this process is a fundamental dynamic in the strategic implementation of green strategies, it provides a perspective that not only ensures compliance with existing norms, but also integrates environmentally friendly practises that increase operational efficiency, reduce costs and provide a competitive advantage by helping organisations monitor and improve their environmental performance in real time.

4. Dynamic Isomorphism: Temporal Evolution and Continuous Transformation

4.1 Definition and Theoretical Expansion

Dynamic isomorphism refers to organisations undergoing long-term strategic transformation processes in the face of ecological, technological and global dynamics. The coercive, mimetic and normative isomorphism highlighted in DiMaggio and Powell's (1983) model explains the adaptation of organisations to their existing institutional structures; however, this model does not fully capture the need for organisations to make fundamental changes to their underlying business models and strategic visions. While Tushman and Romanelli (1985) argue that technological change triggers strategic restructuring processes in organisations, dynamic

isomorphism argues that these innovations require continuous evolution and radical transformation rather than temporary adaptation. Castells (2011) emphasises the role of the digital revolution and the global network society in restructuring organisations and links the fundamental dynamics of dynamic isomorphism to today's environmental and technological constraints. Furthermore, Powell and DiMaggio (1991) emphasise that change processes in the institutional environment are not limited to adaptation, but also include processes of creative destruction and restructuring.

4.2 Evolution of Green Policies over Time

Green policies in the field of knowledge management not only adapt to short-term regulations, but also develop as part of long-term strategic transformation processes. Acemoglu and Robinson (2012), using their applied theories of structural change, found that organisations revise their fundamental strategies to achieve their environmental sustainability goals, i.e. green strategies are constantly renewed and this is part of corporate transformation. Organisations are considering strategic reorientation processes related to digitalisation and technological innovation to achieve their long-term goals. This dynamic points to the radical transformations caused by the isomorphism of the fundamental business models of organisational structures. Porter and Kramer (2011) emphasise the undeniable importance of strategic transformation for the development of green policies, as companies that integrate social and environmental issues into their business strategies can not only provide social benefits but also achieve competitive advantages.

4.3 Organisational Change Processes

Dynamic isomorphism requires organisations to radically restructure their fundamental strategic and cultural structures. While Nelson and Winter's (1982) theory of organisational evolution attributes continuous renewal to environmental and technological pressures, Senge's (1990) concept of the learning organisation refers to a long-term strategic transformation that is only possible through continuous organisational learning and innovation. This process cannot be understood as a simple optimisation of operational processes, but requires radical changes in corporate culture, strategic vision and business models and encourages organisations to pursue green strategies in the area of knowledge management. In this context, the concept provides a perspective from which organisations pursuing green policies to achieve environmental sustainability goals can theorise the fundamental and lasting changes that this process requires. In some ways, Teece's (2007) theory of dynamic capabilities overlaps with the concept of dynamic isomorphism, as it points to the need to constantly reconfigure and develop internal factors (capabilities) in response to external factors. In this adaptation process, this concept refers not only to external pressures but also to internal renewal (such as strategic learning and capacity building). This is consistent with the perspective of the two arguments in terms of long-term goals and helps to explain how they approach the angle of developing innovative practises.

5. Integration of Adaptive and Dynamic Isomorphism: A New Ontological Framework

5.1 Theoretical Synthesis: The Unity of Adaptive and Dynamic Isomorphism

Although the institutional isomorphism model was developed by DiMaggio and Powell (1983) to explain the responses of organisations to environmental pressures, this model has been criticised for not adequately capturing organisational change processes over time (Greenwood et al., 2008; Scott, 2014). While the theory of institutional isomorphism generally assumes that organisations adapt to existing institutional structures with which they have previously had experience, adaptive and dynamic isomorphism treat and extend the topic from a completely different temporal perspective. Adaptive isomorphism explains how organisations are able to respond quickly to ever-changing environmental, economic and technological constraints (Oliver, 1991), while dynamic isomorphism focuses on long-term strategic change, radical innovation and the complete redesign of institutional structures (Tushman & Romanelli, 1985).

In a sense, the concepts of adaptive and dynamic isomorphism are temporally complementary. While adaptive isomorphism is associated with short- to medium-term change processes, dynamic isomorphism can help to explain longer-term, more strategic and structural transformations and sustainability. However, in the context of knowledge management and environmental policy strategies, it can be a strategic mistake for organisations to choose only one isomorphism model, which can lead to an incomplete or incorrect reading of the process. Therefore, the two concepts should be considered together and organisations should always have both short- to medium-term action plans and long-term strategic and fundamental change goals (Seo & Creed, 2002; Greenwood & Hinings, 1996).

This integrative approach adds a new ontological dimension to institutional theory. It goes beyond the reactive responses of organisations to isomorphic pressures and explores how organisations translate these pressures through active transformations. This new framework takes a more holistic perspective on how knowledge management processes and environmental policies are shaped at both the micro level (organisational learning, cultural adaptation) and the macro level (institutional norms, industrial regulations).

5.2 Practical and Political Implications: Transforming Dynamics of Strategic Cohesion

Organisations can achieve their environmental sustainability goals not only by adapting to existing norms, but also through strategic processes that involve long-term transformations (Bansal & Roth, 2000). Under adaptive isomorphism, organisations can respond quickly to changing environmental conditions by developing short-term strategies, while dynamic isomorphism determines how these strategies are institutionalised and integrated into radical transformations in the long term (Garud & Karnøe, 2003).

When analysing corporate sustainability strategies, for example, (short-term) compliance with regulations to reduce the carbon footprint can be seen as an adaptive isomorphism, while green innovation processes can be seen as a dynamic isomorphism, as a radical transformation process of industry standards is a long and arduous journey (Hoffman, 2001). In the face of environmental regulation, the lens through which organisations view the issues will be their strategic choice. While some will be content to comply with existing requirements, others will achieve long-term competitive advantage through radical change (Hart, 1995). In this context, green information technologies and sustainable business models provide important examples of how adaptive and dynamic processes interact.

From a strategic perspective, the integration of adaptive and dynamic isomorphism can also provide clues as to how policy makers should develop sustainability strategies. While short-term incentives and regulations support adaptive isomorphism, promoting long-term structural changes will contribute to the spread of dynamic isomorphism (Etzion, 2007). The European Union's Green Deal, for example, aims to ensure that companies not only comply with current environmental standards, but also make long-term sustainability changes (Geels, 2011).

5.3 Case Studies and Examples: Green IT and Environmental Innovation

To better understand the combined effect of adaptive and dynamic isomorphism, the processes of companies introducing green IT strategies can be analysed. For example, technology giants such as Google and Microsoft have developed strategies that incorporate both adaptive and dynamic isomorphism processes by investing in renewable energy sources to achieve their carbon neutrality goals (Porter & van der Linde, 1995).

5.3.1 Google's sustainability strategy

When Google set a goal to become carbon neutral in 2007, the company initially took an adaptive isomorphic approach to comply with regulations. Later, however, the company radically changed its energy consumption and developed energy management systems based on artificial intelligence. This is one of the most concrete examples of an adaptive process that evolves into a dynamic transformation over time (Pinkse & Kolk, 2012).

5.3.2 Tesla and dynamic isomorphism

To increase sustainability in the automotive industry, Tesla not only adapted to the existing regulatory framework, but also undertook a strategic transformation that completely reshaped the industry (Unruh, 2000). In order to increase the acceptance of electric vehicles, the company developed a competitive advantage based on innovation and combined this process with a radical reorganisation. In the electric vehicle market, Tesla has managed to undertake an organisational restructuring and turn this advantage into a comprehensive consolidation to increase end-user acceptance and turn innovation into an effective competitive strategy. These approaches simply show how they are influenced by adaptive isomorphism (short to medium-term planning) and how they are driven by dynamic isomorphism (long-term strategic structural changes).

5.3.3 Conclusion: Towards a new ontological framework

By integrating the concepts of adaptive and dynamic isomorphism, this model offers the possibility to view organisations in the context of knowledge management and sustainability strategies from a broader perspective of institutional transformation. While institutional isomorphism theory generally assumes that organisations respond (adapt) isomorphically within existing institutional structures, this new ontological framework expands the explanation of how organisations adapt in the context of change and, furthermore,

their ability to actively promote change to achieve benefits. This model encourages organisations to undertake long-term strategic structuring in addition to short to medium-term planning, as new opportunities can only be achieved through new competition.

6. Conclusion

This study explores how a more holistic approach can be pursued by integrating adaptive and dynamic isomorphism. It draws on DiMaggio and Powell's (1983) critique of the traditional model of institutional isomorphism prevalent in the literature. While DiMaggio and Powell's three-part theorem can explain institutional convergence, organisations are not able to respond appropriately to technological advances and evolving knowledge management, at least not within the framework of this theory. The model takes a more holistic approach and expands the theoretical framework by focusing on adaptive isomorphism - how organisations are able to respond quickly to ever-changing environmental, economic and technological constraints - and dynamic isomorphism - how long-term strategic change, radical innovation and a complete redesign of institutional structures occur. It therefore challenges organisations to use these two dimensions together in the face of environmental sustainability and the knowledge-based environment. It thus complements the missing aspects of the concept of institutional isomorphism developed by DiMaggio and Powell (1983).

6.1 Theoretical Contributions

As a theoretical proposal, this study aims to expand the theoretical framework of institutional isomorphism and reconceptualise isomorphism as a more flexible and comprehensive model. While the existing literature focuses on institutional change in the context of external pressures and institutional norms (DiMaggio & Powell, 1983; Scott, 2001), this study emphasises the importance of internal learning processes, knowledge management and strategic decision making (Wijen, 2014; Porter & van der Linde, 1995). This extended model is intended to make a theoretical contribution, particularly in the field of green policy and environmental sustainability. As Oliver (1991) and Hoffman (2001) point out, while the traditional isomorphism model is suitable for explaining the external challenges organisations face and change, it is far from explaining how they can actively drive this change, i.e. it may not explain their ability to actively promote change. Linking these theoretical concepts (adaptive and dynamic isomorphism) shows that organisations are not just passive adaptive mechanisms to these external pressures, but also have the resilience to channel these pressures and achieve a sustainable competitive advantage (Porter & Kramer, 2011).

6.2 Future Research Directions

Although this study attempts to address the concepts of adaptive and dynamic isomorphism together, there are several areas that should be further investigated in the future. In particular, empirical studies evaluating the applicability of this model are needed and should be expanded. In particular, case studies investigating how the model works in the energy, finance and manufacturing sectors could show how valid the model is in practise. In addition, research on digital transformation and artificial intelligence technologies should investigate their impact on organisational change processes. Research could focus on the impact of digitalisation on adaptive isomorphism, i.e. how it accelerates and subsequently manifests dynamic isomorphism (Bocken et al., 2014).

Another important area of research is the study of patterns (adaptive and dynamic isomorphism) under the influence of political and regulatory factors. The question of how national (government policy) and international (regulations) and organisations contribute to sustainability strategies will be an important topic for future research (Hoffman & Ventresca, 2002). In this context, the theoretical and practical dimensions that the model will add will not only deepen the literature on institutional isomorphism, but also contribute to the fields of knowledge management and sustainability studies.

Ethics declaration: There is no need for ethical clearance for this research/manuscript.

AI declaration: No AI tools were used in this research and both AI and plagiarism were checked with the plagiarism programme Turnitin.

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Creating Knowledge-Based Value for Data Security in Enterprises

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Abstract: The objective of this study is to analyze and understand how knowledge-based value creation can enhance data security in enterprises. In today's rapidly evolving technological landscape, data has become a critical strategic asset. In this context, knowledge management and its application to strengthen information security processes are essential priorities for organizations. The study identifies factors influencing the effectiveness of knowledge management in data security, such as organizational culture, innovative technologies, and employee engagement. It integrates theoretical frameworks from knowledge management, including Nonaka and Takeuchi's SECI model, with practical approaches to information security, such as the ISO 27001 standard. The findings suggest that organizations effectively combining knowledge management processes with cybersecurity initiatives achieve greater resilience against threats and enhanced incident response capabilities. Special attention is given to the role of tacit knowledge and its transfer in employee education and awareness programs. The study concludes with recommendations for implementing knowledge management practices to improve data security. These include fostering continuous employee skill development, leveraging technologies such as artificial intelligence and blockchain, and creating systems to support knowledge sharing within organizations. The proposed model serves as a tool to help enterprises build sustainable knowledge-based value, enhancing not only data security but also their overall competitiveness in the market.

Keywords: Knowledge management, Data security, Knowledge-bas knowledge transfer, Organizational culture, Innovative technologies, Employee awareness

1. Introduction

In the contemporary digital economy, data security has emerged as a critical concern for enterprises. With the increasing volume of sensitive data being generated, processed, and stored, organizations face growing challenges in safeguarding information from cyber threats, data breaches, and unauthorized access. Ensuring robust data security is not merely a technical issue but a multidimensional challenge that requires a strategic approach integrating technological, organizational, and human factors (Almustafa and Kalash 2025; Khan and Wallom 2022). One of the key strategies to enhance data security is leveraging knowledge management (KM) as a fundamental tool for creating knowledge-based value (Pandey et al. 2023; Żywiołek et al. 2022b). Knowledge, both explicit and tacit, plays a vital role in improving an organization's resilience to security threats by fostering a culture of awareness, continuous learning, and innovation. Effective knowledge management practices enable enterprises to develop proactive security measures, improve incident response capabilities, and minimize vulnerabilities arising from human error or lack of awareness (Żywiołek et al. 2025). This study aims to explore how knowledge management principles can be applied to enhance data security within enterprises. By integrating theoretical frameworks such as Nonaka and Takeuchi's SECI model with practical security approaches (Masucci et al. 2020), including the ISO 27001 standard, this research identifies the key factors influencing knowledge-based value creation for data security (Tarasova 2024). These factors include organizational culture, innovative technologies, and employee engagement, all of which contribute to strengthening cybersecurity resilience and fostering sustainable competitive advantages.

The intersection of knowledge management and data security has been the subject of extensive academic inquiry. Previous research highlights the crucial role of KM in improving cybersecurity practices and reducing organizational risks (Żywiołek and Abbas 2021). Nonaka and Takeuchi's SECI model (1995) provides a fundamental framework for understanding how knowledge is created, transferred, and utilized within organizations. This model emphasizes the conversion of tacit knowledge into explicit knowledge and vice versa, enabling enterprises to institutionalize security best practices and improve knowledge sharing among employees. ISO 27001, an internationally recognized standard for information security management systems, underscores the significance of a structured approach to data security (*Proceedings of the Second International Conference on Electronics and Renewable Systems (ICEARS 2023)* 2023; Żywiołek et al. 2022a). It aligns with KM principles by advocating for systematic policies, risk assessment, and continuous improvement mechanisms. Studies by Alavi and Leidner suggest that KM systems (Alavi and Leidner 2001), when integrated with security protocols, enhance an organization's ability to mitigate threats and respond effectively to security incidents.

Furthermore, research by von Solms and van Niekerk highlights the role of organizational culture in shaping cybersecurity awareness (Solms and van Niekerk 2013). A strong security culture, supported by effective knowledge-sharing mechanisms, reduces vulnerabilities and improves compliance with security policies.

Employee engagement, training programs, and leadership commitment are critical components in fostering a knowledge-driven security approach. Innovative technologies such as artificial intelligence (AI) and blockchain have also gained attention in the context of knowledge-based security enhancement. AI-driven threat detection and predictive analytics enable enterprises to identify potential risks proactively, while blockchain technology ensures data integrity and traceability. Studies by Xu et al. and Salah et al. emphasize the potential of these technologies in strengthening data security frameworks (Salah and Ayyash 2024; Xu et al. 2020).

Despite these advancements, challenges remain in integrating KM effectively with cybersecurity practices. Many organizations struggle with knowledge silos, resistance to change, and inadequate knowledge-sharing infrastructures. Addressing these issues requires a holistic approach that combines technological solutions with strategic knowledge management initiatives. This study builds upon existing literature by proposing a comprehensive model that merges knowledge management principles with advanced security strategies. By emphasizing the role of tacit knowledge transfer, continuous learning, and technological innovation, the research aims to provide actionable insights for enterprises seeking to enhance their data security through knowledge-based value creation (Corvello et al. 2023).

2. Literature Review

Despite the extensive research on the role of knowledge management in cybersecurity, a significant gap remains in understanding how tacit knowledge transfer and organizational culture specifically influence data security practices. While technological advancements such as artificial intelligence and blockchain have been recognized for their security potential, their integration within knowledge-based security frameworks is still underexplored (Hussain et al. 2024). Addressing these gaps, this study investigates how knowledge management processes contribute to enhanced cybersecurity resilience and strategic data protection in enterprises (Suuronen et al. 2022; Schiavone et al. 2021; Żywiołek et al. 2024). To achieve this objective, the following hypotheses are proposed. First, the effective implementation of knowledge management processes positively influences data security performance in enterprises (H1). Knowledge-based value creation fosters an environment where employees develop a deeper awareness of security threats, share best practices, and strengthen risk management strategies. Second, the integration of innovative technologies, such as artificial intelligence and blockchain, within knowledge management frameworks enhances organizational resilience against cybersecurity threats (H2). As enterprises increasingly rely on data-driven decision-making, these technologies support advanced threat detection, secure information sharing, and improved incident response mechanisms. By validating these hypotheses, the study aims to contribute both theoretically and practically to the understanding of how enterprises can leverage knowledge management and technological innovation to fortify their data security strategies.

The relationship between knowledge management (KM) and data security has been examined in various contexts, reflecting the growing importance of intellectual assets in protecting digital infrastructures. Alavi and Leidner (2001) were among the first to emphasize that knowledge management systems can facilitate better decision-making and enhance organizational responsiveness to security incidents. Their foundational work underscores the role of KM in building institutional memory, which is critical for incident response and risk mitigation. Nonaka and Takeuchi's (1995) SECI model serves as a conceptual cornerstone for many KM-based studies, explaining how tacit and explicit knowledge interact within an organization. In the context of data security, this model helps illuminate how experiential knowledge (e.g., from previous incidents) can be codified into protocols and procedures, supporting ISO 27001-aligned practices (Żywiołek et al., 2022a). This integration of formal and informal knowledge flows is increasingly recognized as a vital mechanism for developing organizational resilience (Masucci et al., 2020). Additionally, research highlights the importance of organizational culture and leadership in enabling effective knowledge-sharing for security purposes (Solms & van Niekerk, 2013). Without a supportive culture, even the most advanced knowledge systems are unlikely to deliver security benefits. Trust, engagement, and communication are consistently identified as enablers of secure knowledge environments (Xu et al., 2020; Żywiołek & Abbas, 2021). Technological innovation is another major dimension explored in the literature. Artificial intelligence and blockchain technologies have been cited as powerful tools for improving data protection and facilitating secure knowledge exchange (Salah & Ayyash, 2024; Hussain et al., 2024). AI enhances real-time threat detection and response, while blockchain ensures traceability and authenticity of shared knowledge assets. However, integrating these tools into KM systems presents both technical and organizational challenges, including user skepticism and knowledge silos (Żywiołek et al., 2024). Despite extensive academic focus, there is a research gap in examining how tacit knowledge transfer, particularly in the context of employee behavior and organizational learning, contributes to data security. Few studies systematically assess how informal knowledge-sharing mechanisms influence compliance,

incident handling, or resilience (Schiavone et al., 2021). Similarly, while ISO 27001 and GDPR are widely implemented, their synergy with KM strategies remains underexplored, especially across different cultural and regulatory environments (Tarasova, 2024; Suuronen et al., 2022). This study seeks to bridge these gaps by proposing a model that integrates knowledge-based value creation with data security enhancement. Specifically, the research focuses on how enterprises operationalize knowledge management to foster awareness, strengthen internal protocols, and adopt innovative technologies for cyber resilience.

3. Materials and Methods

This study employed a quantitative research approach using the Computer-Assisted Web Interviewing (CAWI) method to examine the role of knowledge management in enhancing data security within enterprises. The research was conducted in three European countries—Poland, Germany, and Spain—to provide a cross-national perspective on the integration of knowledge-based value creation into cybersecurity strategies. The primary objective was to assess how enterprises implement knowledge management processes to improve data security, increase employee awareness, and leverage technological solutions for cybersecurity resilience.

The study was conducted in two phases. In the first phase, a conceptual framework was developed to outline key constructs related to knowledge management and data security. This framework guided the creation of the research instrument. In the second phase, a large-scale CAWI survey was conducted to gather empirical data efficiently while minimizing the limitations associated with in-person interviews. The survey took place in the latter half of 2023, and a total of 9,837 valid responses were collected, with 3,256 from Poland, 3,421 from Germany, and 3,160 from Spain. These countries were selected due to their comparable levels of digital transformation, cybersecurity regulations under the General Data Protection Regulation (GDPR), and shared approaches to knowledge management.

The survey instrument was a structured questionnaire divided into three sections: (1) demographic and organizational background, including participants' roles, industries, and experience in data security management; (2) knowledge management and data security practices, evaluating knowledge-sharing mechanisms, employee training, and the adoption of innovative technologies; and (3) perceived effectiveness and challenges, measuring confidence in cybersecurity strategies, organizational resilience, and existing knowledge gaps. Responses were collected using a five-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree) to assess attitudes, awareness, and the perceived impact of knowledge management on security. The questionnaire comprised twenty-four inquiries, including nine specific questions based on the Servqual methodology, designed to analyse discrepancies between expected and actual knowledge-based security implementations.

The sample was designed to be representative of enterprises operating within the selected countries. Although national contexts may differ, the study assumes that economic development levels, regulatory cybersecurity frameworks, and organizational security strategies are comparable across these nations. Additionally, the freedom of movement and cross-border knowledge exchange within the European Union facilitate a unified approach to knowledge management in cybersecurity.

For data analysis, Microsoft Excel was used to perform descriptive statistics, including frequency distributions and percentage breakdowns, to identify trends in cybersecurity awareness and knowledge-sharing practices. Comparative analyses were conducted across the three countries to assess regional differences and similarities in the implementation of knowledge-driven cybersecurity strategies. The findings from this study contribute to a deeper understanding of how enterprises can integrate knowledge-based value creation to strengthen their cybersecurity frameworks and enhance data protection measures.

Figure 1 illustrates the research process, outlining the sequential steps undertaken in the study, from defining the research objectives to data collection, analysis, and deriving conclusions. The diagram highlights the structured approach, including the conceptual framework development, survey implementation using the CAWI method across three countries (Poland, Germany, and Spain), and the subsequent data analysis using Excel-based statistical processing. Each stage is designed to ensure a comprehensive examination of how knowledge management contributes to enhancing data security in enterprises. To ensure methodological transparency, additional details regarding the sampling frame and response metrics are provided. The total population targeted in this study included medium and large enterprises operating in Poland, Germany, and Spain, which actively engage in digital transformation and implement cybersecurity measures. Based on data from national enterprise registries and business databases, the estimated total population across these three countries was approximately 145,000 enterprises. The final dataset comprised 9,837 valid responses, which corresponds to an

overall response rate of approximately 6.8%. This rate is considered appropriate for large-scale CAWI (Computer-Assisted Web Interviewing) studies targeting organizational representatives on specialized topics such as data security and knowledge management.

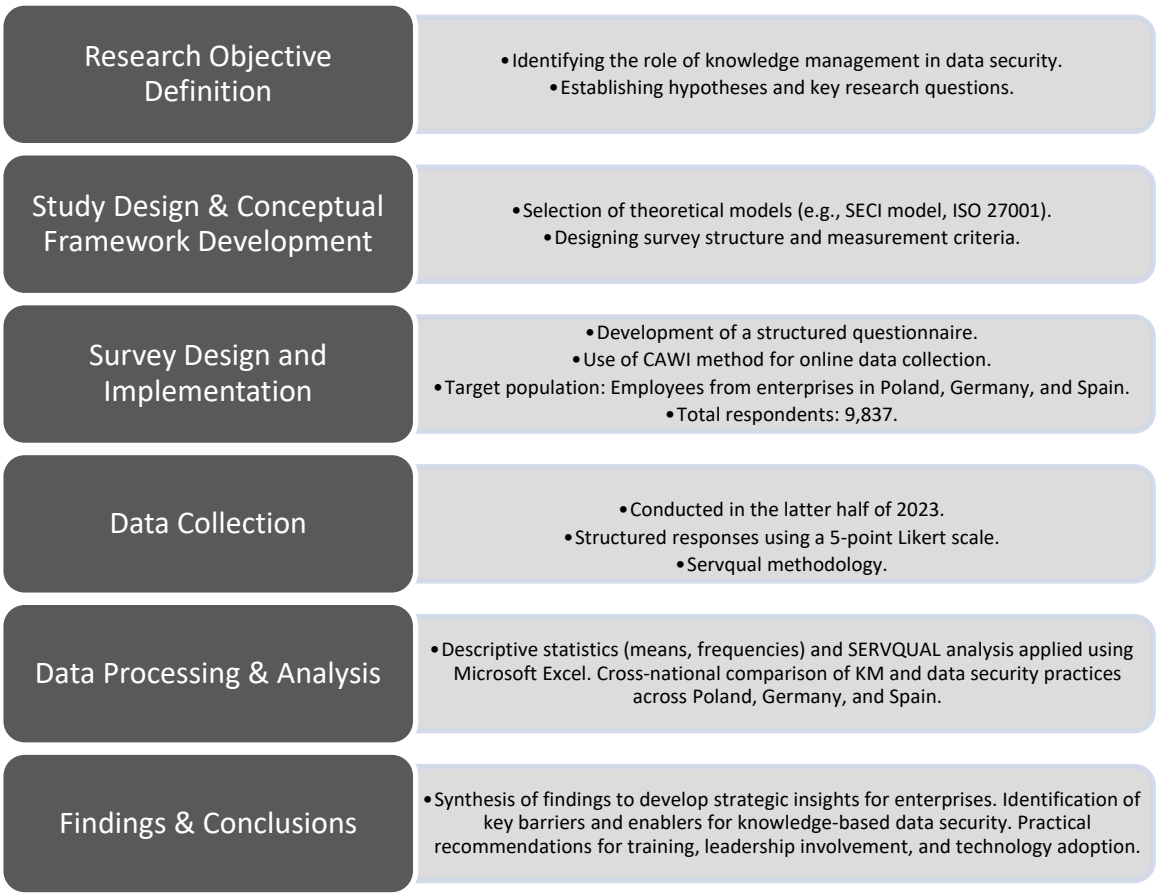


Figure 1: Research procedure

Figure 1 provides a structured overview of the research process, from defining objectives and designing the survey to data collection and analysis. This systematic approach ensures a comprehensive examination of how knowledge management influences data security in enterprises. The following section presents the study's findings, offering insights into the effectiveness of knowledge-sharing practices, employee cybersecurity awareness, and the impact of technological solutions on organizational resilience.

4. Results

Figure 2 illustrates key challenges and concerns related to knowledge management and data security in enterprises. The increasing reliance on digital technologies and cybersecurity frameworks highlights the importance of effectively managing security knowledge within organizations. While enterprises recognize the value of cybersecurity awareness and structured knowledge-sharing mechanisms, several issues persist, including gaps in employee training, resistance to adopting new security protocols, and inconsistencies in knowledge transfer. These challenges impact the overall effectiveness of cybersecurity strategies and increase vulnerability to cyber threats. Figure 2 presents an overview of these factors, emphasizing the need for comprehensive knowledge-based security solutions to enhance organizational resilience.

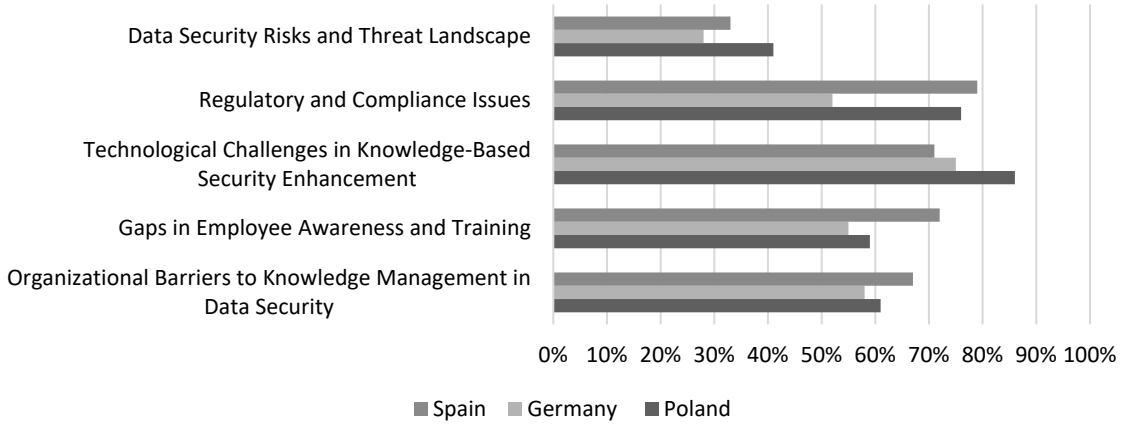


Figure 2: Problems with data security in selected countries

The identification of barriers and challenges in cybersecurity knowledge management has enabled a clearer definition of strategies to enhance security practices within enterprises. Table 1 presents an overview of key areas influencing knowledge management in data security, assessing factors such as employee awareness, organizational responsibility, accessibility of security knowledge, trust in security technologies, and challenges in knowledge transfer. The descriptive statistics for these constructs indicate moderate levels of awareness and implementation of security knowledge within organizations. The mean value for Knowledge and Awareness of Data Security Practices is 3.28, reflecting a need for improved training and education initiatives to enhance employees' understanding of cybersecurity threats and best practices. Similarly, Organizational Responsibility and Leadership in Data Security scored 3.07, suggesting that while leadership acknowledges the importance of cybersecurity, there are gaps in policy enforcement and managerial involvement in knowledge-sharing initiatives. Furthermore, Accessibility and Implementation of Security Knowledge received a mean score of 2.94, indicating challenges in integrating structured security knowledge management systems across enterprises. The Trust and Awareness in Security Technologies score of 2.83 highlights a lack of confidence in automated security solutions such as AI-driven threat detection and blockchain-based security frameworks. Lastly, Challenges in Security Knowledge Management were rated at 2.91, pointing to issues such as resistance to adopting new security protocols, gaps in cybersecurity literacy, and difficulties in transferring security expertise across teams. These findings emphasize the need for a holistic approach to cybersecurity knowledge management, integrating structured training programs, leadership commitment, and technological innovations to enhance organizational resilience against cyber threats. The study's next section further explores how enterprises can address these challenges by adopting knowledge-based security strategies.

Table 2: Mean values and Cronbach's α coefficient

Variable	Average value	Cronbach's α
Knowledge and Awareness of Data Security Practices	3,28	0,82
Organizational Responsibility and Leadership in Data Security	3,07	0,87
Accessibility and Implementation of Security Knowledge	2,94	0,76
Trust and Awareness in Security Technologies	2,83	0,81
Challenges in Security Knowledge Management	2,91	0,85

The initial phase of the study was establishing the presence and magnitude of the relationship. In the initial stage of the Servqual study, we calculated the discrepancies between the levels of energy management perception and consumer awareness and the expected levels for the five dimensions. Table 3 presents the outcomes.

Table 3: Differences in perceptual levels were studied using Servqual

	Features	P	E	Servqual Results "SS" Is the Level of Satisfaction SS = E − P
Knowledge and Awareness of Data Security Practices				
Average Servqual: 0,23				
1	Level of employee cybersecurity knowledge	7	7,35	0,35
2	Knowledge-sharing culture	8	7,86	-0,14
3	Effectiveness of training programs	6	6,42	0,42
4	Awareness of phishing and social engineering threats	8	7,93	-0,07
5	Adoption of best practices for password security	8	8,17	0,17
Organizational Responsibility and Leadership in Data Security				
Average Servqual: 0,35				
6	Commitment from top management	5	5,24	0,24
7	Implementation of formal security policies	6	6,64	0,64
8	Collaboration between IT and other departments	6	5,61	-0,39
9	Security incident response effectiveness	6	6,28	0,28
10	Investment in cybersecurity knowledge development	8	8,19	0,19
Accessibility and Implementation of Security Knowledge				
Average Servqual: 0,21				
11	Availability of cybersecurity resources	7	7,36	0,36
12	Ease of interpreting security policies	8	7,82	-0,18
13	Integration of knowledge management systems (KMS)	8	8,61	0,61
14	Automation of knowledge-based security insights	7	7,39	0,39
15	Use of blockchain for secure knowledge storage	7	6,76	-0,24
Trust and Awareness in Security Technologies				
Average Servqual: 0,66				
16	Perceived reliability of cybersecurity tools	5	6,14	1,14
17	Adoption of emerging security technologies	7	7,67	0,67
18	Trust in automated security processes	8	8,49	0,49
19	Perceived effectiveness of knowledge-based security models	4	3,75	-0,25
20	Security knowledge retention in remote work environments	7	6,28	-0,72
Challenges in Security Knowledge Management				
Average Servqual: 0,43				
21	Gaps in cybersecurity literacy	5	5,11	0,11
22	Resistance to adopting new security protocols	8	8,24	0,24
23	Barriers to knowledge transfer	7	6,18	-0,82
24	Misinformation and cybersecurity myths	5	4,37	-0,63
25	Employee engagement in cybersecurity initiatives	5	4,67	-0,33

A graph was produced based on the Table 3 data, which included the results of the Servqual method of perception and expectancies analysis. Figure 3 depicts the graphical representation of the Servqual method's outcomes.

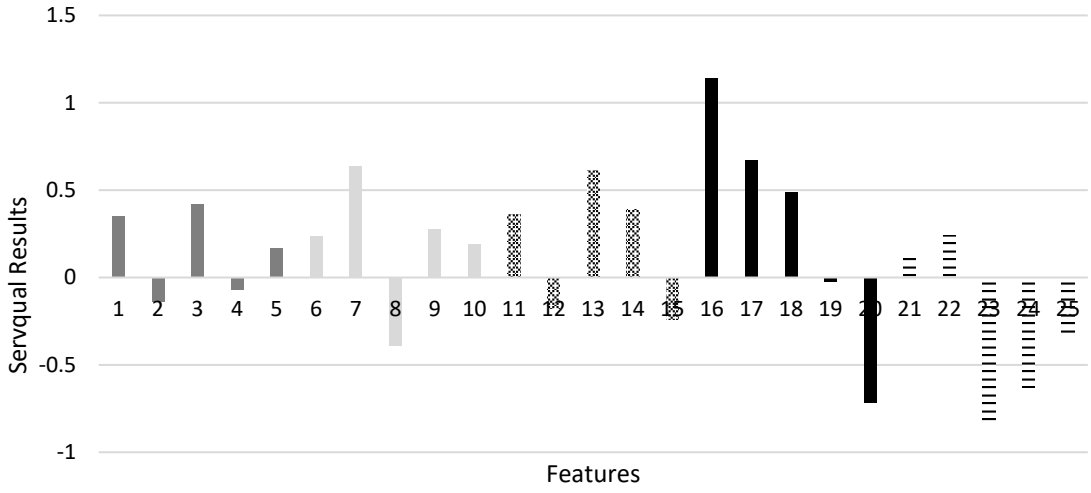


Figure 3: Results of the Servqual analysis

The Servqual analysis of the 25 cybersecurity factors reveals key strengths and weaknesses in knowledge management for data security. Strong areas include high confidence in firewall and intrusion detection systems (Factor 16), effective internal security communication (Factor 7), and the integration of knowledge-sharing platforms (Factor 12), indicating that organizations have successfully established structured mechanisms for security awareness and collaboration. However, critical weaknesses emerge in several areas. Awareness of phishing and social engineering threats (Factor 2) shows a negative gap, suggesting that employees remain vulnerable to cyberattacks due to insufficient training. Collaboration between IT security teams and other departments (Factor 8) also exhibits a deficit, highlighting a lack of interdisciplinary coordination in security management. Additionally, gaps in cybersecurity literacy (Factor 19) and trust in handling security breaches (Factor 25) indicate that many employees do not feel adequately prepared to respond to incidents, which could compromise organizational resilience. Overall, while organizations have successfully implemented security tools and communication strategies, deficiencies in employee awareness, IT collaboration, and breach response capabilities require immediate attention. Strengthening cybersecurity training programs, improving interdisciplinary cooperation, and fostering a more security-conscious workplace culture will be essential to closing these gaps and enhancing knowledge-based data security practices.

Figure 2 illustrates key challenges and concerns related to knowledge management and data security in enterprises. The increasing reliance on digital technologies and cybersecurity frameworks highlights the importance of effectively managing security knowledge within organizations. While enterprises recognize the value of cybersecurity awareness and structured knowledge-sharing mechanisms, several issues persist, including gaps in employee training, resistance to adopting new security protocols, and inconsistencies in knowledge transfer. These challenges impact the overall effectiveness of cybersecurity strategies and increase vulnerability to cyber threats. Figure 2 presents an overview of these factors, emphasizing the need for comprehensive knowledge-based security solutions to enhance organizational resilience. The identification of barriers and challenges in cybersecurity knowledge management has enabled a clearer definition of strategies to enhance security practices within enterprises. Table 1 presents an overview of key areas influencing knowledge management in data security, assessing factors such as employee awareness, organizational responsibility, accessibility of security knowledge, trust in security technologies, and challenges in knowledge transfer. The descriptive statistics for these constructs indicate moderate levels of awareness and implementation of security knowledge within organizations. The mean value for Knowledge and Awareness of Data Security Practices is 3.28, reflecting a need for improved training and education initiatives to enhance employees' understanding of cybersecurity threats and best practices. Similarly, Organizational Responsibility and Leadership in Data Security scored 3.07, suggesting that while leadership acknowledges the importance of cybersecurity, there are gaps in policy enforcement and managerial involvement in knowledge-sharing initiatives. Furthermore, Accessibility and Implementation of Security Knowledge received a mean score of 2.94, indicating challenges in integrating structured security knowledge management systems across enterprises. The Trust and Awareness in Security Technologies score of 2.83 highlights a lack of confidence in automated security solutions such as AI-driven threat detection and blockchain-based security frameworks. Lastly, Challenges in Security Knowledge Management were rated at 2.91, pointing to issues such as resistance to adopting new

security protocols, gaps in cybersecurity literacy, and difficulties in transferring security expertise across teams. These findings emphasize the need for a holistic approach to cybersecurity knowledge management, integrating structured training programs, leadership commitment, and technological innovations to enhance organizational resilience against cyber threats. The initial phase of the study focused on evaluating the perception gaps between expected and experienced levels of knowledge-based data security practices within enterprises. Using the SERVQUAL method, we measured discrepancies across the five key dimensions outlined above. Table 3 presents the results of this analysis by comparing participants' expectations (E) and perceptions (P) for each of the 25 indicators. The SERVQUAL score (SS = E – P) reveals areas where expectations exceeded actual experience, as well as those where organizations performed better than anticipated. For instance, in the Knowledge and Awareness of Data Security Practices dimension, the largest positive gap (+0.42) appeared in the Effectiveness of training programs, suggesting that some organizations surpassed expectations in their employee development initiatives. However, Knowledge-sharing culture (–0.14) and Awareness of phishing and social engineering threats (–0.07) displayed negative gaps, indicating critical areas for improvement in informal knowledge transfer and threat preparedness. In the Organizational Responsibility and Leadership category, the implementation of formal security policies showed a strong positive gap (+0.64), reflecting well-established governance in some enterprises. In contrast, Collaboration between IT and other departments showed a significant negative gap (–0.39), pointing to the need for improved cross-functional coordination. The Accessibility and Implementation of Security Knowledge dimension was mixed, with positive outcomes such as Integration of KMS (+0.61) and Automation of knowledge-based insights (+0.39), but also weak areas like Use of blockchain for secure knowledge storage (–0.24). In the Trust and Awareness in Security Technologies domain, results varied significantly. Although Perceived reliability of cybersecurity tools showed the highest positive gap (+1.14), Security knowledge retention in remote work environments revealed a concerning negative gap (–0.72), highlighting persistent post-pandemic challenges. Lastly, the Challenges in Security Knowledge Management dimension uncovered significant weaknesses. For example, Barriers to knowledge transfer (–0.82) and Misinformation and cybersecurity myths (–0.63) were among the most severe negative gaps, confirming that human and cultural factors continue to hinder secure knowledge dissemination.

5. Discussion and Conclusions

The study demonstrated a strong organizational commitment to cybersecurity knowledge management, emphasizing the growing importance of structured security awareness and knowledge-sharing practices. As enterprises continue to integrate digital security strategies, there is a critical need to enhance knowledge-based cybersecurity frameworks to strengthen resilience against emerging threats. The increasing complexity of cyberattacks necessitates a proactive approach that incorporates structured training, technological advancements, and interdisciplinary collaboration. Organizations must focus on creating an integrated security culture, ensuring that employees at all levels understand best practices, security policies, and incident response protocols. The research findings highlight both progress and challenges in the implementation of cybersecurity knowledge management. The mean score for Knowledge and Awareness of Data Security Practices was 3.28, indicating that while organizations recognize the importance of security knowledge, there is room for improvement in raising employee awareness and providing more effective training programs. Organizational Responsibility and Leadership in Data Security scored 3.07, reflecting a moderate level of managerial commitment but suggesting that top leadership needs to be more actively involved in fostering a security-driven culture. Accessibility and Implementation of Security Knowledge scored 2.94, pointing to difficulties in integrating cybersecurity knowledge-sharing platforms and ensuring that employees can easily access and apply security-related information. Trust and Awareness in Security Technologies received a mean score of 2.83, highlighting skepticism toward AI-driven security monitoring and blockchain-based solutions, which may hinder adoption. Lastly, Challenges in Security Knowledge Management were rated at 2.91, revealing persistent barriers in knowledge transfer, resistance to new security policies, and difficulties in maintaining cybersecurity literacy across different organizational levels. These results indicate that organizations have successfully adopted firewalls, intrusion detection systems, and knowledge-sharing platforms, but significant gaps remain in social engineering awareness, interdisciplinary cooperation, and confidence in handling security breaches. Addressing these weaknesses requires a systematic approach to cybersecurity education, ensuring that employees possess the necessary skills to recognize, mitigate, and respond to threats effectively. The study also underscores the necessity of leadership commitment in driving security initiatives, as management involvement plays a crucial role in fostering a security-conscious workplace culture. Despite these advancements, limitations persist in the widespread adoption of emerging cybersecurity technologies. Employees exhibit skepticism regarding AI-driven security automation and blockchain-based data protection, indicating a need for further education on the

benefits and reliability of these technologies. Additionally, resistance to adopting new security protocols remains a significant challenge, often stemming from a lack of clear communication or inadequate training programs. Future research should explore the long-term impact of cybersecurity training and evaluate how organizations can integrate AI-driven risk assessment tools to enhance security knowledge-sharing processes. The study also identifies broader implications for cybersecurity knowledge management, particularly in the context of regulatory compliance and industry standards. As enterprises navigate complex data protection regulations, ensuring alignment with frameworks such as ISO 27001 and GDPR becomes essential. Future research should focus on assessing the effectiveness of security knowledge transfer in regulatory compliance, as well as the role of cybersecurity literacy in mitigating organizational risks. Longitudinal studies comparing security knowledge adoption across different industries would provide valuable insights into best practices for knowledge-based security implementation. One of the main limitations of this study is the inability to compare data across multiple research periods, which restricts the ability to assess long-term trends in cybersecurity knowledge adoption. Future studies should aim to conduct follow-up assessments within the next few years to track improvements in security knowledge management and identify evolving challenges. Additionally, further qualitative research could provide deeper insights into employee perceptions of cybersecurity training effectiveness and the practical challenges associated with implementing knowledge-based security solutions. By addressing these areas, organizations can develop more robust cybersecurity strategies that integrate both technological innovations and human-centered knowledge-sharing approaches, ultimately fostering a more resilient and security-aware enterprise environment. The study confirms that enterprises need to prioritize structured cybersecurity training, improve leadership engagement, and enhance security knowledge accessibility to effectively mitigate cyber risks and strengthen organizational security resilience.

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The Impact of Generative Artificial Intelligence on Knowledge Exchange in Supply Chains

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Abstract: This study aims to understand and evaluate the impact of generative artificial intelligence (GenAI) on knowledge exchange processes in supply chains. In the era of digital transformation, tools such as ChatGPT, DALL·E, and other generative models enable the automation of knowledge creation and sharing, significantly transforming collaboration between organizations. The analysis focuses on key aspects such as supporting decision-making processes, optimizing real-time communication, and enhancing knowledge management in distributed structures. The research explores the benefits GenAI can bring to supply chains, including faster information sharing, more accurate forecasting, and automation of operational documentation. At the same time, it identifies potential challenges, such as data security risks, unpredictability of generated outcomes, and ethical considerations regarding the use of artificial intelligence in strategic knowledge management processes. The study includes a literature review and empirical research conducted among companies in sectors such as logistics, manufacturing, and retail. The results indicate that generative artificial intelligence not only supports knowledge exchange but also facilitates more dynamic and integrated models of collaboration. However, the research emphasizes the need to develop guidelines for implementing this technology that address organizational, technological, and regulatory aspects. In conclusion, the findings suggest that the responsible and strategic implementation of GenAI can significantly enhance efficiency and innovation in supply chains while highlighting the importance of investing in employee education and the development of knowledge management policies.

Keywords: Generative artificial intelligence (GenAI), Knowledge exchange supply chain management, Automation of knowledge sharing ,Real-Time Communication

1. Introduction

The rapid advancement of artificial intelligence (AI), and particularly the emergence of generative AI (GenAI) models such as ChatGPT and DALL·E, has introduced profound changes to knowledge management practices across industries. In supply chain management (SCM), where the speed and accuracy of information flow are critical, GenAI presents new opportunities to enhance collaboration, automate knowledge sharing, and support decision-making processes. Unlike traditional AI, which often focuses on predictive analytics or automation of specific tasks, generative AI possesses the capability to create new content, synthesize large datasets, and facilitate real-time communication, offering transformative potential for supply chains (Guojian 2023; Żywiołek et al. 2024).

Despite the increasing interest in the application of AI in SCM, existing research has predominantly focused on areas such as automation, forecasting, and operational optimization (Yong-Suo 2004). Limited studies have explored how GenAI specifically impacts knowledge exchange mechanisms within supply chains, particularly in terms of enabling real-time collaboration, improving decision-making quality, and addressing knowledge silos across organizations (Żywiołek et al. 2025). Furthermore, concerns surrounding data security, ethical use of AI-generated content, and regulatory compliance add complexity to the adoption of these technologies (Khan et al. 2023).

This study addresses these gaps by investigating the influence of generative AI on knowledge exchange processes in supply chains, focusing on three key sectors: logistics, manufacturing, and retail. Using a large-scale survey conducted in Poland, the Czech Republic, and Slovakia, the research examines how organizations adopt and utilize GenAI tools to support knowledge management functions. It evaluates both the benefits and challenges associated with GenAI implementation, including improvements in communication efficiency, enhancements in predictive capabilities, and potential risks related to data privacy and content reliability (Hongfei 2020).

The primary contributions of this study are threefold. First, it provides empirical evidence on the role of GenAI in shaping knowledge exchange practices in contemporary supply chains. Second, it identifies critical factors that influence successful adoption, such as organizational readiness, tool accessibility, and technological familiarity. Third, it offers practical recommendations for organizations seeking to strategically integrate GenAI into their knowledge management processes, emphasizing the importance of ethical governance, employee training, and infrastructure readiness.

The structure of the paper is as follows: Section 2 presents a review of relevant literature on generative AI and knowledge management in supply chains. Section 3 outlines the research methodology, including sample characteristics and data analysis techniques. Section 4 presents and analyzes the empirical results. Section 5 discusses the findings in the context of existing research, and Section 6 concludes the paper with implications for practice and directions for future research.

2. Review of Literature

This section presents the conceptual foundations of generative artificial intelligence (GenAI) and its application in supply chain knowledge management. It outlines the evolution of GenAI technologies, their unique capabilities compared to traditional AI systems, and the relevance of these technologies for inter-organizational knowledge exchange.

2.1 Generative Artificial Intelligence: Characteristics and Capabilities

Generative AI refers to machine learning models capable of creating original content, including text, images, and code, based on learned patterns from large datasets. Technologies such as OpenAI's ChatGPT, DALL·E, and Google's Bard exemplify the application of GenAI across various domains. Unlike traditional AI models that focus on classification or regression tasks, GenAI models generate new data outputs, making them particularly valuable for tasks involving documentation, report synthesis, or real-time decision support.

In the context of organizational settings, GenAI supports a range of functions, from automated knowledge generation to intelligent assistance in decision-making (Kostavelis et al. 2025; Żywiołek 2024). In particular, these models can improve the accessibility and contextualization of knowledge within distributed teams, aligning well with the decentralized nature of supply chains.

2.2 Knowledge Management and Exchange in Supply Chains

Knowledge management (KM) in supply chains refers to the systematic handling of information and expertise among stakeholders to ensure timely and accurate decision-making. Efficient KM enables firms to react to disruptions, optimize resource allocation, and enhance coordination with partners (Hu and Zhao 2024; Shang et al. 2024). However, KM in supply chains is often challenged by fragmented information systems, cultural differences, and poor interoperability between partners. Generative AI can bridge these gaps by providing common communication interfaces, translating documentation, and summarizing knowledge assets dynamically across systems and languages (Żywiołek 2024; Sterbak et al. 2022).

2.3 Research Gaps and Emerging Trends

While AI has been widely adopted in areas such as demand forecasting, route optimization, and robotic process automation (Tao 2020; Shang et al. 2024), the application of GenAI specifically to KM in supply chains remains underexplored. Most studies focus on predictive or prescriptive AI, overlooking the knowledge-creation and communication capabilities that are essential for dynamic and agile supply chains (Zhou et al. 2024).

Additionally, few empirical studies assess how GenAI influences organizational behavior, inter-organizational trust, and the development of innovation capabilities. This study contributes to filling this gap by exploring how companies in logistics, manufacturing, and retail are currently using GenAI tools and what factors affect their adoption (Sterbak et al. 2021).

2.4 Ethical and Regulatory Considerations

The use of GenAI in knowledge processes also raises critical issues related to data governance, transparency, and bias. Organizations must consider regulatory frameworks such as the EU AI Act and develop internal policies to mitigate risks linked to misinformation, misuse of generated content, and employee resistance (Ooi et al. 2024; Perera et al. 2021). In conclusion, the literature suggests that GenAI offers transformative capabilities for knowledge management in supply chains. Yet, there is a clear need for more empirical research that connects these technological advancements with practical outcomes (Yordanova 2025), organizational culture, and regulatory alignment. This study aims to address these needs through a comprehensive survey-based analysis in Central Europe (Pandey et al. 2023).

3. Materials and Methods

This study employed a quantitative research design using the Computer-Assisted Web Interviewing (CAWI) technique. The empirical investigation was conducted among organizations operating in the logistics,

manufacturing, and retail sectors in three Central European countries: Poland, the Czech Republic, and Slovakia. A total of 13,271 respondents participated in the study, representing a broad and diverse sample in terms of industry, organizational structure, and level of technological maturity. This allowed for an in-depth examination of how generative artificial intelligence (GenAI) is adopted and utilized across different segments of the supply chain. The research instrument consisted of a structured questionnaire comprising 24 items organized into thematic blocks. The key areas addressed in the survey included the degree of familiarity and usage of GenAI tools (such as ChatGPT and DALL·E), the role of these tools in enhancing communication and supporting decision-making processes, challenges and barriers to GenAI adoption, and organizational attitudes toward AI-enabled knowledge management. Respondents evaluated statements on a 7-point Likert scale, where 1 indicated strong disagreement and 7 indicated strong agreement. The demographic profile of the sample revealed that 72% of respondents were male and 28% female, with the majority falling in the 30–49 age range. Regarding education, 53% had completed secondary education and 47% held higher education degrees. In terms of professional roles, 42% of respondents identified as managers, followed by 29% as business owners, 18% as specialists, and 11% as IT department personnel. Concerning their experience with AI technologies, 47% reported having prior knowledge, 36% declared general familiarity, and 17% indicated practical experience in using such tools. To analyze the collected data, Structural Equation Modeling with Partial Least Squares (SEM-PLS) was employed. This method was chosen due to its suitability for testing complex models involving latent variables and assessing relationships between constructs such as perceived usefulness, organizational readiness, and technological accessibility. The data were processed using the SmartPLS3 software, enabling rigorous model estimation and path analysis.

The research process was carried out in four structured stages: (1) identifying the research gap through an in-depth literature review; (2) designing and piloting the survey instrument; (3) collecting data via the CAWI method in the selected countries; and (4) analyzing the results using SEM-PLS techniques. This methodological approach ensured high reliability and validity of the results, providing a solid foundation for evaluating the role of GenAI in enhancing knowledge exchange within supply chains. The following figure illustrates the detailed steps undertaken during the empirical research process on the impact of generative artificial intelligence (GenAI) on knowledge exchange in supply chains (fig 1.).

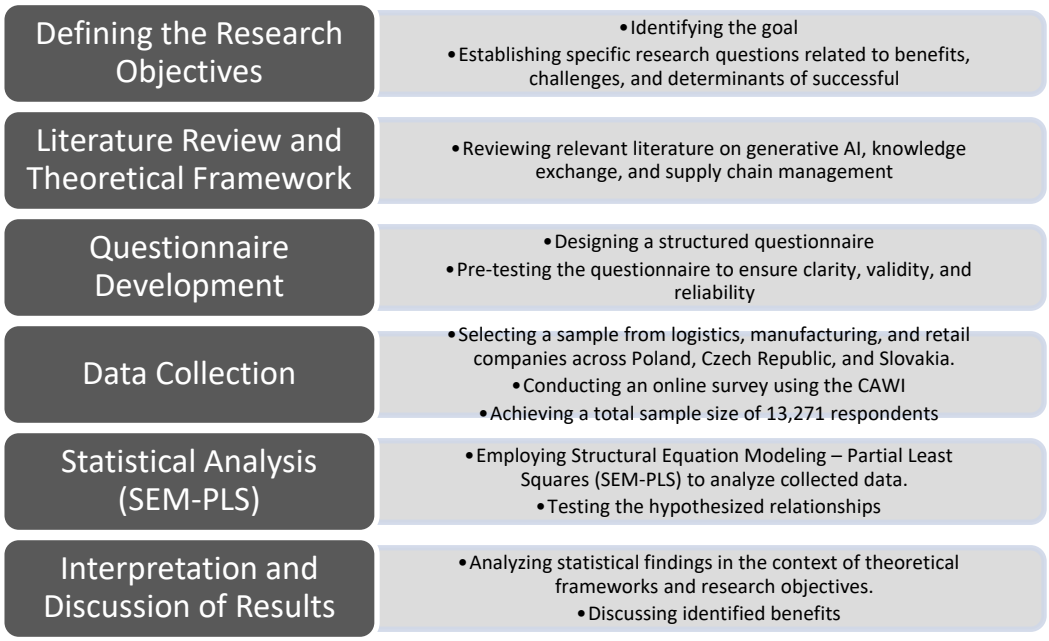


Figure 1: Research Steps

The identification of research gaps was a critical initial step, enabling clear direction and structuring of subsequent research activities. A thorough literature review revealed that, despite growing interest in artificial intelligence, few studies have systematically explored the impact of generative artificial intelligence (GenAI) specifically on knowledge exchange processes within supply chains. This gap relates primarily to understanding how GenAI influences collaboration, real-time communication, and decision-making support among organizations in various sectors, including logistics, manufacturing, and retail.

Table 1: Description of the research group

	description of the research group				
1	Sex	Man 72%		Woman 28%	
2	Age	18-29 years	19%	18-29 years	6%
		30-39 years	31%	30-39 years	45%
		40-49 years	42%	40-49 years	36%
		Over 50 years	8%	Over 50 years	13%
3	Education	high school 53%		higher education 47%	
4	Professional Position or Role	Owner	managerial level	specialists	IT department personnel
		29%	42%	18%	11%
5	Experience with AI Technologies	prior knowledge	familiarity	practical experience	
		47%	36%	17%	

The analysis of the research group indicates significant demographic diversity, with male respondents (72%) strongly prevailing over female respondents (28%). The majority of respondents fall into the age categories of 40-49 years (42% men, 36% women) and 30-39 years (31% men, 45% women), indicating that the surveyed professionals predominantly represent active, mid-career individuals. Educationally, the sample is balanced, with slightly more participants having completed high school (53%) compared to higher education graduates (47%). Regarding professional roles, managerial-level respondents constitute the largest group (42%), followed by business owners (29%), specialists (18%), and IT department personnel (11%), highlighting that decision-makers dominate the sample. The respondents' experience with AI technologies is relatively high; almost half report prior knowledge (47%), while fewer indicate familiarity (36%) and practical experience (17%), suggesting that theoretical understanding of AI outweighs direct implementation experience among participants.

After conducting the survey, the collected data were systematically analyzed, and relevant conclusions were formulated. The questionnaire was divided into multiple thematic sections, where participants were asked to evaluate statements using a 7-point Likert scale, with 1 representing complete disagreement and 7 indicating complete agreement. The initial section of the questionnaire assessed respondents' familiarity and understanding of generative artificial intelligence (GenAI) technologies and their application in supply chain management. The subsequent section identified the roles within organizations responsible for decision-making regarding knowledge management and the integration of AI-driven solutions. Another part of the survey concentrated specifically on investments related to the implementation of generative AI tools (e.g., ChatGPT, DALL·E) aimed at enhancing knowledge exchange processes. This included exploring the utilization of advanced IT solutions, software applications, and digital platforms supporting real-time communication and documentation automation. The questionnaire further examined aspects of accessibility, cooperation between supply chain partners facilitated by AI solutions, and the practical adoption of GenAI tools within organizational structures. Respondents' preferences, attitudes, and intended future behaviors toward adopting GenAI were evaluated, enabling the classification of their readiness and openness into three distinct groups: low, medium, and high acceptance of AI-supported knowledge exchange. Such classification allowed for a clear identification of barriers, opportunities, and potential directions for further technology implementation tailored to each group's awareness level. The research sample comprised professionals aged predominantly between 26 and 50 years, with 54% male respondents and 46% female respondents, considered representative of the target professional population involved in supply chain management. Considering statistical rigor, the analysis applied a significance level of 0.01 and a maximum estimation error of d = 1% (u = 3.1426). The study was intentionally conducted in selected European Union member countries known for their strategic approach and progressive implementation of digital and AI-based solutions in supply chain operations, reflecting comparable planning practices and technological maturity. The author utilized Microsoft Excel, Statistica, and SmartPLS3 software to perform statistical analyses. SmartPLS3 was specifically chosen for its capability to manage complex data relationships through Structural Equation Modeling (SEM-PLS). This allowed for robust verification of the research model and hypotheses, providing precise insights into the effects of generative artificial intelligence on knowledge exchange and management effectiveness within supply chains.

4. Empirical Results

This section presents the empirical findings related to the impact of generative artificial intelligence (GenAI) on knowledge exchange processes within supply chains. The survey assessed six key constructs: awareness of GenAI technologies, availability of GenAI tools, organizational responsibility for knowledge management, improvement in real-time communication, forecasting efficiency, and effectiveness of knowledge sharing. Table 2 summarizes the mean values and Cronbach's Alpha coefficients for each construct, ensuring the reliability of the measurements. The results indicate that Forecasting Efficiency received the highest mean score (M = 5.12; α = 0.93), suggesting that respondents perceive GenAI as particularly valuable in enhancing forecasting and planning activities within supply chains. Real-Time Communication Improvement also scored highly (M = 4.68; α = 0.84), demonstrating that GenAI significantly contributes to streamlining communication processes between supply chain partners. Awareness of GenAI technologies was rated moderately high (M = 4.45; α = 0.87), indicating that knowledge and familiarity with generative AI tools such as ChatGPT and DALL·E are increasingly widespread across organizations. Similarly, Knowledge-Sharing Effectiveness achieved a positive evaluation (M = 4.07; α = 0.83), highlighting GenAI's role in facilitating better collaboration and learning within supply chain networks. On the other hand, Availability of GenAI Tools (M = 3.15; α = 0.91) and Responsibility for Knowledge Management (M = 3.28; α = 0.85) recorded lower mean values. These findings suggest that despite rising awareness, many organizations still face barriers related to limited access to GenAI solutions and a lack of clearly assigned roles or strategies for managing AI-generated knowledge. Overall, the empirical data emphasize the need for organizations not only to build awareness of GenAI technologies but also to invest in accessible infrastructures and formalize knowledge management structures to fully leverage the benefits of GenAI in supply chain operations.

Table 2: Mean values and Cronbach's α coefficient

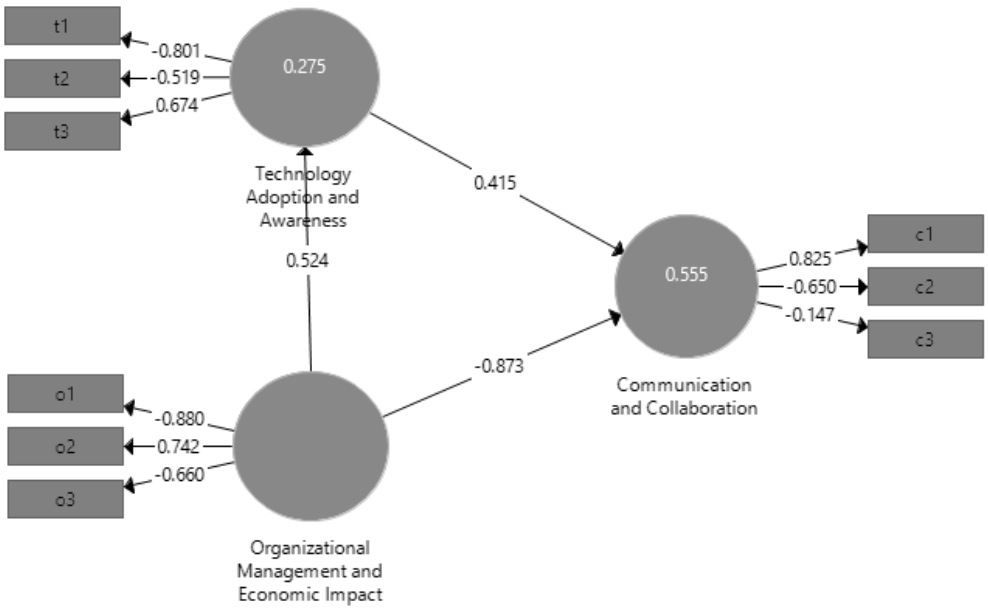
Variable	Mean	Cronbach's Alpha
Awareness of GenAI	4,45	0,87
Availability of GenAI Tools	3,15	0,91
Responsibility for Knowledge Management	3,28	0,85
Real-Time Communication Improvement	4,68	0,84
Forecasting Efficiency	5,12	0,93
Knowledge-Sharing Effectiveness	4,07	0,83

Based on the collected data related to the application of generative artificial intelligence (GenAI) for enhancing knowledge exchange in supply chains, Table 3 provides a detailed summary of the factors investigated, including their respective average values and reliability coefficients (Cronbach's alpha). The presented factors encompass key dimensions such as awareness and understanding of GenAI technologies, organizational responsibility for knowledge management, economic benefits from implementing AI-based solutions, availability and accessibility of GenAI tools, adoption of decision-support applications, improvements in real-time communication, forecasting accuracy, supply chain collaboration, and overall knowledge-sharing efficiency. Respondents rated each factor, enabling subsequent analysis of inter-factor correlations. Additionally, the standardized Cronbach's alpha was calculated for each category to verify the internal consistency and reliability of the measurement scales utilized, ensuring the robustness of the findings and conclusions drawn from the analysis.

Table 3: Relationships between factors

	Awareness	Availability	Responsibility	Communication	Forecasting	Knowledge Sharing
Awareness	1	0,62	0,59	0,48	0,5	0,46
Availability	0,62	1	0,56	0,52	0,49	0,45
Responsibility	0,59	0,56	1	0,41	0,43	0,39
Communication	0,48	0,52	0,41	1	0,58	0,51
Forecasting	0,5	0,49	0,43	0,58	1	0,57
Knowledge Sharing	0,46	0,45	0,39	0,51	0,57	1

The analysis of the survey results provides empirical insights into the application of generative artificial intelligence (GenAI) in supporting knowledge exchange within supply chains. Key variables measured in the study include awareness of GenAI, availability of GenAI tools, organizational responsibility for knowledge management, real-time communication improvement, forecasting efficiency, and overall effectiveness of knowledge sharing. Each variable was evaluated using a 7-point Likert scale, and internal consistency was assessed using Cronbach's Alpha. Among the six measured dimensions, the highest average score was recorded for Forecasting Efficiency (M = 5.12; α = 0.93), indicating that respondents perceive GenAI as a highly valuable tool for improving predictive capabilities in supply chain planning. Similarly, Real-Time Communication Improvement (M = 4.68; α = 0.84) and Awareness of GenAI (M = 4.45; α = 0.87) received relatively high scores, reflecting a growing recognition of GenAI's role in enhancing organizational communication and awareness. Conversely, the lowest average scores were observed for Availability of GenAI Tools (M = 3.15; α = 0.91) and Responsibility for Knowledge Management (M = 3.28; α = 0.85). These results suggest that despite increasing awareness, many organizations still lack sufficient access to GenAI tools or clearly defined structures responsible for AI-integrated knowledge management. Correlation analysis revealed strong and meaningful relationships among several variables. Notably, Forecasting Efficiency was strongly correlated with Knowledge-Sharing Effectiveness (r = 0.57) and Communication Improvement (r = 0.58), demonstrating that organizations that leverage GenAI for predictive purposes also benefit from improved collaboration and knowledge flow. Furthermore, Availability of GenAI Tools showed significant correlations with both Communication (r = 0.52) and Awareness (r = 0.62), highlighting that accessibility to AI solutions is a key enabler of effective implementation. Overall, the results underscore the importance of not only technological capability but also organizational readiness and structural support in the successful integration of GenAI into supply chain knowledge management. These findings support the hypothesis that generative AI can substantially improve collaboration, communication, and decision-making in complex, distributed supply networks.



Technology Adoption and Awareness		**Organizational Management and Economic Impact**		**Communication and Collaboration**	
T1	Awareness and Understanding of GenAI Technologies	O1	Organizational Responsibility for Knowledge Management	C1	Real-Time Communication Improvement through GenAI
T2	Availability and Accessibility of GenAI Tools	O2	Implementation of GenAI Solutions with Economic Benefits	C2	Enhanced Collaboration and Integration in Supply Chains

Technology Adoption and Awareness		**Organizational Management and Economic Impact**		**Communication and Collaboration**	
T3	Adoption of AI-based Decision Support Applications	O3	Accuracy and Efficiency of Forecasting and Planning	C3	Knowledge-Sharing Efficiency and Learning within Organizations

Figure 3: SEM structural equations for GenAI

To better understand the relationships between the examined constructs, a structural equation modeling (SEM) analysis was conducted using the Partial Least Squares (PLS-SEM) method. The model tested the influence of two latent variables—Technology Adoption and Awareness and Organizational Management and Economic Impact—on the outcome construct Communication and Collaboration, which is critical for effective knowledge exchange in supply chains. The figure below illustrates the tested structural model along with factor loadings, path coefficients, and explained variance (R^2). Technology Adoption and Awareness has a positive and significant effect on Communication and Collaboration ($\beta = 0.415$), with an R^2 value of 0.555, indicating that this construct explains over 55% of the variance in communication and collaboration effectiveness. This highlights the importance of technology familiarity and readiness in facilitating GenAI-supported knowledge exchange. Organizational Management and Economic Impact shows a strong negative relationship with Communication and Collaboration ($\beta = -0.873$), which may reflect that organizational inefficiencies or economically driven AI initiatives without strategic alignment can undermine effective collaboration. This finding requires further qualitative investigation, but may point to overly cost-focused implementations lacking employee or knowledge integration. In addition, Organizational Management and Economic Impact significantly predicts Technology Adoption and Awareness ($\beta = 0.524$), suggesting that managerial structures and perceived economic outcomes directly influence how organizations approach and adopt GenAI tools. The R^2 values are 0.275 for Technology Adoption and 0.555 for Communication and Collaboration, suggesting that the model has moderate to strong explanatory power.

The findings from the structural equation model reveal that economic incentives alone are insufficient to ensure the successful implementation of generative artificial intelligence (GenAI) in supply chain knowledge management. While the organizational management and economic impact construct positively influences technology adoption, it simultaneously exerts a strong negative effect on communication and collaboration outcomes. This indicates that organizations focusing solely on cost efficiency or short-term performance metrics may unintentionally hinder the broader collaborative benefits that GenAI can deliver.

In contrast, the adoption and awareness of GenAI technologies have a clear and positive influence on communication and collaboration across supply chain networks. This highlights the importance of technological readiness, digital competence, and internal knowledge culture as enablers of effective AI-supported knowledge exchange.

To fully leverage the potential of GenAI, organizations must ensure that their implementation strategies are not limited to financial justification or operational efficiency. Instead, they should adopt a more holistic approach that emphasizes strategic alignment, cross-functional cooperation, and employee engagement. Balancing economic performance with an inclusive, knowledge-driven culture will be essential to achieve sustainable and collaborative value from GenAI in supply chain contexts.

5. Discussion and Conclusion

The findings of this study provide significant insights into the role of generative artificial intelligence (GenAI) in enhancing knowledge exchange processes within supply chains. The empirical results confirm that the application of GenAI technologies such as ChatGPT and DALL·E positively impacts several critical areas, including real-time communication improvement, forecasting efficiency, and the overall effectiveness of knowledge sharing. Organizations that demonstrated higher awareness of GenAI tools and greater accessibility to these technologies reported notable improvements in decision-making processes and inter-organizational collaboration. These outcomes support the premise that GenAI facilitates faster, more accurate knowledge dissemination, helping to overcome traditional barriers such as information silos and fragmented communication channels. Despite the promising potential of GenAI, the study also identified significant barriers to its widespread adoption. Limited availability of GenAI tools and insufficient organizational structures for

knowledge management emerged as key obstacles. Additionally, concerns regarding data security and ethical use of AI-generated content persist across industries. These challenges align with the observations of Ooi et al. (2024) and Perera et al. (2021), who emphasized the need for robust governance frameworks to mitigate risks associated with misinformation, algorithmic bias, and compliance with regulations such as the EU AI Act. Sectoral differences in GenAI adoption were also evident. Companies in the logistics and manufacturing sectors exhibited a higher degree of GenAI integration compared to the retail sector. Organizations operating in logistics and manufacturing, where real-time data exchange and predictive analytics are critical, have been more proactive in adopting GenAI solutions. In contrast, retail companies showed a more cautious approach, driven by heightened concerns about data protection and the unpredictability of AI-generated content. These findings are consistent with previous research by Hu and Zhao (2024), which indicated that industries with operational dependencies on real-time information processing are more inclined to invest in AI technologies. In relation to the existing literature, this study extends prior knowledge by providing empirical evidence specifically focused on the application of generative AI in knowledge exchange within supply chains—an area that has been underexplored compared to studies centered on traditional predictive AI models (Tao, 2020; Shang et al., 2024). Unlike previous works that largely addressed automation and operational optimization, the current study highlights GenAI's unique contributions to enhancing collaborative practices and dynamic knowledge flows across distributed supply networks. From a practical perspective, the findings suggest that companies aiming to leverage GenAI for competitive advantage in supply chain management should prioritize three strategic actions. First, they should invest in broadening employee awareness and technical competencies related to GenAI tools to increase organizational readiness. Second, it is critical to ensure the widespread availability and accessibility of scalable GenAI applications tailored to sector-specific needs. Third, firms must develop clear knowledge governance frameworks that address ethical considerations, data integrity, and compliance with emerging AI regulations. To translate these insights into actionable strategies, we propose a three-stage GenAI Management Integration Framework (GMIF) tailored for supply chain environments. First, the Preparation Phase requires organizations to assess technological readiness, including IT infrastructure, data maturity, and employee digital competencies. This phase should include awareness campaigns and GenAI literacy programs to ensure strategic alignment between stakeholders. Second, the Implementation Phase emphasizes modular deployment of GenAI tools—starting with communication automation and decision-support systems—under strict compliance with AI governance frameworks such as the EU AI Act. During this stage, firms should assign formal roles for AI-knowledge oversight, ensuring traceability and accountability for generated content. Third, the Sustainability Phase focuses on continuous evaluation and adaptation of GenAI practices through performance audits, stakeholder feedback loops, and cross-sector benchmarking. These phases aim to facilitate structured, ethical, and scalable integration of GenAI into SCM knowledge management models. Importantly, this framework can be adapted to sector-specific dynamics, as demonstrated by the differentiated adoption trajectories observed between logistics, manufacturing, and retail in this study. Overall, the study emphasizes that while GenAI offers transformative opportunities for supply chain knowledge management, its successful adoption requires a strategic, structured, and ethically responsible approach.

6. Conclusion

This study examined the impact of generative artificial intelligence (GenAI) on knowledge exchange processes within supply chains, focusing on key areas such as real-time communication, forecasting efficiency, and organizational knowledge-sharing practices. The findings confirmed that greater awareness and accessibility of GenAI tools are strongly associated with improved decision-making, enhanced collaboration, and more effective knowledge management across supply chain networks. However, barriers such as limited tool availability, unclear organizational responsibility for knowledge management, and concerns about data security and ethical use of AI-generated content continue to hinder widespread adoption. Despite providing important insights, the study is not without limitations. The research was geographically restricted to Central Europe (Poland, the Czech Republic, and Slovakia), which may limit the generalizability of the findings to other regions. Additionally, the study relied on self-reported survey data, which may be influenced by subjective perceptions rather than objective measurements of GenAI adoption and effectiveness. Future research should aim to address these limitations by conducting in-depth case studies within individual organizations to explore specific adoption paths and challenges. Qualitative research approaches, such as interviews and focus groups, could provide richer insights into organizational dynamics, employee perceptions, and leadership strategies related to GenAI integration. Moreover, longitudinal studies tracking the implementation of GenAI technologies over time would be valuable to assess their evolving impact on supply chain performance and innovation capabilities. In conclusion, while GenAI presents transformative opportunities for enhancing knowledge exchange in supply

chains, achieving its full potential requires strategic investment in technology, governance structures, and human competencies.

Ethics Declaration: Ethics approval was not required.

AI Declaration: AI tools were not used to create this article.

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PhD Research Papers

Collaborative Innovation Spaces as Enablers of Collective Leadership in Catalysing Ecosystem Emergence

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Abstract: This conceptual paper explores how collaborative innovation spaces (CIS) enable collective leadership in catalysing ecosystem emergence. Responding to current shifts in innovation management driven by digitalisation and platform ecosystems, this study builds on the recognition that cross-sector collaboration in ecosystems is essential to tackle complex societal challenges, from sustainability transitions to digital transformation for sustainable value creation. Although CIS, such as living labs, makerspaces, innovation hubs, virtual collaboration spaces, and communities, have been widely studied as promising arenas for open innovation and experimentation, their role in enabling collective leadership for ecosystem emergence remains undertheorised. To address this shortcoming, this study reviews literature on CIS and collective leadership, offering a novel synthesis of spatial, relational, and processual perspectives to explore the role of CIS as an enabler of collective leadership. In this paper, I define CIS as liminal: temporary, transitional spaces of being and becoming, where actors' relation(ship)s and interactions are deeply situated in a particular setting. Such in-between, transitional states where established roles, norms, and boundaries are suspended foster alternative ways of thinking, learning, and relational dynamics. Building on relational and processual perspectives, I introduce the concept of situational embeddedness to describe how it emphasises the context-dependent nature of CIS and underscores the importance of appreciating the possibilities created by space and shared interests. It draws on the notion of the social field—the interior dimension of a social system—to argue that leadership is not just enacted by individuals but co-created through collective attention, intention, and relational presence within CIS. Consequently, CIS enables collective leadership by fostering conditions in which individual decisions, interactions, and actions within a specific context become sources of emergence, reflecting individuals' transformative potential. As a result, I develop a conceptual overview of CIS as an enabler for collective leadership in catalysing ecosystem emergence. Rather than presenting new empirical data, this study advances theoretical understanding with several theoretical contributions and provides practical implications for innovation managers, ecosystem actors, and policymakers seeking to foster collaborative approaches.

Keywords: Collaborative innovation space, Collective leadership, Ecosystem emergence, Liminality, Situated embeddedness

1. Introduction

The ongoing shift in innovation management, driven by platform ecosystems and grand challenges, has extended the perspective on open innovation models to a broader ecosystemic understanding (Ferrigno et al., 2023; Ritala, 2023). This evolution necessitates multifaceted and sustained cross-sector collaboration as an imperative for value co-creation and problem-solving in complex environments (Autio & Thomas, 2022; Ritala, 2023). As collaborative innovation spaces (CIS) are characterised by less formal structures, routines, and practices, they allow actors to collectively navigate inter-organisational politics (Caccamo, 2020; Ollila & Yström, 2021) to initiate collaborations (e.g., Adibe et al., 2024). Accordingly, CIS provide an ideal setting for creating conditions for ecosystem emergence (Thompson et al., 2018; Daymond et al., 2023)—a process in which actors collectively discover, negotiate, and develop the structures, roles, and shared value propositions that constitute a functioning ecosystem (Autio et al., 2014; Thomas, Autio & Gann, 2022; Daymond et al., 2023). This processual, socially constructed view of ecosystem emergence aligns well with the concept of collective leadership, understood as a property of a social system that arises when individuals engage in collaborative thinking and action (Drath, 2001). However, although collective leadership and CIS have been widely studied, the intersection between these theoretical perspectives (Barney, 2018), particularly in the context of enabling ecosystem emergence, remains underexplored.

To address this shortcoming, I review literature on CIS and collective leadership to explore the role of CIS as an enabler of relational, collective leadership. In doing so, I advance theoretical understanding by integrating and extending existing research rather than presenting new empirical data (Gilson & Goldberg, 2015; Yadav, 2010). In this conceptual paper, I define CIS as liminal—temporary, transitional spaces of being and becoming (Küpers, 2011), where actors' relationships and interactions (Bradbury & Lichtenstein, 2000) are deeply situated within a particular setting (Scharmer & Pomeroy, 2024). In other words, drawing on Scharmer and Pomeroy's (2024) notion of the social field as the interior dimension of a social system, I propose that situational embeddedness in CIS refers to how relational dynamics shape processes of being and becoming. These dynamics create a living relational space of a social system as a property of collective leadership. In other words, by highlighting this context-dependent nature of CIS (Leminen et al., 2024), I suggest that such embeddedness, shaped by the

dynamic relations between being and becoming, is inherently alive. This insight invites a deeper appreciation and evaluation of the possibilities that emerge from space (Caccamo, 2020) and from the situation through shared interests (Thomas & Autio, 2014; Dzhengiz & Patala, 2023). Consequently, CIS enables collective leadership by fostering conditions in which individual decisions, interactions, and actions within a specific context become sources of emergence, reflecting individuals' transformative potential (Ospina, 2017). As a result, I develop a conceptual overview of CIS as an enabler for collective leadership in catalysing ecosystem emergence.

With these insights, my study makes theoretical contributions to CIS, collective leadership, and ecosystem literature. Through synthesising spatial, relational, and processual perspectives, I offer a conceptual foundation for future research and suggest further explorations of how different relational and contextual conditions in CIS interact to influence collective leadership within cross-sectoral collaborations and support broader ecosystem transformation.

Below, I first review the existing literature on CIS, their diverse forms, liminality, and situational embeddedness. Next, I elaborate on collective leadership and introduce relational perspectives on social interaction that clarify situational embeddedness within CIS, enabling emergence in collective leadership. I then propose a new conceptualisation of CIS as enablers of collective leadership, providing insights for innovation managers and ecosystem actors seeking to initiate and catalyse ecosystem emergence. I conclude with the key contributions, practical implications for innovation managers, policymakers, and ecosystem actors, and finally, with the limitations and suggestions of directions for future research.

2. Collaborative Innovation Spaces (CIS)

Although innovation scholars have conducted profound research on inter-organisational collaboration and made progress in analysing the relationship between collaboration, innovation, and the role of space (Boutillier et al., 2020; Caccamo, 2020; Ollila & Yström, 2021; Doloreux et al., 2023), they have paid less attention to the role of CIS—the context in which innovation takes place (e.g., Leminen et al., 2024)—as enablers of collective leadership in the context of ecosystem emergence. As a result, the implications of CIS for collective leadership remain largely unexplored in the ecosystem emergence literature.

CIS, such as cross-sector partnerships, living labs, innovation hubs, makerspaces, and virtual collaboration spaces and communities (Leminen et al., 2024) are characterised by less formal structures, routines, and practices. For example, living labs are open innovation ecosystems in real-life environments that foster co-creation and open innovation through testing and experimentation among the key actors of the Quadruple Helix Model: citizens, government, industry, and academia (ENoLL, 2025). In their recent article, Ollila and Yström (2025) examined large-scale Triple Helix (academia, industry, and government) collaborations in Northern Europe, which were combining public and private funding with the aim of organising collective activities to promote innovation and support industrial or regional development and sustainability. They shared similar concerns about the conditions for interaction and how members could relate to one another, expressing interest in learning more about multi-stakeholder management to foster value creation.

According to Caccamo (2020), innovation spaces have a material dimension, such as physical or digital infrastructure and objects, and a social dimension, which encompasses relationships and organisational culture. In their study of collaborative innovation practices, Yström and Agogué (2020) introduced the concept of "*in-between spaces*" as physical, cognitive, and virtual spaces between actors. These in-between spaces are "*relational spaces of becoming*", embracing disorder and ambiguity, "*created through social relationships*" (Ollila & Yström, 2025, 2). What is noteworthy here are the dynamics shaping these recursive spaces "*between actors created by and simultaneously creating social interaction*" (Yström & Agogué, 2020, 140).

Similarly, Oldenburg's (2001) "*third places*" are informal venues for social interaction beyond primary work activities that foster substantial innovation in community involvement activities. Furnari (2014) builds on the concept of third places, using it as a metaphorical and analytical anchor to characterise *interstitial spaces* as experimental, occasional, and transitory settings. Individuals interacting in these settings are more attentive to the immediate situation and the context, can experiment more easily, and are likely to experience liminality. Indeed, instances of interstitial spaces are common in contemporary cases of emerging practices (Furnari, 2014), catalysing interaction in the initiation of cross-field collaboration (Villani & Phillips, 2020) and innovation activities of collaborating groups and organisations (Powell et al., 1996; Greer & Lei, 2012; Ollila & Yström, 2016; Heil & Bornemann, 2018).

2.1 Liminality—a Transitional State of Becoming

Despite their diverse forms, CIS share core characteristics: They are socially constructed, experimentally oriented, and inherently liminal spaces (Caccamo, 2020). In organisational space literature, liminal spaces are studied as, e.g., physical corridors, university-industry centres, incubators, or social networks (Stephenson et al., 2020). Liminality denotes a transitional state of becoming, being on the threshold or boundary—no longer in the previous state, yet not fully in the next (Küpers, 2011; Tagliaventi, 2019; Piironen, 2024; Popova et al., 2025). This is an in-between, transitional state in which established roles, norms, and boundaries are suspended (Turner, 1974).

As individuals or groups inhabit this liminal space—no longer bound by former identities or structures yet not entirely redefined (e.g., Tagliaventi, 2019)—they become more open to alternative ways of thinking, relating, and acting. This can foster the potential for innovation, collective sensemaking, and the reconfiguration of social or organisational arrangements. As such, liminality often entails intense learning and development, and the ambiguity of liminal space blurs boundaries between actors. This may also cause confusion and hinder navigation in the complexity of relationships (Ollila & Yström, 2025). Despite the "strangeness" of the liminality, it embraces endings and new beginnings so that it can offer a transformational outcome. Popova et al. (2025, 40) describe liminoid transition processes as situations in which individuals *"step out of their old world, generate new ideas, and experiment and innovate to initiate change*." Similarly, Cartel, Boxenbaum, and Aggeri (2019) conceptualise experimental spaces as transitory social settings where actors test alternative action models within institutionalised fields.

2.2 Situational Embeddedness of CIS

Scharmer and Pomeroy (2024) denote these spaces of collaboration, relationships, and interactions as the social field—the interior dimension of a system—where the *"whole is viewed as an emergent entity worthy of attention and its own specific forms of inquiry"* (2024, p. 26). Understanding the collective interior dimensions of social systems, beyond visible relational patterns, highlights the social field where these patterns originate and potential futures are sensed (ibid). Drawing on this conceptualisation in combination with liminality, I define CIS as *temporary, transitional spaces of being and becoming, where actors' relation(ship)s and interactions are deeply situated in a particular setting* (Scharmer and Pomeroy, 2024). This situatedness emphasises the context-dependent nature of CIS (Leminen et al., 2024) and underscores the importance of appreciating the possibilities created by space (Caccamo, 2020) and shared interests (Furnari, 2014; Thomas & Autio, 2014; Dzhengiz & Patala, 2023).

To sum up, situational embeddedness in CIS refers to how interactions, decisions, and innovations are shaped by the dynamic, relational, and contextual conditions of a specific moment in space and time. This approach recognises space as an essential catalyst in co-shaping encounters and emphasises the social field and full presence in the moment (Scharmer & Kaufer, 2013; Scharmer & Pomeroy, 2024) as crucial for sensing and presencing emerging opportunities— *"to see the coming-into-being of the new" (Scharmer, 2001, p. 137).* Scharmer (2001) refers to this capacity as a form of tacit knowledge that precedes its embodiment in everyday practice. Such knowledge arises from the interplay between individual and collective intention and attention (Scharmer & Pomeroy, 2024), where alignment between the two can create conditions for emergence. In this article, I extend this perspective to the realm of collective leadership enabled by CIS.

3. Collective Leadership

In this paper, collective leadership is understood as relational leadership (Drath, 2001; Uhl-Bien, 2006; Drath et al., 2008; Ospina, 2017), which is enacted through social interactions that generate shared direction and meaning (Crevani, Lindgren, & Packendorff, 2010; Denis et al., 2001, 2012; Raelin, 2016; Empson et al., 2023). Consistent with Drath's (2001) notion of relational dialogue, collective leadership is conceptualised not as an individual's act but as a social system's property (Ospina, 2017). Thus, leadership becomes a collaborative process in which individuals reflect and contribute to collective participation.

Collective leadership does not depend on hierarchical positions within the organisation or on followers (Uhl-Bien, 2006). Instead, it focuses on the system of relationships (Ospina, 2017) that continuously evolve in relating with oneself, others, and 'world' (Scharmer & Pomeroy, 2019). Here, 'world' denotes the situational context and inter-organisational reality of individuals. Relating with others can be easily understood by establishing connections, understanding, and/or engaging with them emotionally or socially. For example, how we relate to each other shapes the group dynamic. Individual and cultural qualities of relating then affect the patterns of

thinking, conversing, and organising (Scharmer & Pomeroy, 2019). Thus, relating with self and world matters, too.

Leadership's relational dimensions are amplified when it is viewed as the outcome of shared sense-making, emerging from the interdependencies among organisations and their members (Ospina et al., 2012; Foldy et al., 2023). Similarly, Fletcher (2004) describes distributed leadership as fostering high-quality social interactions that require relational skills such as self-awareness, empathy, vulnerability, and openness to learning. This highlights the possibilities of encounters in specific situations and the importance of presencing—being fully present in the moment.

Ospina (2017, 275) underscores the importance of space in collective leadership as *"intentional work to create spaces where participants can enact their leadership for the common good."* Relational leadership builds on this by emphasising leadership's collective and situated nature, focusing on how it is produced and performed in specific contexts (Crevani et al., 2007; Denis et al., 2012; Shevchuk & Reuter, 2025). Individual actors (self), the group or network (others), and the situational context (space) are all significant as they all contribute to the processual dynamics in the in-between space. Therefore, the individual mindsets—including values, beliefs, worldviews, and related cognitive, emotional, and relational capacities (often referred to as inner or personal dimensions, e.g., Wamsler, 2020, or conditions, e.g. Hakio & Mattelmäki, 2023)—play a crucial role. Alongside activities, they represent what Meadows (1999) calls 'deep leverage points' for enabling transformational change. The importance of inner dimensions is highlighted by social movements such as the IDG Initiative, which promotes Inner Development Goals (IDGs) as a means better to achieve the Sustainable Development Goals (SDGs) (IDG Foundation, 2023).

To summarise, Scharmer and Pomeroy's (2024) conceptualisation of the social field—the interior dimension of a system encompassing collaboration, relationships, and interactions (i.e., CIS in this paper)—can be understood as central to collective leadership, which fundamentally revolves around relation(ship)s in social systems (Ospina, 2017). This relational social system is alive, continuously engaged in being and becoming through relationships and interactions (Bradbury & Lichtenstein, 2000) with oneself, others, and world. Thus, acknowledging the inner and outer dimensions of individuals' relational experiences is critically important for the transformational potential to emerge in CIS.

4. Discussion and Conclusions

In this article, I have examined how CIS can be understood as enablers of relational, collective leadership, catalysing ecosystem emergence. I have expanded existing conceptions of CIS and collective leadership beyond the social interactions and interconnections between individuals to include the significance of situational embeddedness in the constant process of being and becoming. To address liminality as an inherent quality of CIS, I defined CIS as temporary, transitional spaces of being and becoming, where individuals' relation(ship)s and interactions are deeply embedded in specific contexts. Drawing on Scharmer and Pomeroy's (2024) concept of the social field as the interior of a social system, I proposed that situational embeddedness in CIS and the dynamics shaping the process of being and becoming—how individuals relate with themselves, others, and world—create a living relational space of a social system as a property of collective leadership.

Recognising the inner and outer dimensions of relational experiences in this process to align individual and collective intention and attention around, e.g., a shared vision and purpose, can enable transformative potential to emerge. Consequently, CIS enables collective leadership to catalyse ecosystem emergence (Figure 1).

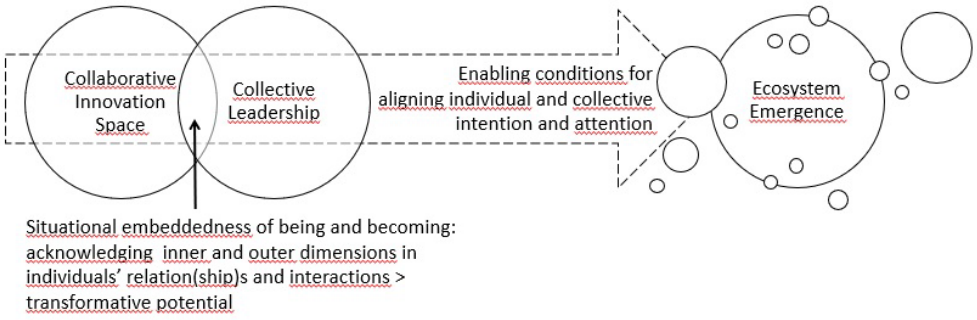


Figure 1: A conceptual overview of collaborative innovation space as an enabler for collective leadership in catalysing ecosystem emergence

4.1 Theoretical Contributions

This paper makes several theoretical contributions to the literature of CIS, collective leadership, and ecosystem research. First, it offers a novel synthesis of spatial, relational, and processual perspectives by conceptualising collaborative innovation spaces (CIS) as temporary, transitional spaces of being and becoming. This integration advances relational collective leadership theory (e.g., Uhl-Bien, 2006; Ospina, 2017) by demonstrating how the spatial (and temporal) dimensions of CIS shape the emergence of leadership through situated interactions and relation(ship)s. Second, by framing CIS as liminal, the study deepens the understanding of leadership as a state of becoming, rather than a fixed role, thereby extending the literature on liminality in organisations (Küpers, 2011; Tagliaventi, 2019) and connecting it to processual ontology (cf. Chia, 1995) of relational leadership (Crevani et al., 2010; Ospina, 2017). Finally, the concept of situational embeddedness—highlighting how relational and contextual dynamics shape leadership emergence in space and time—adds conceptual clarity to the role of recursive spaces in collaborative innovation (Yström & Agogué, 2020), offering a more nuanced understanding of how individuals' relational experiences influence systemic transformation.

4.2 Practical Implications

The study also provides practical implications for innovation managers, policymakers, and ecosystem actors. First, it reframes CIS not only as spaces for collaborative innovation but also as active enablers of relational, collective leadership. This perspective encourages managers to design CIS with intentionality, fostering environments where individual and collective intention and attention support emergent leadership practices and create enabling conditions. Second, the study emphasises recognising the inner dimensions of individuals as 'deep leverage points' (Meadows, 1999) that managers and facilitators should invest in developing practices and processes. Lastly, the paper highlights the potential of CIS to enable collective leadership in catalysing ecosystem emergence, e.g., in complex cross-sector partnerships. CIS can help actors transcend organisational and institutional boundaries and co-create shared visions by providing a liminal, temporarily non-hierarchical environment for experimentation and dialogue to nurture relationships and to create conditions for catalysing emergence. These insights can inform not only the design of CIS but also broader approaches to fostering innovation in ecosystems through relational and context-sensitive practices.

4.3 Limitations and Future Research

A key limitation of this work is the focus on the CIS's enabling side of collective leadership. As widely acknowledged, the innovation barriers and collaboration challenges may include, e.g., inherent tensions or paradoxical ones that can easily lead to conflict or an early failure of collaboration (e.g., Adibe et al., 2024; Ollila & Yström, 2025). However, recognising this limitation as a potential bias, my paper is purposely focused on integrating theoretical perspectives (Barney, 2018) for conceptual exploration rather than explicitly seeking solutions to innovation challenges addressed by the literature. Despite its limitations, my paper offers novel insights and a conceptual overview into how CIS can be understood as enablers of relational, collective leadership, catalysing ecosystem emergence.

Future research could benefit from empirically exploring the theoretical insights of this study. For example, examining the role of CIS and collective leadership in cross-sector partnerships could provide valuable insights for broader ecosystem transformation. Longitudinal research with theoretical lenses of process studies could be particularly useful in studying the ecosystem emergence and evolution phases and clarifying the dynamic nature of interconnectedness and the relational dimensions in the process. Closer attention to the qualities of relations and leadership emerging from the social field could shed light on the processes of being and becoming within CIS. More philosophical exploration of CIS's different forms and dimensions (e.g., virtual, cognitive, mental) in relation to collective leadership could further explicate the nuances in the underlying dynamics of emergence.

Acknowledgements

The author would like to sincerely thank the Finnish Foundation for Economic Education for funding this study.

Ethics declarations: Ethical clearance was not required for the research.

AI declarations: AI tools were used to the extent of initial ideation and language proofreading in the creation of this paper.

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AI-Driven Knowledge Management in Megaprojects: The Leadership Factor

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Abstract: With the increasing complexities and uncertainties, the integration of artificial intelligence has become paramount as the utilization of digital technologies has transformed the management practices across industries, especially in the domain of megaprojects. The paper analyzes the influence of integrating artificial intelligence (AI)- based knowledge management initiatives on the decision-making process of leadership in large-scale initiatives. As the supply chains of large-scale initiatives face complex challenges, leveraging artificial intelligence-based knowledge management initiatives has become essential to enhance resilience and operational efficiency. The qualitative data analysis has shown how AI-driven tools can significantly improve the data analysis in real time, ultimately facilitating knowledge management and enhancing the predictive insights shaping and devising strategic decisions. The AI adoption helps in fostering collaboration through knowledge sharing among the stakeholders, facilitating and promoting innovation and sustainability throughout the lifecycle of the project. Moreover, the AI utilization can deal with the upcoming challenges and uncertainties, helping in informed choices that align with the strategic objectives. The paper discusses the challenges in adopting the AI-based knowledge management initiatives. Leadership support can be marked vital as a clear support with visionary guidance is necessary to gain traction. The study investigates the role of leadership support in the AI-based KM initiatives for the success of the project. Leadership support plays an important role in the implementation of AI by creating a culture of knowledge sharing and embracing innovation and change. Furthermore, strong leadership assists in utilizing the resources, sustainably, and allocates them in the training and development of the human resource to equip them with the necessary knowledge with the help of AI. The qualitative interviews from the industry professionals reflected the positive influence of this step, as it not only empowered the employees but also mitigated the resistance to change. In summary, the paper reflects preliminary findings from an ongoing study that there is a need for leadership support to implement AI-based KM initiatives in megaprojects by articulating a clear vision, securing resources, addressing challenges, and maintaining and sustaining competitive advantage in megaprojects. This supportive framework ultimately enhances the likelihood of achieving project success and driving sustainable growth.

Keywords: AI, Knowledge management, Megaprojects, Leadership, Decision-making, Sustainability, Collaboration

1. Introduction

Megaprojects, large-scale, ambitious ventures involving staggering investments, diverse stakeholders, extended durations, and uncertainties, are crucial for economic development (Li et al., 2024). Megaprojects create new jobs, address social needs, and enhance the infrastructure. They also encounter complex challenges, including cost overruns, delays, governance issues, and other social and economic hurdles (Damayanti et al., 2018). Mainly, the changing market trends, environmental uncertainties, and political factors influence the effective operations of the megaprojects. China-Pakistan Economic Corridor (CPEC) is one of the megaprojects launched in 2015 under the Belt and Road Initiative, which aims to enhance connectivity between China and Pakistan. CPEC is spread over 3000 km, including infrastructure projects like highways, railways, and energy facilities. The primary goal of this megaproject is to stimulate economic growth, attract foreign direct investment, and create job opportunities, particularly in developing and underdeveloped areas of Pakistan. CPEC is aimed at improving trade routes and access to services, benefiting around 220 million people with an investment exceeding $62 billion. Energy security is also one of the focuses of the megaproject through power generation, fulfilling Pakistan's energy crisis. With the help of this bilateral cooperation, Pakistan and China can shape their economic future and strengthen the ties, ultimately promoting sustainable growth and regional integration (Awan et al., 2022).

Due to the expansive spread of the megaproject, complexities are inherent, which necessitates advanced strategies to manage risks and ensure resilience, calling for the integration of artificial intelligence (AI) in knowledge management (KM). AI can play a vital role in enhancing decision-making processes by doing real-time data analysis and predictive insights, which are critical for navigating the disruptions associated with megaprojects. AI tools can be leveraged to enhance collaboration among the stakeholders, ultimately promoting innovation throughout the lifecycle of the project (Ghobakhloo et al., 2025).

Leadership support is necessary for the implementation of AI based knowledge management initiatives in the organization by encouraging knowledge sharing and innovation to deal with the challenges due to the scale and complexity of the megaprojects (Wang et al., 2020). Strong leadership not only empowers employees but also mitigates resistance to change and facilitates the implementation of AI technologies through resource allocation (Ahmed et al., 2025). Although AI has significant potential in enhancing resilience but many organizations still lack the infrastructure and support for its integration in the decision-making process. Leadership support is required to fill this gap and ensure the implementation of AI-based KM initiatives to articulate a clear vision to allocate resources effectively (Li et al., 2025).

Previous research regarding megaprojects indicates a need for in-depth exploration of AI-based KM initiatives focusing on the economic impacts and the project's overall success (Cui, n.d). This study aims to fill the existing gap by exploring how AI-driven KM initiatives can enhance resilience amid a dynamic environment, including geopolitical instability and logistical complexities. The ongoing disruptions, previously exacerbated by COVID-19 and other geopolitical tensions, highlight the need for robust crisis management strategies by focusing on preparedness and adaptive resilient strategies ensuring business continuity (Yu et al., 2018).

The study investigates the critical role of AI-based knowledge management initiatives in enhancing the project's resilience and success. The role of leadership in the phenomenon is also explored by investigating the stakeholders' experiences. The research aims to provide valuable insights that can assist in the effective planning and implementation strategies for the success of megaprojects. The findings will be useful for policymakers and practitioners in the navigation of the complexities arising in the management of megaprojects, ultimately contributing to sustainable growth and project success in the long term.

2. Literature Review

Artificial intelligence is the capability of a machine to imitate human behaviour, assisting in real-time data analysis and decision-making. Moreover, effective knowledge sharing is also critical for sustaining resilience, enabling the stakeholders to address the potential risks proactively. AI-based knowledge management initiatives are mainly the integration of artificial intelligence technologies with the knowledge management practices to enhance knowledge creation, sharing, application, utilization, and transfer within the organization (Majumder, 2022). These initiatives are utilized to enhance the decision-making process and inculcate proactive risk management strategies by fostering collaboration among the stakeholders (Pomaza-Ponomarenko et al., 2023).

Implementing AI-driven KM initiatives mainly depends on the role of leadership in the megaprojects. Strong leadership fosters knowledge sharing and innovation, ultimately supporting the integration of AI (McDermott et al., 2024). Moreover, this support also empowers the employees resulting in the facilitation of the change management process and optimum resource utilization amid the ongoing complexities in the megaprojects (Wang et al., 2020). Effective leadership also supports stakeholder engagement and promotes teamwork within megaprojects (Safari et al., 2024). AI has been empirically tested to enhance resilience by enhancing the visibility, managing risks, and facilitating decision making (Riad et al., 2024; Attah et al., 2024). Project success demands the achievement of the objectives within the defined scope, time, and budget, ultimately ensuring the stakeholders' satisfaction. Through AI utilization for real-time data analysis, organizations swiftly anticipate and respond to disruptions. With the assistance of AI tools, knowledge sharing can be automated, ultimately enhancing organizational agility (Yang, 2024). The interplay of leadership, AI, and knowledge management practices can assist in the development of resilience in organizations. Resilience is the ability of the organization to be proactive and reactive in an uncertain environment. The organization can anticipate, respond to, and recover from unexpected disruptions (Wang et al., 2023). In the domain of CPEC, there are several disruptions ranging from environmental risks, political risks, to social disruptions (Awan et al., 2022). This integration not only helps the organization to adapt to a dynamic environment proactively but also helps deal with the disruptions, maintaining and sustaining the competitive advantage in the long term (Sullivan & Wamba, 2022; Božić, 2023).

3. Methodology

The research study utilizes a qualitative research design to explore the role of leadership support on the implementation of AI-based KM initiatives in megaprojects, specifically CPEC. Data is being collected through conducting semi-structured interviews from the "elite workers", influencing the decision making; i.e., project managers and industry experts, to gather insight regarding the research topic (Sumbal et al. 2017). The conference paper highlights the preliminary findings of the pilot study from the six participants from various projects under CPEC (Table showing the participants' details). This preliminary research aimed to refine the

interview guide and to gain insights for the final research design. The research analysis follows the technique of Charmaz's constructivist grounded theory and ATLAS.ti as software for organizing data, coding, and identification of research themes. Charmaz's theory has been utilized to explore the subjective experiences of the stakeholders. As the methodology allows for a nuanced understanding of how individuals interpret their experience, along with the challenges within this complex environment. Grounded theory is a step-by-step process where researchers revisit and refine their ideas back and forth to think critically and make analytical connections at any point (Gupta, 2024; Charmaz, 2006). The research study emphasized the critical role of leadership support for fostering knowledge sharing and innovation through the collaboration of AI. The research findings aim to enhance the resilience and operational efficiency in megaprojects, specifically (CPEC, ultimately contributing to the success of the project by sustaining its growth in the long term.

Table 1: List of the Participants in the Pilot Study

Company	*Designation*	*Domain*
A	Project Manager	Energy (CPEC)
B	Project In-charge	Energy (CPEC)
C	Research Analyst	Belt & Road Initiative Research Institute
D	Supply Chain Manager	Energy (CPEC)
E	Project Manager	Energy (CPEC)
F	General Manager	Energy (CPEC)

4. Results and Discussion

The integration of AI in the knowledge management initiatives offers crucial opportunities to enhance the success and the resilience of the mega project, i.e., CPEC. The interviews reveal that although the technology-driven knowledge management initiatives contribute to problem solving and overall project management, leadership support plays a critical role. The results back the AI's ability to analyze vast datasets, which resultantly enables organizations to identify potential risks before they escalate and creation of new relevant knowledge, as a participant told,

> *"AI can change how we run supply chains... With predictive analytics, we can make backup plans ahead of time."*

By this, the organization can maintain continuity in operations and mitigate disruptions with the participative leadership style within its projects. Moreover, the results highlighted that the leadership of their project utilizes AI's potential in real-time monitoring, and then knowledge is shared as this immediate intervention can prevent minor issues from developing into significant disruptions, enhancing the overall project's resilience.

The findings also state that AI facilitates the knowledge transfer among the stakeholders through collaborative platforms, which not only streamlines the data recording but also enables organizations to draw lessons from past practices. The knowledge-sharing collaborative platforms enabled by AI foster better communication among all stakeholders involved in megaprojects. As said by a participant,

> *"The use of collaborative platforms also fosters better communication... ensuring that everyone is aligned and informed."*

This alignment is critical in large-scale projects, as such a setup results in coordinated responses to challenges and ensures that all parties are working towards common goals. The results indicate that participative leaders play a crucial role in aligning the stakeholders and ensuring the effective usage of communication channels to address the challenges. This strategy maintains the operational focus amid this complex venture.

The results proved that AI-driven tools can enhance decision-making by providing insights derived from comprehensive data analysis. A participant mentioned,

> *"AI-driven tools can improve decision-making by analyzing vast amounts of data to predict trends and outcomes."*

This aspect not only allows the organization to respond quickly to disruptions such as regulatory changes. Some projects face delays and shutdowns as those projects lack the adaptive capability, stated by a participant, *" we*

are not asked for any opinion, we are told to perform any task, that's why there are a lot of issues". Moreover, in such projects, the utilization of AI to support knowledge management initiatives is also lacking, which can be regarded as one of the reasons for failure. The results suggest that leadership support has a direct influence on the implementation AI AI-based KM initiatives. More specifically, the authoritarian and abusive leadership style hinders its adoption, whereas participative leadership inculcates a supportive environment, to attain successful implementation and tangible outcomes, which demands reforms for the leadership in the projects where the implementation of AI-based KM initiatives is low.

4.1 AI Tools and Environmental Monitoring

The integration of AI-driven tools into decision-making is crucial as the interviews reveal how these technologies enhance knowledge sharing and collaboration among stakeholders, thereby improving the overall project's resilience. The findings described the utilization of AI tools for environmental monitoring. As per the results, the carbon footprints and emissions can be tracked through these tools, enabling real-time monitoring (Huang & Mao, 2024). The research found that the developing countries lack the leadership support to utilize AI for social coordination. As per the interviews, some of the projects have a portal where all the news is shared, hence the knowledge sharing is better. This indicates ongoing efforts to utilize technology for managing stakeholder communication (Iaia et al., 2023).

4.2 Leadership's Role in AI-Based Knowledge Management

Effective leadership is required to ensure operational continuity with the implementation of AI-based KM initiatives. Participative leadership facilitates the resolution of minor disruptions through sharing knowledge when and where required, proactively, ultimately enhancing the resilience of megaprojects.

4.3 Training and Generative AI Tools

According to the results, regular training sessions and workshops supported by the leadership keep everyone in the loop on best practices and new rules. These initiatives ensure that all team members are knowledgeable, fostering a culture of collaboration (Khare et al., 2025). The use of generative AI tools, such as the "net zero cloud," was noted to be used by some projects under CPEC, showing significant advancement. The AI tool reads the data and generates the reports, which need more focus and are non-compliant with the requirements. Such capabilities streamline knowledge management and facilitate proactive decision-making (Leoni et al., 2024). Despite the positive aspects of AI integration, challenges remain, particularly in developing countries. The results show a gap in the utilization of technology and transfer of knowledge, which can be filled with the help of leadership support. This study helps to distinguish itself from present literature by highlighting the practical applications of AI in uplifting knowledge sharing, specifically within developing countries where such technologies are used or underutilized. This research provides actionable insights for practitioners aiming to strengthen resilience in complex megaprojects through the utilization of AI-based KM initiatives.

4.4 Bridging the Gap: Leadership Support

A critical hurdle identified in the results is the lack of leadership support for utilizing AI-driven KM initiatives. Lack of top management support disturbs the allocation of required resources in decision-making processes. This finding highlights the importance of engaging top management (leadership) in promoting the utilization of AI tools to attain real-time data and analytics to enhance the knowledge base. The preliminary results highlight the fundamental role of leadership in the implementation of AI-based KM initiatives. In developing countries, the participative leadership style not only enhances collaboration but also ensures proactive planning to deal with disruptions and enhance resilience. So leadership support can be regarded as the missing link in the success of AI-driven KM initiatives. The following table summarizes the leadership styles and their influence on the AI-based KM initiatives and outcomes.

Table 2: Leadership styles and their influence

LEADERSHIP STYLE	KEY CHARACTERISTICS	IMPACT ON AI-BASED KNOWLEDGE MANAGEMENT INITIATIVES	OUTCOME
AUTHORITARIAN LEADERSHIP	- Centralized decision-making - Minimal stakeholder involvement	- Suppresses innovation - Reduces knowledge sharing - Hinders AI utilization	- Delays and disruptions - Ineffective implementation - Low project resilience

LEADERSHIP STYLE	KEY CHARACTERISTICS	IMPACT ON AI-BASED KNOWLEDGE MANAGEMENT INITIATIVES	OUTCOME
	- Rigid and hierarchical control		
ABUSIVE LEADERSHIP	- Hostile work environment - Lack of trust and collaboration - Disregard for stakeholder input	- Negligible or zero adoption - Lack of knowledge sharing - Resistance to change	- Complete failure of KM initiatives - Disengaged teams - Operational inefficiencies
PARTICIPATIVE LEADERSHIP	- Inclusive and collaborative decision -making - Encourages stakeholder participation - Proactive and supportive	- Facilitates AI utilization - Enhances knowledge sharing - Promotes proactive planning	- Improved operational resilience - Successful implementation- Timely responses to disruptions
LACK OF LEADERSHIP SUPPORT	- Limited resource allocation - Absence of strategic vision - Lack of training and engagement	- Underutilization of AI tools - Inadequate knowledge transfer - Poor collaboration	- Reduced project outcomes - Low adaptability to challenges - Missed opportunities for innovation

5. Conclusion and Future Work

The ongoing PhD research study highlights the interplay of AI-driven tools integrated in knowledge management and leadership support, significantly influencing the project's resilience and collaboration initiatives, specifically in megaprojects like CPEC. The preliminary results state the critical role of leadership support in AI-based KM initiatives, enabling real-time monitoring, predictive analytics, and effective knowledge sharing among stakeholders. However, there is a gap in the support from leadership and technological adoption, especially in developing countries. The ongoing research study can provide insights regarding other factors hindering the integration of AI in KM to enhance resilience and sustainability. Moreover, the future work can quantitatively analyse the different leadership styles and their influence on AI-based KM initiatives through mediating and moderating effects of different factors.

Acknowledgement

The authors are thankful for the support from the research office of the Hong Kong Polytechnic University, Hong Kong, under program code - RKSS.

Ethical Consideration: The research study prioritizes ethical considerations, which include informed consent, confidentiality, and cultural sensitivity. Transparency, data integrity, and beneficence are guiding the study to positively contribute to participants, communities, and sustainable practices within the megaproject framework.

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Quadruple Helix and Knowledge Management: Partnerships, Data Management and Regional Development

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Abstract. This paper summarises aspects from the doctoral thesis "Regional Development in Romania and Finland. Examples from Remote and Sparsely Populated Areas". It reffers to regional and rural development processes within cross-sectoral partnerships quadruple helixes. Knowledge management is a component of regional and rural development, generally and of local development processes and project management particularly. It is insufficiently acknowledged and accounted for. There are numerous cases when *involuntary knowledge management* occurs while carrying on regional or rural development, therefore the specific processes related to knowledge creation and management are conducted without awareness, harnessing less a more efficient functioning of the activity. At a very general level, social structure consists of the uneven puzzles of social subsystems facilitating or hindering different kinds of interactions (Giddens 1984). The conceptual model takes over Giddens' consideration about sub-systems, therefore it also assumes that each of them has different degrees of structuration and there are different kinds of interactions to be considered (Aldea-Partanen 2007). The theoretical framework employed accounts for concepts associated with regional development such as knowledge creation and management, innovation, sustainability, social networks and social capital, quadruple helix, and place-based development. Other terms, related to the policy framework, are considered in a critical manner: main available policies are briefly examined, at different levels, connecting them to elements from the theoretical framework. Policy implementation and evaluation tools, such as project cycle management are summarised and critically reviewed. This paper focuses on the way knowledge management may be used for knowledge based regional and local development. This paper provides a review of concepts related to knowledge management in regional development processes.

Keywords: Knowledge management, Regional development, Sustainable innovation, Quadruple helix, Involuntary knowledge management, Knowledge transfer

1. Introduction

"Locales are not just places but settings of interaction" (Giddens 1984, p. 118) The settings of interactions are determined by the locations being them physical or virtual. Regional development is understood in a broader sense, as the sum of the intentional or unintentional results of various policies implemented at EU, national or regional level, amended by the cultural, historical and organisational backgrounds' influences and accounting local policy context and international processes. Knowledge has a definitive role in formulation and implementation of regional and rural development policies.

In the context of Manuel Castells' information society (Castells 2004, Castells 2000), social networks play a crucial role in defining the significant differences between, and advantages of, regions.

This paper considers both the intentional knowledge management processes as well as the involuntary ones. Knowledge management is always a component of regional and rural development, generally, and of local development processes and project management, particularly. It is insufficiently acknowledged and especially accounted for in the interactions between local and regional level. There are numerous cases when involuntary knowledge management occur while carrying on regional or rural development. Therefore, the specific processes related to knowledge creation and management are conducted without proper awareness of the fact and functioning principles, hindering a more efficient functioning of the activity. From a policy point of view, special attention is paid to place-based development and research, as well as to learning regions.

The paper adopts Anthony Giddens' theory, according to which society is a combination of subsystems having different degrees of structuration and interactions. (Giddens 1984). The above model is used to analyse the changes occurring in particular regions. At a very general level, social structure consists of the uneven puzzles of social subsystems facilitating or hindering different kinds of interactions. The conceptual model takes over Giddens' consideration about sub-systems, therefore it also assumes that at regional level each of them has different degrees of structuration and there are different kinds of interactions to be considered (Aldea-Partanen 2007).

This perspective applies both on the fact that there are different subsystems to be considered while describing regional development, as well as on the various connections between policy makers and implementers, and

between various social groups within the society. This paper provides a summary of some key concepts used in the doctoral thesis as well as brief illustrations related to knowledge management.

2. Definitions of Innovation, Sustainability, and Knowledge Management

These definitions of innovation, sustainability and knowledge management are interconnected in the field of regional development. This section presents a selection of definitions to be accounted for and some of the implications considered important for regional development, generally, and for the one of sparsely and remote populated areas, particularly. This selection of definitions may be of use to regional developers or regional development researchers interested in adopting and adapting their tools.

2.1 Innovation – Selected Definitions

The novelty element is always a precondition while defining innovation. Nuances are set, reflecting upon economic, social or technological aspects. Some definitions are considered below, followed by focus on two innovation models. The successful exploitation of any new ideas may occur in the cases of local communities or regional or central government. (Aldea-Partanen, A, Keränen, H and Nevalainen 2003, p. 3) – "Social innovation is distinct from economic innovation because it is not about introducing new types of production or exploiting new markets in itself but is about satisfying new needs not provided by the market (even if markets intervene later) or creating new, more satisfactory ways of insertion in terms of giving people a place and a role in production" (OECD, LEED forum on social Innovation 2006).

Alternative foci of innovation are presented. While economic innovation has been seen as the main motor for development, more attention is paid to social innovation, as it brings a larger perspective to the solving of the problems. "'Social innovation' seeks new answers to social problems by: – Identifying and delivering new services that improve the quality of life of individuals and communities. – Identifying and implementing new labour market integration processes, new competencies, new jobs, and new forms of participation, as diverse elements that each contribute to improving the position of individuals in the workforce. – Social innovations can therefore be seen as dealing with the welfare of individuals and communities, both as consumers and producers. The elements of this welfare are linked with their quality of life and activity. Wherever social innovations appear, they always bring about new references or processes." (OECD, LEED forum on social Innovation 2006)

While the definition may still seem too related to the economic dimension, the long-lasting effects are possible just when social, cultural and environmental aspects are accounted for in economic development. "Social innovation is one key element of prosperity and a crucial aspect of sustainable development. … There is social innovation wherever new mechanisms and norms consolidate and improve the well-being of individuals, communities and territories in terms of social inclusion, creation of employment, quality of life. Social enterprises and the non-profit sector in general, have demonstrated to be means to achieve social and economic goals." (OECD, Social Innovations at Local Level) This definition of social innovation is very rich, referring to many aspects to be accounted for. The novelty element is contextualised and related to mechanisms and norms with a clear finality; enhancing and refining well-being as the purpose of the social innovative processes has multiple target groups: individuals, communities and territories. The definition also specifies the directions for well-being operationalisation, which is seen in relation to social inclusion, employment and quality of life. Therefore, social innovations at the local level are seen as crucial whenever they provide, with new mechanisms or norms positively affecting social inclusion, employment and quality of life in a manner serving not only some individuals but also communities and territories. Furthermore, this definition underlines the important roles of social enterprises and non-profit sector in achieving social and economic goals.

The concurrent innovation paradigm proposes a more complex approach of social innovation taking into consideration the type of actors involved in the interaction. Furthermore, it proposes a cycle perspective on innovation. Central to the Concurrent Innovation paradigm is "the human centric KBS virtual professional communities, which are intended to interplay in entanglement with traditional business entities, as well as with collaborative networked organizations such as companies' clusters and Virtual Enterprises" (Santoro, Bifulco, 2006, p. 2). *Knowledge Business Social* (KBS) Community consists of researchers, individual professionals, authorities, and other key persons aiming at addressing agreed business activities and sharing a common vision. The concrete activity is carried on by virtual teams, which combine the achievement of the jointly set results and the self-fulfilment of the members. The mechanisms through which they generate value are interaction, sharing and collaboration. There is certain communality between communities of practice, formed around knowledge sharing and the KBS communities. Whereas the communities of practice especially part the knowledge and social dimensions, the KBS community adopts an outcome-oriented approach. Santoro and Bifulco bring in two types

of such communities, "Incipient discipline KBS communities", potential creators of new knowledge disciplines and "Challenge-oriented KBS communities", where the knowledge purpose is less specified, but the activity is decided upon (Santoro, Bifulso, 2006, p. 4). The core elements of the concurrent innovation paradigm are co-creation, shared intent and the problem identification. Co-creation refers to the joint efforts of producing set results, such as products, services or whatever the members agree upon.

The shared intent is the actual starting point and the precondition for starting the activity, together with the problem recognition. As scope, the concurrent innovation paradigm must feed in the social innovation lifecycle. From a strategic perspective, it has human focus, and the strategic objectives are to increase creativity through full realization of individuals' human potential, to foster innovation driven business competitiveness and to enhance the capability of determining systemic innovations (same source, p. 7). Social innovation lifecycle is placing the knowledge creation and the activity of the KBS community in the centre of the cycle, in this manner a larger probability to achieve systemic innovations occurs.

Another form of generating innovation and of participation is witnessed in a Quadruple Helix partnership, a citizen extended version of Triple Helix (TH). As Leydesdorff and Etzkowiz mentioned (2001), university-private-governance partnership allows for the creation of innovation systems and generates a knowledge-based system. However, it is important to note that the degree of understanding how such systems function may enhance or limit the access to and performances of such a system (Leydesdorff, Etzkowiz 2001).

All aforementioned, certain preconditions are needed to allow and stimulate the formation of "business clusters that tap niche markets for products and services" (OECD, 2005, p. 12). Service provision has particular relevance in the countryside as urban areas are better endowed with such facilities while, quite often, rural areas struggle to maintain or build such services. Critically considering the initial linear patterns of the innovation, Etzkowitz' and Leydesdorff's Triple Helix model proposes a different approach modelled as a spiral for the innovation capturing multiple reciprocal interactions among institutional settings (public, private and academic) "at different stages in the capitalization of knowledge" (Etzkowitz' and Leydesdorff 1995; Viale, Ghiglione 2006). Etzkowitz' and Leydesdorff's Triple Helix model refers to the European Regional Innovation Systems and various examples of Industry-University cooperation (Aldea-Partanen 2007). The helixes' number of dimensions is not fixed at three or four. And any type of helix with a larger number of dimensions than three builds upon the original triple helix. The n-tuple helixes may as well contribute to regional development and a functioning of a quadruple helix having local-global as fourth dimension is just one of the possible extensions of the traditional Triple Helix (Leydesdorff 2012).

This paper reflects upon the relationships between knowledge management and project management for rural and regional development of sparsely and remote areas. The sustainability of innovations created in such development processes is facilitated by quadruple helix partnerships.

The Quadruple Helix concept has been used in various projects and programmes, being expanded as a co-operation forging tool in regional policies in European Union. It is nowadays taken into consideration in the current regional projects and programmes. "In addition to the three strains of the triple helix, knowledge regions pay an increasing attention to the participation of citizens, of engaging the public in the processes of knowledge creation, creating quadruple helix interactions" (Reichert 2006, p. 41). The current EU regional development policy aiming at creating knowledge regions accounts for the necessity of pooling together various knowledge resources, including the ones of the local inhabitants. However, the formulation of this preferable choice indicated a top-down approach, in which policymakers involved with knowledge regions see participation as a form to engage the public, usually a less involved part. The participation of citizens is a crucial part of the Quadruple Helix (QH), allowing for a better mobilisation of local capacity in local development. The innovation emerges and is consolidated or spread in the quadruple helix partnerships (Aldea-Partanen 2011). The role of QH in innovative processes is accounted for in many policies and projects, such as the **C**reating **L**ocal **I**nnovations through **Q**uadruple Helix CLIQ project co-financed by European Regional development Fund and made possible by Interreg IVC Programme. The "Quadruple Helix, with its emphasis on broad cooperation in innovation, represents a shift towards systemic, open and user-centric innovation policy" (Arnkil et al. 2010, p. 2). In their scientific reports CLIQ researchers identify four different types of QH models: 1) the "TH + users model", 2) the "Firm-centred living lab model", 3) the "Public-sector-centred living lab model", and 4) the "Citizen-centred model" (Arnkil et al. 2010, p. 7). In their analyses, they noticed that QH has the capacity of narrowing downs and sometimes even bridging innovation gaps. Their reflections illustrate in a practical manner how quadruple helix networks may contribute to building trust and how it may be reinforced by participation. The participants contributing to the cooperation for the concrete purpose of supplying certain services or products are sharing a

concrete common purpose and they may be aware of each other's capacities and they may be willing and able to actively allow the others to contribute to the process trusting that this will serve the innovation process. Furthermore, the public and regional authorities have an active role in renewing the local-regional "innovation ecosystem" (Arnkil et al. 2010, p. 11 /131). "This new innovation policy approach includes also a general shift … towards a more flexible, enterprise-oriented policies focusing on market developments. This has meant a transition from policy models looking for general 'best practices' towards more customized policies and policies supporting the development of in-house competencies, in both private enterprises and public organizations" (Arnkil et al. 2010, p. 12 /131). Pragmatically, the cooperation process allows for competencies development, therefore facilitating knowledge creation and transfers.

2.2 Knowledge Creation, Types and Management and Their Implications on Policy

Usually, knowledge is associated with the cognitive processes of individuals and organisations. Rarely all the implications of the analysis are noticed or considered. At a philosophical level, there is a tendency to search too much in the abstractions and to ignore concrete forms of knowledge. Andrew Sayer considers that "we reduce practice to knowledge, knowledge to science, and science to observation and contemplation". He considers it necessary to observe the context of knowledge and attempts to combat "the following (interrelated) misconceptions:

1. that knowledge is gained purely through contemplation or observation of the world;
2. that what we know can be reduced to what we can say;
3. that knowledge can be safely regarded as a thing or product, which can be evaluated independently of any consideration of its production and use in social activity;
4. that science can simply be assumed to be the highest form of knowledge and that other types are dispensable or displaceable by science." (Sayer 1992, p. 13)

Relating to the first misconceptions, Sayer reminds us that the formation of knowledge simultaneously depends on two contexts: the one of work, in which it occurs, and the one of language, which mediates its emergence. He combats the contemplative stance of knowledge, pointing out how different social scientists are an active part of the knowledge creation and change. Different languages, as culturally embedded, have slightly different ways in shaping processes. Speaking and writing are as important as making and doing, proposing the scientists to be more aware of these last aspects, as well as of what he calls "the unexamined practical consciousness". He also refers to academics' blind spot that is practical and tacit skills. (Sayer 1992, p. 15) Therefore, it is worth it to have a more careful look to tacit and local knowledge concepts, as well as to the involuntary knowledge management, for better understanding the social reality in regional and rural development processes.

Concluding he argues: "Knowledge – whether adequate or not – never develops in a vacuum but is always embedded in social practices and we can more fully understand the former if we know the latter" (Sayer 1992, p. 43). His view is adopted and adapted here. Consequently, examining knowledge in regional development of the sparsely populated areas can and should be done by both examining different theoretical concepts used by scientists in describing the processes, and by accounting how the social practices are shaped around them or ignoring them. For instance, being aware that social innovation is born even when the 'producers' have not the slightest clue of innovation concepts they apply. In the case of investigating mechanisms allowing for long-lasting cooperation, the researcher should be aware of the need to acknowledge the social practices, the local context as well while portraying regional development processes. This is why place-based development is a suitable approach in general and especially in the case of sparsely populated areas. Here the definition used is of knowledge management as the process of managing the knowledge in its various forms, occurred both at individual, organisational or network level. In European and North American contexts, it usually refers to dissemination of explicit knowledge, mainly through IT-mechanism and in some happy cases, also to management of tacit knowledge. The relevance of knowledge management in the context of regional and local development relates to the capacity of the regions to mobilise and attract resources, as well as to better use their own capacity, in an innovative way allowing for lasting development. Knowledge is one resource available in various forms at individual and organisational level.

Nowadays, there are some forms of *involuntary knowledge management* in regional development processes *whenever, in an ad-hoc manner, some of the available knowledge is mapped and managed for the use of development*. It may be the case of a certain development project or a regional body who has such an initiative. More profitable for the development processes is communication on the on-going processes of knowledge creation, as well as sharing information on the existing or past projects, programmes and processes. Ideally, each local or regional development body should have their own knowledge management operational plan,

allowing for knowledge creation and sharing. This builds as well upon Einstein's view, who appreciated that "the only source of knowledge is experience" (Kazi et al. 2006, NET source).

Knowledge management is also seen as discovery learning. In the context of knowledge society, which is set ahead, "a firm understanding of the interplay between the management of knowledge and learning is of strategic importance to create and maintain effective leaning processes in a large variety of non-traditional learning situations" (Naeve et al. 2008, p. 2). Practically, the views proposed here analyse the dominance in the definitions of knowledge between Western societies and Japan, illustrated with pertinent models, proposing concepts and approaches which can be used in the traditional learning environments and in the regional and local development processes, dominated nowadays of necessity of transferring best practices. Furthermore, according to the authors, managers should be 'drivers of learning' (Naeve et al. 2008 p. 2). Regional managers or regional development managers of dominantly rural areas need to be drivers of learning, stimulating knowledge sharing and creation, leading to better use of local resources. The next table presents the forms of knowledge and the correspondent investigation research methodology.

Table 1: Types of knowledge and corresponding methods of exploration

Type of knowledge	Consists of	Method of exploration
Explicit knowledge	Statements easy to recall	Quantitative method: standardised surveys
Implicit knowledge	Statements needing reflection and introspection	Qualitative methods: deep interviews and ethnographic methods
Silent knowledge	Practical actions	Qualitative methods: deep interviews and ethnographic methods
Subconscious knowledge	Feelings	Psychological methods
Tacit knowledge	*Practical actions and Statements needing introspection*	*Qualitative methods: deep interviews and ethnographic methods*
Local knowledge	*Statements easy to recall or practical actions or statements needing reflection and introspection*	*Quantitative qualitative standardised and methods: surveys, deep interviews and ethnographic methods*

Note: Table is based on the Göranzon typology, as presented by Naeve et al, for the first 4 forms of knowledge (Naeve et al. 2008, p. 4), with two additions (by author) taking account of the forms of knowledge existent in regional development processes, whether accounted or not.

There is a need for acknowledgment of tacit knowledge in development processes. While previous authors consider in a distinct manner knowledge creation and knowledge management, there is also a complementary view: knowledge management supposes the creation of knowledge, together with the skills and communication based on a desired and shared vision of the future. Knowledge management builds upon jointly defined values. "Knowledge management requires innovative responsible leadership" (Suurla et al. 2002, p.V, Aldea-Partanen 2003)

Is knowledge power per se, as Bacon proposed? The management of knowledge and especially its transfer is seen as power (Piepkorn 2010). Transferring knowledge suits the regional development processes, generally and the sparsely populated areas, in particular. Being aware of existing individual and organisational capacities, mobilising them in a targeted manner, as well as improving them by sharing acquired complex knowledge, as a part of the local development processes will positively impact the well-being and the development of the region. Cooperation is done more fruitfully when partners are knowledgeable about their organisational and region's capacities; therefore a well-conducted knowledge management serves the development process. If the resources are not yet enough for a proper in-house management, perhaps action-researchers may be used to

contribute to proper knowledge management. A particular situation of transfers occurs in the case of so called "knowledge triangle" (Myklebust 2009, Tenhunen 2009, Serra 2009, Flodström et al. 2009, Gordon 2010, Vilalta et al. 2010, Melin et al. 2011, Saublens et al. 2011). *The interactions between education, research and innovation are seen as key drivers of knowledge-based society* (Flodström et al. 2009, p. 7). While the hope is to convert university acquired knowledge into innovation stimulating development and generating revenues, the real challenge is done by the changing role of universities, which should remodel their functioning in a manner relying less on state aid and generating more profit. (Myklebust 2009) The ideal situation is that the knowledge acquired in the research to be transferred both through education and innovation processes in a manner benefiting citizens and businesses, therefore stimulating or preserving at least economic development. How do we administrate knowledge? One reply to this question is proposed by the following definition. "Knowledge management (KM) is the process of capturing, documenting, storing, retrieving, reusing, creating, and sharing the knowledge to increase company productivity and efficiency" (Piepkorn 2010). Similar operations are needed also in regional development processes in general and especially for the sparsely populated areas with low access to other pools of knowledge. As place-based development perspective proposes, the local resources must be known and put to use, and knowledge is essential for that. In the case of such region, it is less the case of increasing its productivity; sometimes it may just mean maintaining its productivity or re-inventing ways to be productive. Designing and conducting knowledge management combined with a place-based approach, it will certainly increase the efficiency of the region. Piepkorn also presents certain steps to be followed in the knowledge management process, to be also applied in the regional development of sparsely populated areas. The next table illustrates how each step proposed by Pipkorn is adapted for regional development.

Table 2: Steps to be followed in the Knowledge Management Process

Steps as proposed by Piepkorn (2010)	**Implications for regional development processes (Aldea Partanen 2011)**
Knowledge capture which involves content management and lessons learned	Capturing knowledge in regional development means being aware of local knowledge and the various settings around it. It is also a solution-oriented process by accounting conclusions of relevance for further development. Best practices are not the only way to move forward; learning from 'failures' is of crucial importance as well.
Knowledge document, store and retrieval for reuse which involves entering the captured knowledge in a retrievable repository (such as a database or competence center).	Knowledge document, store and retrieval for reuse which involves entering the captured knowledge in a retrievable repository (such as a database or competence center).
Knowledge creation, which involves activities such as project knowledge and experience or knowledge from innovation.	Creating knowledge is based on past experiences seen in a new manner; being aware of past projects and knowing while trusting innovation concepts may allow for a speedier and more robust knowledge creation. A "translation" in lay terms is recommended while working with innovations at local level, so common understanding may be assured.
Knowledge sharing which involves making the knowledge available to those who may benefit from it such as use of intranet, documenting good practices, and communities of practice.	While using of intranet and documenting good practices are already accepted as ways of knowledge sharing in most of the efficient regional development processes, creating and maintaining *communities of practice* still needs oriented efforts in development work. Communities of practice are a good way to share tacit knowledge. Working together and sharing what we individually worked on allows for joint learning and potentially stimulates knowledge creation as well.

3. Conclusions

The mentioned steps propose a linear approach of the corresponding processes. However, in reality many of such processes related to each step may overlap and so partially may also the steps themselves. The practitioners need to be aware of the complexity and non-linear nature of the reality. Innovation, knowledge and sustainability should be considered in their larger sense for a lasting effect in regional development processes. Cooperation and multi-disciplinary approach are necessary while investigating regional development

processes in general and for reshaping it in particular. “Transparent processes that facilitate effective two-way transfers of knowledge between public organizations and stakeholders are fundamental for establishing successful partnerships.” (Riege et al. 2006, p. 37)

Involuntary knowledge management could be converted in a form of open-system knowledge management. Knowledge management in public organisations and in participative processes of partnerships creation needs further attention both in terms of research and development processes.

Ethics declaration: The conceptual paper presented here is part of my doctoral thesis and no permission was needed.

AI declaration: I did not used any AI tool in the development of the paper

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Resilience and Sustainability in Organizations: A Conceptual Exploration

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Abstract: In an age where unexpected and disruptive events are becoming more frequent, businesses must be resilient to allow for sustained success. Over the past four years, global crises such as the COVID-19 pandemic, large-scale warfare in Europe, and ongoing trade conflicts have significantly impacted European and global businesses, economies, and societies. In addition to long-term disruptions, short-term challenges like natural disasters also pose risks. Scholars suggest that the latter may become more frequent due to rising global temperatures and climate change. This brings sustainability into focus – a concept centered on conducting activities without compromising the ability of future generations to meet their own needs. In this article, we look into organizational sustainability, an ability of businesses to operate with long-term success while balancing environmental, social, and economic factors. The aim of the article is to systematically explore and analyze the relationship between organizational resilience and organizational sustainability by reviewing existing literature. The study consists of a systematic review of 22 articles on organizational resilience and organizational sustainability, which resulted from a larger body of literature narrowed down to strictly relevant publications. The findings of this review reveal that the relationship between organizational resilience and organizational sustainability is multifaceted. Several studies indicate that sustainability enhances resilience by providing firms with the resources, knowledge, and adaptive practices needed to withstand crises, whereas others suggest that resilience contributes to sustainability by enabling organizations to maintain operations and achieve long-term goals. Some research highlights a bidirectional influence, where resilience and sustainability mutually reinforce each other, through continuous learning and knowledge-sharing mechanisms, whereas a few studies distinguish them as separate but interrelated components. Additionally, external factors, such as venture capital, knowledge networks, and digitalization are identified as influencing both resilience and sustainability.

Keywords: Organizational resilience, Organizational sustainability, Literature review, Conceptual model

1. Introduction

In times when sudden and unprepared events seem to appear frequently, businesses need to be prepared to perform sustainably. In the previous four years, the world experienced different crises such as Covid-19, large-scale mechanized warfare, and trade conflicts, which all had severe repercussions on European businesses, economies, and societies. At the same time, two important overarching issues, namely worldwide climate change and demographic change in most industrialized societies, bring sustained challenges and external change to organizations. Apart from long-term challenges, there are also singular, disruptive events, for instance natural disasters, data losses through defects or hackers, terrorist attacks, sabotage, and many more. Some of the latter may occur in the near to medium-term future even more frequently as side effects of larger-scale crises. Clearly, organizations that want to sustain their operations and their success need to be able to cope with and adapt to all these challenges. Therefore, there seems to be a connection between organizational sustainability and resilience, although, as will be seen below, this connection is not yet particularly well researched, despite the relevance of sustainability and resilience in today's societal and research discourse. In contrast, these two concepts have been researched separately from one another in a significant number of research works (Winnard *et al.*, 2014). However, the above way of thinking is a great motivation to study these concepts together, because both may be required in order to not just survive but to flourish as an organization (Winnard *et al.*, 2014).

This work's research hypothesis is that, beyond the aforementioned connection that directly arises from definitions of the two terms, there is little research on the finer grained detail of the connection between the two. To test this hypothesis, this article aims to assess the state of the art regarding the connection between organizational resilience and organizational sustainability. The questions for the ensuing literature research are formulated as follows:

- What is the relationship between organizational resilience and organizational sustainability as discovered and shown in published research works?
- Which other concepts influence the interconnectedness of organizational resilience and organizational sustainability?

2. Background

Before conducting the actual literature review, it is important to first better define the terms organizational resilience and organizational sustainability in the meaning relevant to the work. This will also help to define keywords and suitable search strings as starting points for the systematic literature review, and it will give some theoretical hints on how connections between the two concepts may look like.

2.1 Organizational Resilience

Regarding organizational resilience, as is often the case for such seemingly intuitive notions, there is no single agreed-upon definition. Etymologically, resilience is derived from Latin *resilio*, which means "to jump back" (Klein, Nicholls and Thomalla, 2003). Thus, organizational resilience can be understood as the ability of organizations like companies, businesses, or state actors to bounce back from unexpected adverse events, to recover and renew as a response to disruptive events, and even to thrive as a result. More generally, organizational resilience can be understood as a capability, outcome, process or behavior (Hillmann and Guenther, 2021), which shows that there is no perfectly sharp yet universal definition of the term. Organizations need resilience in order to cope with adversities (Bachtiar *et al.*, 2023). (Duchek, 2020) writes that resilience has stages: activation, response, and organizational learning. A possible sub-classification is to distinguish between proactive and reactive organizational resilience. While a reactive ability is very important, a proactive type of resilience can be crucial for sustained success (Raetze *et al.*, 2022). Proactive resilience consists of an organization's internal capability to leverage its resources and capabilities not only for tackling change but also for emerging from challenges with a greater repertoire of actions.

One can also categorize resilience according to the organizational level that is in focus. On the macro level, the organization is inspected as a whole. On this level, resilience can be seen as the capability of an organization to quickly adapt and respond to disruptions while maintaining continuous operations and safeguarding its workforce, assets, and overall viability. On the meso-level, according to (Hartwig *et al.*, 2020), team resilience is an outcome or a capacity at a team level. The work (Hartmann *et al.*, 2020) states that team resilience can be understood as an emergent process that arises from interactions within the team and manifests as a higher-level phenomenon. Resilient teams are able to deal with challenges, overcome problems and resist adversity (Borg *et al.*, 2022). On the micro-level, there is individual resilience. Resilient individuals are characterized by a stable personality (Kossek and Perrigino, 2016) and their ability to overcome and withstand adversity (Shin, Taylor and Seo, 2012). Some researchers see individual resilience as a capacity, i.e., as a state-like attribute that, while stable over certain periods, can be altered in the long term (Hartmann *et al.*, 2020). And, indeed, literature suggests that understanding individual resilience is the first step in order to understand organizational resilience as both influence each other (Hillmann and Guenther, 2021).

2.2 Organizational Sustainability

Based on the literal meaning of the word, etymologically stemming from Latin *sustinere* (to keep up, maintain, support), sustainability can be defined as the capacity to maintain some entity, outcome or process over time (Basiago, 1998). Whereas this definition covers today's usage in research and current debates, some attach a narrower meaning to it. For instance, in development literature, it usually explicitly refers to improving and sustaining a healthy ecological, social, and economical system for human development (Milne and Gray, 2013) and is, thereby, generally positively connotated. As such, in (Hák et al., 2016) it is argued that making economy and society sustainable is one of the biggest tasks mankind faces today as it is connected to the planet's fundamental limits. However, there is, again, no universal, sharp definition of organizational sustainability fully agreed upon in research. Like resilience, sustainability was also first used in the business context in the 1980s (Weber, 2023), and the term was defined as signifying "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987). Following this way of thinking, one can define organizational sustainability as when organizations can operate successfully in the long run while balancing environmental, social, and economic challenges and impacts (Weber, 2023). In this way of thinking, appearing often in today's scientific and public discourse, there are three conceptual pillars that sustainability rests on: "economic sustainability", "social sustainability", and "environmental sustainability" (Purvis, Mao and Robinson, 2019).

Many authors use corporate social responsibility (CSR), a related business-focused concept, when they refer to social sustainability (Tang, 2018). It is a business approach that aims to positively impact society and the environment while enhancing a company's brand image, encompassing four key areas: environmental impact, ethical responsibility, and financial obligations. Another, newer yet related, concept are ESG (Environmental,

Social, and Governance) criteria. ESG scoring can be seen as a framework to assess a company's sustainability and ethical impact by evaluating its environmental responsibility, social practices, and corporate governance standards. For instance, (Yan *et al.*, 2025) prefers ESG over CSR in their work because ESG scores are based on independent evaluations, making them more objective and less susceptible to bias. According to (Yan *et al.*, 2025), unlike CSR, which often consists of self-reported initiatives and voluntary disclosures, ESG provides quantifiable metrics that offer a more reliable and standardized assessment of a firm's sustainability performance.

3. Methodology of Systematic Literature Review

Concerning the first step of this work's approach to the systematic literature review, Figure 1 shows the article selection protocol adopted. Regarding the sample selection, the articles for the literature review were retrieved from the Scopus and Web of Science databases, and the gathered information was last updated in February 2025. Scopus, a scientific research database by Elsevier, was chosen for this review due to its reputation as a high-quality resource with extensive coverage of authoritative and influential scientific journals (Vieira and Gomes, 2009). Web of Science is also one of the most established and reputable research databases, which offers a comprehensive collection of high-quality academic journals across various disciplines (Baas *et al.*, 2020).

The keyword search on the Scopus and Web of Science databases was conducted within article titles, abstracts, and keywords, and based around the search terms organizational resilience and organizational sustainability. Moreover, based on synonyms of the word "organization", such as firm, corporation, company, and enterprise, the search was augmented to look for combinations of these synonyms in combination with resilience and/or sustainability. Importantly, an appropriate use of the wildcard character (asterisk, *) ensures that different grammatical constructions and different writings of the words (e.g., organizational vs. organizational in American vs. British English) are all covered. Purposefully, no forms of synonyms for the words "resilience" and "sustainability" were included in the search because the aim was to focus specifically on articles that directly address the core concepts of organizational resilience and organizational sustainability. The exact search string resulting from this and used in this work is depicted in Step 1 from Figure 1.

The first dated articles containing these terms in the databases are from 2003, so the systematic review looks at articles with publishing dates between 2003 and 2025. The search was then limited only to journal articles, i.e., excluding conference proceedings, books, and book chapters, and restricted to the following fields: Social Sciences; Business, Management and Accounting; Environmental Sciences; and Economics, Econometrics and Finance. The search results in Scopus showed 68 articles, whereas Web of Science found 41 articles, for a total of 109 articles. An Excel sheet was used to eliminate duplicates, where most duplicates could be eliminated automatically based on the given digital object identifier (DOI), and only a few had to be inspected by hand, e.g., when the DOI was missing. This way, 81 unique articles were obtained.

These 81 articles were then filtered according to a quality criterion, considering only articles from journals listed in the AJG ranking with a rating of 1 or higher or in the JUFO ranking with a rating of 1 or higher. This approach benefits the inclusion of articles of a certain quality standard by using widely accepted and reliable ranking methods. This selection reduced the number of articles from 81 to 44. To ensure that the sample included only articles relevant to our research question, which cannot be inferred from the keyword search alone, the abstracts were reviewed manually, and, when these did not yet allow to conclude definitely the relevance, the full articles. Based on this, only those articles that substantially addressed with their research the link between sustainability and resilience were selected, resulting in 15 articles.

A backwards and forwards search was carried out and a further three articles were added, yielding seven additional articles in total. These 22 articles were read in full, and all results were documented in an Excel spreadsheet, as discussed subsequently.

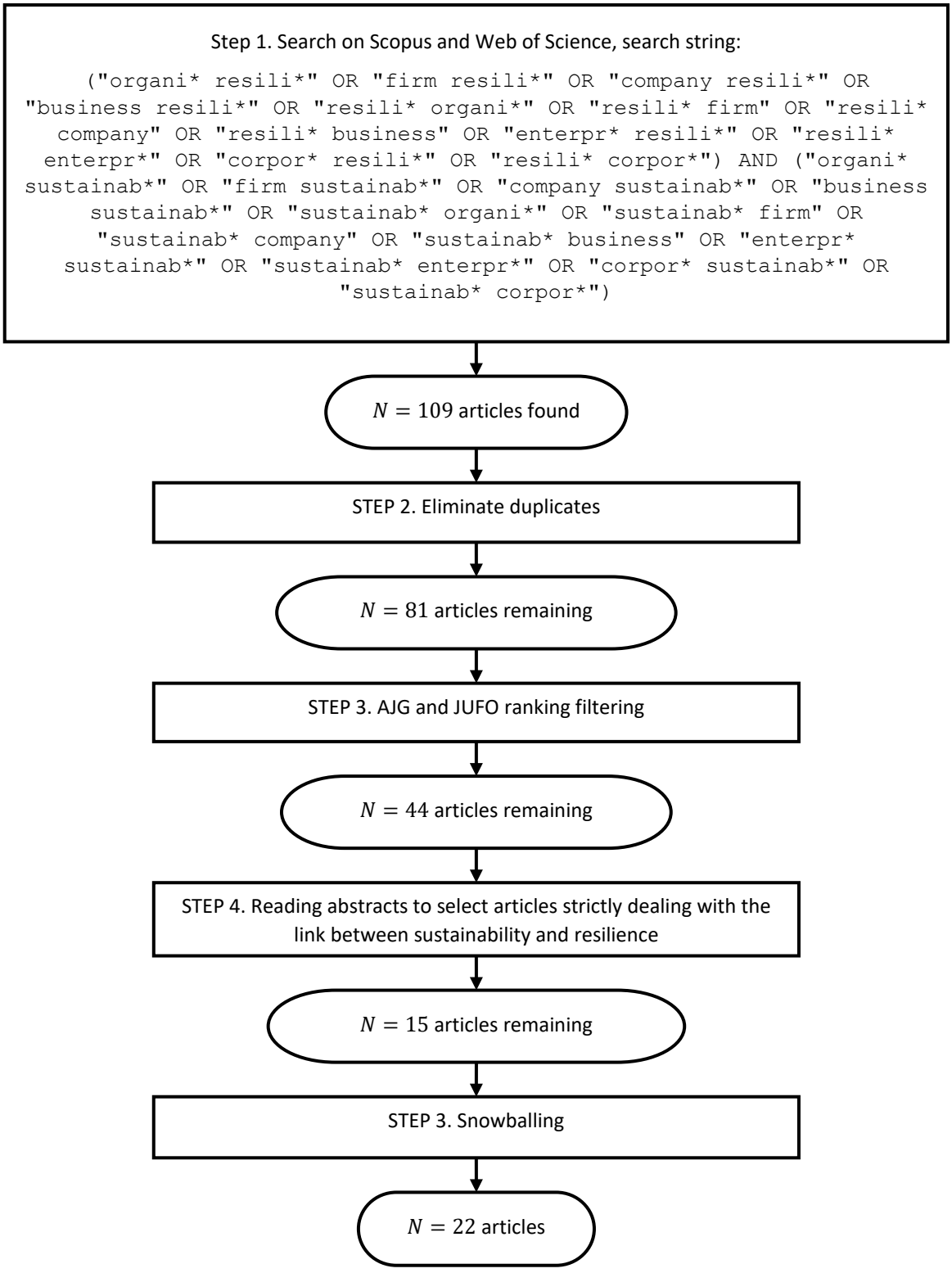


Figure 1: Article selection protocol and initial, intermediate, and final numbers of candidate articles

4. Findings

Table 1: Findings

Document	Document Type	Sustainability contributes to resilience	Resilience contributes to sustainability	Other components contributing to resilience and/or sustainability
Souza *et al.* (2017)	empirical		x	
Bachtiar *et al.* (2023)	empirical		x	Digitalization
Kato (2024)	theoretical	x		Venture Capital
Freze et al. (2023)	empirical			Separate Concepts
Mohy-ud-Din *et al.* (2024)	empirical	x		
Vallet-Bellmunt *et al.* (2024)	empirical			Separate Concepts
Winnard *et al.* (2014)	theoretical	x	x	
Florez-Jimenez *et al.* (2024)	theoretical	x	x	
Damiano *et al.* (2023)	theoretical	x		
Yahya (2023)	empirical	x		
Hossain *et al.* (2022)	empirical	x		
Cardillo *et al.* (2023)	empirical	x		
Ortiz-de-Mandojana *et al.* (2016)	empirical	x		
Rai *et al.* (2021)	empirical		x	
Derissen *et al*. (2011)	empirical	x	x	Separate Concepts
Marchese *et al.* (2018)		x	x	
Parra-Requena *et al.* (2024)	empirical		x	Purpose Orientation
Yan *et al.* (2025)	empirical	x		
Ciasullo *et al*. (2024)	theoretical	x	x	
DesJardine *et al.* (2019)	empirical	x	x	
Golicic *et al.* (2017)	empirical		x	Separate Concepts
Espiner *et al.* (2017)	theoretical	x	x	

Based on a review of 22 academic articles, the relationship between organizational resilience and sustainability can be categorized into four types: sustainability enhancing resilience, resilience supporting sustainability, mutual influence, and the role of external factors impacting both. Studies like (Winnard *et al.*, 2014) highlight that reducing uncertainty and promoting knowledge within firms can improve both resilience and sustainable performance. Table 1 presents the findings from the analysis of the selected 22 research articles. Apart from technical publication details, the table distinguishes between empirical and theoretical works and outlines the key arguments of each article, specifically whether the respective article suggests that sustainability contributes to resilience, resilience contributes to sustainability, and if other factors are identified or claimed to influence either concept. Notably, some articles, such as (Espiner, Orchiston and Higham, 2017), which is a theoretical study, propose that resilience contributes to sustainability and vice versa, but that they are still markedly separate and distinct notions.

Numerous empirical studies demonstrate how sustainability practices, such as CSR and ESG, contribute to resilience by helping firms withstand crises like climate change and the COVID-19 pandemic (Mohy-ud-Din, Shahbaz and Du, 2024). Evidence from diverse contexts, including U.S. firms, Nordic countries, and Chinese manufacturers, shows that responsible environmental and social practices enhance financial stability, flexibility, and long-term survival (Yan *et al.*, 2025). Conversely, resilience is also shown to drive sustainability outcomes. For instance, resilience mediates the link between a company's purpose orientation and its sustainability performance, as seen in tourism and manufacturing sectors across Spain and India (Parra-Requena *et al.*, 2024). Resilience is found to influence various stages of organizational growth and help maintain social and economic values during crises (Rai, Rai and Singh, 2021).

Several theoretical studies emphasize that resilience and sustainability are deeply interrelated and interdependent (Ciasullo, Chiarini and Palumbo, 2024). They are sometimes viewed as complementary or even inseparable in ensuring long-term organizational success. Additionally, external factors like sustainable investment strategies, technological innovation, and pioneering orientation influence both resilience and sustainability. Some researchers suggest that resilience alone may not be enough unless supported by a strong sustainability orientation (Parra-Requena *et al.*, 2024), whereas others caution that not all resilient firms can tackle disruption and sustainability challenges simultaneously.

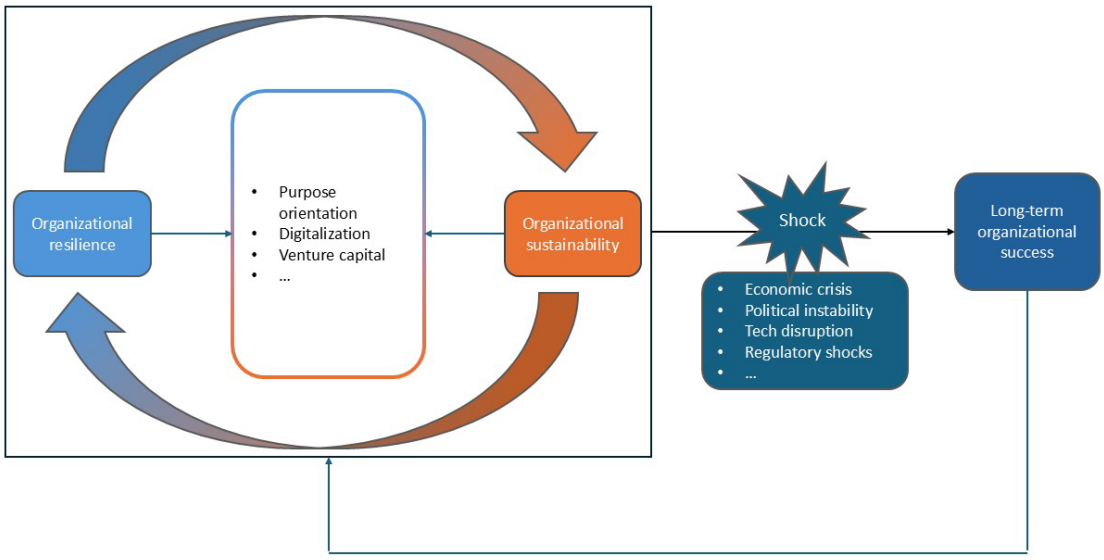


Figure 1*:* Conceptual Model of Long-Term Organizational Success Through the Interplay Between Organizational Resilience and Sustainability

The conceptual model illustrates the dynamic and reciprocal relationship between organizational resilience and organizational sustainability, as identified through the analysis of 22 articles. It demonstrates that sustainability can strengthen resilience by enabling firms to function effectively over time, while resilience can, in turn, support sustainability by allowing organizations to adapt, withstand shocks, and maintain continuity in their sustainable practices. This mutual reinforcement is central to long-term organizational viability and has been emphasized across various theoretical and empirical studies.

Embedded within this relationship are dynamic capabilities such as purpose orientation, digitalization, and venture capital, which act as internal drivers that enhance both resilience and sustainability. These capabilities help organizations respond more effectively to challenges and align their strategic direction with long-term goals. The framework also recognizes that external shocks, such as economic crises, political instability, technological disruptions, and regulatory changes, pose significant risks to organizational systems. In the face of such shocks, sustainability can serve as a stabilizing force that enhances an organization's ability to endure and recover, while resilience equips the firm to adapt and evolve through the crisis.

Ultimately, the interaction between resilience and sustainability contributes to long-term organizational success. This success is presented not only as a result of overcoming external shocks but also as an outcome of

the strategic integration of sustainable and resilient practices. The model suggests that the experience of navigating challenges and maintaining performance feeds back into strengthening resilience, thereby creating a continuous cycle of adaptation, learning, and improvement. In this way, the model presents resilience and sustainability as interconnected, evolving constructs that are crucial for building organizations capable of thriving in an increasingly uncertain environment.

5. Conclusion and Discussion

This systematic literature review analyzed in depth 22 articles, chosen from a larger set of candidate articles, to explore the relationship between organizational resilience and sustainability, as well as other influencing concepts within an organizational context. The findings revealed that sustainability contributes to resilience, with numerous studies supporting this claim. However, some articles also argued that resilience enhances sustainability. Furthermore, many studies suggested that sustainability and resilience share a bidirectional relationship, mutually reinforcing each other. Some articles examined these concepts separately, highlighting their distinct yet interconnected roles in organizational development. Additionally, various factors influence one or both concepts simultaneously, including digitalization, venture capital, purpose orientation, knowledge networks and technology.

To synthesize and visualize these findings, a conceptual model was developed. This model illustrates the dynamic interplay between organizational resilience and sustainability, positioning them as interdependent forces that collectively drive long-term organizational success. The model also integrates external mediating and moderating variables identified across the reviewed literature

However, this conceptual model, like the review itself, is not without limitations. It is derived from a relatively small body of literature, and as such, may not capture the full spectrum of interactions or contextual nuances between the two constructs. Organizational resilience and sustainability are both broad and evolving constructs, and their interaction is likely shaped by a wide array of sectoral, geographical, and temporal factors not fully accounted for here.

Still, these limitations suggest that the findings should be interpreted cautiously, until more inclusive future research on this topic can be conducted. Comparing the relative numbers of articles solely written on the two distinct concepts with those containing both concepts reveals that, in relative terms, the limited state of the art may indeed require more research to more objectively understand the finer-grained detail of the relationship between organizational resilience and organizational sustainability, confirming this article's initial hypothesis.

Ethics declaration: No ethical clearance was needed for the research referred to in this article.

AI declaration: DeepL Write was used to check for grammatical errors in the manuscript manually and locally for some individual sentences. Discovered errors were corrected manually and up to the author's decision and taste.

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How do we get There Together? Making Sense of and Exploring Ecosystem Orchestration as Practice

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Abstract: An ecosystem perspective recognizes how a complex set of independent, yet interdependent actors collaborate to co-create value toward a shared goal. Such ecosystems are often actively facilitated by an 'orchestrator' who, in many cases, is an individual who has been allocated the task of coordinating an emerging or ongoing ecosystem. In this study, we focus on individuals in a third-party organization performing orchestration duties, alongside a team, helping to build and coordinate innovation ecosystems. Previous literature indicates that ecosystem orchestration involves mobilizing, coordinating, and integrating resources (often knowledge) and actors to achieve the ecosystem's goal(s). Nonetheless, it is still unclear *how individuals make sense of ecosystem orchestration as a practice.* Incorporating evidence from interviews, non-participant observations, and archival documents, we conduct a narrative analysis of the sensemaking of individuals performing ecosystem orchestration as a third-party actor. From an instrumental single case, we explore individual and organization level narratives making sense of ecosystems and ecosystem orchestration. We found that some take an embodied meaning of ecosystems, resonating more deeply with the concept, meanwhile others have a more ambiguous interpretation. Through the narrative accounts of our participants, our findings reveal the highly relational and social nature of ecosystem orchestration, complemented by frameworks and models. As a result, we suggest that ecosystem orchestration emerges from a set of intersubjective cognitive, social, and material practices, rather than from any individual capability or traits. First, we contribute to the orchestration literature, providing more nuanced insight into how individuals make sense of this role and how it unfolds from a practice perspective. Second, our study provides a methodological contribution to the literature on ecosystem orchestration by exploring the individual level through narrative inquiry. Third, this study offers practical insights for managers and third-party organizations on the knowledge and skill development that can be supported, particularly for developing ecosystem orchestration services.

Keywords: Innovation ecosystems, Orchestration, Third-party orchestrators, Sensemaking, Practice

1. Introduction

Knowledge and innovation are increasingly needed to help solve complex global challenges, driving the need for organizations to renew and grow collaboratively alongside stakeholders and actors. This has led to the popular adoption of the ecosystem concept, framed as a complex set of independent yet interdependent actors collaborating to co-create value toward a shared goal, to help conceive collaboration in such a dynamic context (Jacobides et al., 2018).

Similarly, to manage increasingly dynamic environments such as innovation ecosystems, often characterized by voluntary contributions from complementors and other stakeholders, the orchestration approach has emerged as an important and relevant role (Dhanaraj & Parkhe, 2006). Orchestration can be seen as a contemporary mode of coordination that is increasingly needed to complement the classic contractual R&D and innovation networks. Most recent definitions remark orchestration as *"a set of activities and roles performed by a hub actor (individual, team, or organization) to coordinate independent network members' interactions within a loosely coupled context"* (Ritala et al., 2023, p. 1143). Significantly, scholars have indicated that this topic is a 'new frontier' to be further investigated and understood as it becomes increasingly relevant for today's R&D issues (Ferrigno et al., 2023). Yet, at present, we do not fully understand how organizations and individuals make sense of these concepts and how it emerges in their practice.

In this study, we address the following question: *How do individuals make sense of ecosystem orchestration as a practice in third-party orchestrator organizations?* In particular, we are interested in exploring the narrative accounts of those involved in this practice to gain deeper understanding of the meaning(s), from their experience, of ecosystem orchestration and how the organizational context shapes it. Deviating from most existing research, we do not concentrate on the actions of the orchestrators (see e.g., Dhanaraj & Parkhe, 2006) or focus so much on the capabilities of orchestrating actors (see e.g. Hurmelinna-Laukkanen & Nätti, 2018). Rather, we build on this knowledge and approach the topic from a narrative inquiry to understand how we can make sense of this phenomena and the practices that encompass it.

We next discuss the literature on sensemaking and orchestrating innovation ecosystems, with an as-practice approach, then introduce our methodology, and present our exploration of making sense of ecosystem orchestration as practice.

2. Conceptual Background

2.1 Sensemaking in Organizations

Sensemaking is a central concept in organization studies, referring to the process through which individuals and groups construct meaning in response to novel, equivocal, or confusing events. The roots of sensemaking date back many years, but it was not until the late 1960s when it became a topic of study (Garfinkel, 1967; Weick, 1969), then really took a hold with the classic text *'Sensemaking in Organizations'* by Karl Weick (1995). This burgeoned empirical research on the topic for it to evolve into a multidisciplinary field that explores how people create order and enable action in complex organizational environments (Maitlis & Christianson, 2014).

Earlier work adopted a cognitive perspective, focusing on the internal mental processes of individuals, and suggesting that sensemaking is primarily an individual cognitive activity where people notice and interpret cues based on pre-existing mental structures (see Louis 1980; Hill and Levenhagen, 1995). Later perspectives argue that these processes are much more interpersonal and discursive, arguing that sensemaking is a fundamentally social process, constructed through dialogues, narratives, and shared experiences which shape organizational reality (see Weick, 1995; Gephart, 1993; Maitlis, 2005). To understand the latter perspective of sensemaking, it is useful to understand Weick's view of organizations; his ideas are built on the principle that organizations act as sensemaking machines, not as static structures, and that they are messy, complex, dynamic, adaptive, open systems that can shape their environment (not just be shaped by the environment) through specific forms of communication.

Most scholars concur that sensemaking is not a rational process, but an embodied, cognitive and affective process. Weick (1995, pp. 14) explained that "*to engage in sensemaking is to construct, filter, frame, create facticity… and render the subjective into something more tangible"*. From this constructionist perspective, sensemaking is understood to be characterized by retrospectivity (making sense of events after they occur), plausibility (favoring coherent narrative over objective truth), socially constructed (meaning is co-created through interaction), and grounded in identity construction (who we think we are shapes what we notice and how we interpret it) (c.f. Weick, Sutcliffe & Obstfeld, 2005; Corley & Gioia, 2004; Pratt, Rockmann, & Kaufmann, 2006).

In a simplified explanation of the process, sensemaking happens through triggers that prompt sensemaking, meaning being constructed through dialogue and narrative, then leading to action which in turn informs future sensemaking (Weick, 1995). Triggers can include crises, identity threats, and planned organizational changes (such as seizing opportunities and shaping new business services). At present, sensemaking theory has generally been studied in silo, other than some connections with e.g. identity theory (Corley & Gioia, 2004; Pratt, Rockmann, & Kaufmann, 2006), yet presents fruitful opportunity to bridge with broader organizational and sociological frameworks, such as practice theory.

2.2 Orchestrating Innovation Ecosystems: Introducing an "As-Practice" Approach

Since the 1990's the business ecosystem concept has emerged to perceive and conduct business collaborations, using ecological metaphors to consider how firms are embedded in their environment and co-evolve over time (Moore, 1993). More recently, scholars have utilized the concept of *innovation ecosystem* to discuss a variety of interdependent and collective groups of individuals and organizations that aim to reach shared innovation-related goals (e.g., Ritala & Almpanopoulou, 2017). In this study, we use the innovation ecosystem concept to describe loosely coupled collectives of organizations and individuals who are bound together via joint goals and project contexts, and who are orchestrated by a third-party actor (in this study, our case organization).

This study focuses on *ecosystem* orchestration, but we draw specifically from the better-established network orchestration literature where ecosystems are often and increasingly the context (e.g. Zucchella and Previtali, 2018; Zaoual and Lecocq, 2018; see also Wang and He, 2024). In management and organization studies, some fields have taken pivoted to praxis theoretical perspectives, with what is known as an "as-practice" approach; originating with strategy-as-practice and extending to other fields such as entrepreneurship, marketing, and most recently leadership (see Iszatt-White, 2011; Raelin, 2016). The commonalities of this approach, in their respective fields, are an interest in an in-depth analysis of what actually takes place (i.e. the 'sayings' and 'doings') rather than focus on an entity or person exhibiting traits and behaviors. Despite some of the original

works on orchestration focusing on actions (Dhanaraj & Parkhe, 2006) and being defined as "a set of activities…" (Ritala et al., 2023), orchestration rarely adopts an as-practice perspective and tends to focus on the orchestrating entity or role.

For instance, the orchestration literature has many ways to describe 'orchestrators', being carried out by many different entities (e.g. large corporations, universities, start-ups, etc). Few studies explore third-party actors as orchestrators (c.f. Zacharia et al., 2011; Pinnington et al., 2021). A third-party orchestrator is an external entity that facilitates and coordinates collaboration and integration among multiple independent parties, without being directly involved in the value exchange between them, and therefore they act as a neutral role (Pinnington et al., 2021).

We conduct our study through this "neutral actor" to gain a better understanding of how such entities make sense of ecosystem orchestration. However, we do not focus on the entity itself but rather the 'sayings' and meanings individuals attach to this work in their organizational context. Through these narratives, we explore the different dimensions of sensemaking as well as concurrent practices. Next, we explain our methodological choices.

3. Method

3.1 Research Strategy and Case Selection

We started with an instrumental single case study design in mind (Stake, 1995). At the time, we felt that Spinverse as a case could allow us to gain a richer understanding of ecosystem orchestration as a practice. Initially, the aim was to get a better understanding of how the concept of ecosystems and how to orchestrate them worked in practice, how Spinverse as an organization offer this as a service, and how this came to be. Our focus on individuals, orchestration as practice, and sensemaking were not predefined but occurred during our in-situ immersion and interactions with individuals at Spinverse and later when examining the data in more detail (see 3.3, 3.4 for more details on data collection and analysis). In other words, our research design developed gradually (Stake, 1981).

We realized that orchestration is not simply something organizations at the aggregate do, but it is an activity individuals and teams perform on behalf of their organization (cf. Grimm and Reinecke, 2024). At this stage, we felt that focusing on individuals was necessary to understand the nuances of ecosystem orchestration practice. Therefore, we redesigned our study as a narrative inquiry and reformulated our research question. Narrative methodology allowed us to take a closer look into the individuals stories, and their sensemaking (Riessman, 1993, 2008; Brown et al., 2008), and focus on what it means to conduct ecosystem orchestration. Moreover, as-practice scholars endorse approaches such as narrative inquiry to capture concurrent social practices in the context at play (Raelin, 2020).

3.2 The Organization in Brief

Spinverse is a Nordic innovation consultancy, headquartered in Espoo (Finland), that helps customers to grow and solve global challenges through ecosystem projects. Spinverse has extensive experience in EU funding instruments and company-led innovation ecosystem projects to help European innovators reach their growth and sustainability targets. Their core services include exploring opportunities for publicly fundable innovation and ecosystems, planning and applying for public and private funding for ecosystem projects, and managing complex innovation projects, ecosystem relationships, and communication.

3.3 Data Collection

Our data was collected from unique access to the study organization, through a 10-week secondment at the Spinverse headquarters, conducted by the first author between February and May 2023. Prior to the secondment, a contextual understanding was gained through reading publicly available materials by or about Spinverse. Semi-structured exploratory interviews with key informants (n=21) were conducted, alongside observations at the workplace. The first author took on the role of observer and enquirer, where the presence and intentions were known and explained to participants. Furthermore, we were given access to internal and archival materials. See Table 1 below for description of the data.

Table 1: Description of data collected

Data items	Description of the data	Purpose
21 interviews (main data)	Transcription of semi-structured exploratory interviews with 21 informants from across the organization (including Ecosystem Leader, Director, Vice President, Team Leader, Analyst, Consultant) lasting between 41 minutes and 1 hour 9 minutes with an average of 49 minutes. Labelled I-1 to I-21 from anonymity purposes.	In-depth understanding of individual narratives.
Archival public materials	Spinverse website: https://spinverse.com/ White papers: https://spinverse.com/insights/?category=white-papers#insights-grid Ecosystem Handbook (co-authored by Spinverse CEO, Ecosystem Leader, and external colleagues): Kola, S., Koivukoski, U., Koponen, L., & Heino, M. (2020). *Ecosystem Handbook: The ART of Leading and Creating IMPACT*. Alma Insights. https://ecosystemhandbook.com/the-book/ Book Chapter (authored by Spinverse Ecosystem Leader): Launonen, P. (2015). 'Determinants for Orchestrating Open Innovation Networks'. In Lappalainen, P., Markkula, M., & Kune, H (Eds). *Orchestrating Regional Innovation Ecosystems – Espoo Innovation Garden*. Finland: Aalto University, pp.199-208.	Enriched understanding of the context and organizational narrative, supporting analysis of the interview data.
Internal materials	Given access to organizational chart (png) and workshop templates (ppt, n=6) for the ecosystem building sessions they run with clients.	Enriched interview data.
Observations	33 pages of notes and reflections from the office space, impromptu conversations at the office, and weekly company-wide 'powwow' (meetings) - stored in a word document, 11 pt font single-spaced.	Complemented sensemaking of the organization and documented study reflections.

3.4 Data Analysis

Our analytical approach applied a thematic narrative analysis (Reissman, 2004) which allowed us to analyze the research participants' different narrative accounts of the phenomenon under study and compare thematic similarities and differences. Following the guidelines of Reissman (2004), we selected purposeful narratives, keeping stories intact rather than fragmenting into categories or codes, looking for recurring ideas, experiences, or values emerging from data. Our unit of analysis focuses on the individual, embedded within the context and case.

The preliminary analysis began with re-familiarizing with the data i.e. revisiting field notes, reading interview transcripts, and reading secondary materials. When revisiting the data, the initial aim was to understand how the organization conducts ecosystem orchestration as a service, and what this means in and for the organization. We realized to understand this practice, we needed to understand what ecosystems mean to individuals and they made sense of orchestration as an activity.

Detailed analysis of the interviews was conducted to draw out the narratives being told by individuals. Through these narratives we were able to gain a deeper understanding as to the framing of the organization, and how the individuals internalized this framing and made sense of it. This was discussed with both authors and peers to clarify our findings and observations. Since the second author is a Spinverse employee, this supported our observations with detailed insight and feedback on interpretations. To ensure a neutral perspective on the analysis, the second author did not have access to the data, only the interpreted findings were discussed, acting as a consultant to the findings rather than a direct participant in the analysis process. When recognizing organizational references in the narratives we also referred to the archival and secondary materials to further enrich our understanding and insights.

In the Findings, we present insights using illustrative excerpts and direct quotes maintaining richness and avoiding reducing to bullet points; congruent with narrative inquiry and practice approaches, staying grounded to the participants telling of their experiences embedded in their context and meanings (Reissman, 2004; Raelin, 2020).

4. Findings

The findings of this study will be presented in the following sections: *Section 4.1* demonstrates a single narrative account of how Spinverse as an organization has evolved alongside the business environment it is situated. This account is constructed by the authors, from multiple 'tellings' of the story, through interviews and archival public materials (see Table 1) with any direct quotations cited. Then, *Section 4.2* presents the parallel narratives that emerged during the analysis of the interviews. To preserve the anonymity of participants, we constructed 2 narrative accounts of embodied vs. ambiguous meanings to represent thematically the sensemaking of individuals, providing direct quotations and paraphrasing with citations where appropriate. We would like to point out that these are representative and not substantive, meaning that the sensemaking processes are much more nuanced, yet we found some overarching similarities to induce these parallels and glean understanding. Finally, in *Section 4.3*, we present the narratives that emerged as recurring ideas core to carrying out ecosystem orchestration from their perspectives.

4.1 Prologue – The Evolution of the Ecosystems Era

Beginning with a visionary founder, Spinverse was set up on the premise to bring together business and research; technology developed in research organizations and universities should see the light of day and become products. In 2004, commercialization was all the buzz. The bravado sounded great and looked achievable on paper, but the reality was a mess of bottlenecks and no such structures to implement this, so Spinverse wanted to create safer spaces and facilitate commercialization. This proved rather challenging.

> *"They come from different organizations ... They may be not so, I would say, direct or intimate … you don't know the external partners, ecosystem companies, and persons so well. So there is a bit of distance there." [I-20]*

Corporate accelerators, incubators, and the like were very popular, alas efforts went no further than these in attempts to commercialize research and technology. Meanwhile, the open innovation concept was gaining traction, gripping the interest of Spinverse. This initiated a moment when Spinverse shifted from technology commercialization to building spaces and platforms for corporates, startups, and research organizations to connect as a starting point and let them talk. Along with the support of national structures, these diverse actors could be brought to the same table. The next challenge was getting them to see eye to eye, first - additionally challenging via online platforms.

> *"How do you make sure the people participate? How do you make sure you get that activity going for everybody? It's quite stressful for the person who runs it over Teams to try to activate them because you can't see them. You can't see 15 people at once in the screen." [I-13]*

With hidden agendas aloof, bringing these actors together can become an uncomfortable environment for all parties involved. One wants ownership, the other wants intellectual property rights, another wants money, and someone else is just trying to figure out what is going on. This is when Spinverse's EU business begins.

> *"When you bring the European Commission into equation, they become a referee, because then no one is supposed to own anything or steal anything from anyone and everyone is supposed to openly share the results of their work and research and whatnot and commercialize it together." [I-8]*

Bringing these events together is what led Spinverse to ecosystems thinking; a desire to create spaces for collaboration, open innovation, and having the public funder as referee. This is how it picked up in Finland around 10 years ago, and ecosystems have become a regular part of business collaboration and innovation.

4.2 Making Sense of Ecosystems: Embodied vs. Ambiguous Meanings

During interviews, participants were prompted to reflect on what ecosystems mean to them, and in relation to their work. It emerged that there were differing levels of sensemaking, and thus different meanings, which is to be expected. Given the commitment from Spinverse dedicating business to this concept, as well as general external acceptance in Finland, it was interesting to learn the difference in experience and values narrating the sensemaking.

Embodied meaning comes from the resonance people feel with the ecosystems concept. Essentially, whether they feel it expresses what their work involves and connect deeply with this thinking. Some felt that ecosystems have been a way of working, even before becoming popularized, and the concept gave a name to this work. When reflecting on their work history and meaning of ecosystems, I-9 states *"I think that I've been always working in an ecosystem model or building or leading smaller or bigger ecosystems in a way."*. Through previous

experience people understand that purpose is the underlying premise bringing an ecosystem together, there needs to be a bottom-up aspiration to get commitment and motivation. Through their own values, they see that ecosystems can create a sense of belonging and connection which can be a driving force for collaboration beyond traditional means. For example, the ecosystem perspective has really consolidated for I-8 *"that's how we see it now, that's what we see now. And now everyone has an ecosystem around them."*.

Ambiguous meaning refers to those that do not feel so connected with ecosystems concept, for them the meaning is simply that – a concept. Some felt ecosystems are a bit too complex to work with day-to-day, so prefer to break down the concept through the frame of projects instead – a concept much more familiar and embedded in day-to-day business life. The sensemaking process could still be evolving, as I-5 shares *"I did think about it two or three weeks ago, because I was thinking is there a difference between project consortiums and ecosystems, and it was clear that the ecosystem is kind of bigger. It's a sort of disparate group of different types of organisations, but with similar interests. And then, possibly from that group comes a project which is a subset of those organisations together focused on certain topics for a period of time. I was just trying to figure that out a little bit."*. They acknowledge the paradox that they work in ecosystems regardless but struggle paradigmatically to find this a functional concept without working through existing or more traditional boundaries (such as project management). I-5 further indicates the collective sensemaking is still processing *"when I think of ecosystems, I always think of [colleague name], and he's a sort of the role model in my mind."*.

In-between these meanings there are multiple interpretations of ecosystems, and perhaps people even use different terms altogether with the same meanings. I-10 reflects *"…people can call things whatever they want, but if they want to really do something that is useful, to me ecosystems means intensive collaboration networks with a common target. So, there should be a purpose.".* The embodied vs. ambiguous meanings highlight the overarching parallel narratives being told, yet there is suggestion of a deeper intersubjectivity that allows people working with this label to engage with practices, despite the constellation of meanings and range of relation with the concept.

4.3 Making Sense of Ecosystem Orchestration

The interviewed individuals were active participants enabling us to see their subjective frames – them making sense of what ecosystem orchestration was about. While we asked them directly what ecosystems meant to them, we did not directly use the term 'orchestration' and instead focused on asking questions about the being and doing of their work. By first considering the individual interview accounts as separate narratives and then collectively as a broader narrative, we observed that while individual characteristics, values, and approaches co-exist and create some divergence, their overall ideas converged in themes:

Leading without authority, or without traditional hierarchical authority, is realized as a key skill to their practice. For example, I-20 explains *"I think it's important for the project manager to have facilitation skills, how do you interact with people, how you lead without authority."*. It is reflected that this practice is different to conventional leading or managing, requiring to be more creative even: "*That you cannot say do this, because you're not in the hierarchical position. And that's why it is more interesting, because you don't lead by authority, but rather by perhaps selling, negotiating."* (I-15).

Another example, **facilitating trust-building,** is known to be important in the beginning of collaborative relationships, and Spinverse consultants understand this well. Reflecting on their approach to bringing partners together, I-15 acknowledges "*I would say, and have been commented on, to be very outward going, positive, encouraging, so try to create the trust, good will among people and in the meetings. At least take time to try to be an energetic person. So try to get people engaged and in speed.*". It is evident to them that their personal conduct and the social conditions they help to create has an influence on how the ecosystem might play out. Echoing this relational importance, I-13 reiterates this narration but also connects it to being embedded in a model, not just a person *"You have to go with that personal relationship building and trust. It is about leading people, in a sense. When you are building those. It's very much a people thing. Give room, try to treat people and companies as equals. We do that in the operative model."*.

Spinverse's sensemaking of ecosystem orchestration (as a service) has led them to a **team-based configuration**: where there are divergences in practices or approaches of individuals, they lean into this by using team configuration and role-switching complementarities to build the practice. As highlighted by I-9 *"For some people it is very much systematic and maybe Excel-oriented and things like that, but I run things more based on my own feeling and intuition"*. The overall narration of Spinverse tells us that they have understood ecosystems orchestration to be comprised of highly relational and social practices, while leveraging this through developed

frameworks and models. To create order and action from this, their solution is to configure teams to conduct these practices reflexively.

5. Discussion and Conclusions

Through narrative inquiry our study provides a nuanced understanding of what it means to do 'ecosystem orchestration'. Through understanding how individuals make sense of ecosystem orchestration, we were able to make sense of ecosystem orchestration happening as concurrent cognitive, social, and material practices in their unique contexts.

First, the advent of open innovation and innovation ecosystems emerging in the Finnish and EU business context did not necessarily trigger sensemaking; the discrepancy between the adoption of the terminology in innovation policy and funding (at national and international level) and Spinverse's mission to bring together science and business became great enough for the organization to figure out what this meant and whether they should develop their business toward such a concept. This discrepancy is subjective and is known to be influenced by its impact on professional and organizational identity (Corley & Gioia, 2004; Pratt, Rockmann, & Kaufmann, 2006).

Second, it has been understood that group norms or the organizational culture may mitigate against sensemaking being triggered, even when discrepant cues substantially disrupt identity or goals (Maitlis & Christianson, 2014). Our study reveals parallel narratives, and acknowledges the in-between, of how individuals interpret embodied and/either/or ambiguous meanings of ecosystems. While some deeply resonate with the terminology and way of work, for others it is more practical to work with other ideas under the guise of ecosystems, yet both meanings work together no matter their interpretations. This reflects arguments about leadership-as-practice, being a practice in everyday life rather than existing in the behaviors of individuals (Raelin, 2020).

Third, from the retrospective sensemaking of ecosystems more generally, individuals come to reflect on creating meanings of ecosystem orchestration (as per Weick, 1995). Here, we learn key ideas involved: leading without authority, facilitating trust-building, and having a team-based configuration, which are common in the orchestration literature (e.g. Dhanaraj & Parkhe, 2006; Autio, 2022). Framing ecosystem orchestration as practice, as we propose, draws attention to the cognitive (thinking who you are and your position), social (building and facilitating relationships), and material (working with frameworks, operating models) processes involved in this activity.

5.1 Theoretical Implications

Our contribution to the literature on *innovation ecosystem orchestration* is twofold. First, we gain a richer insight into what ecosystem orchestration is and how it happens, through individual and organizational sensemaking. As with the practice movement in leadership (e.g. Iszatt-White, 2011; Raelin, 2016), we have learnt that despite the similarities and differences in the characteristics or approaches to orchestration, and different levels of sensemaking, it has become clearer that it is the concurrent cognitive, social, and material practices embodying ecosystem orchestration rather than any individual thinking or doing. While the themes presented are not new to orchestration literature, this research provides a new light to our understanding of ecosystem orchestration, typically studied from the perspectives of roles, actions, types, and capabilities (see Dhanaraj & Parkhe, 2006; Hurmelinna-Laukkanen & Nätti, 2018).

Second, we make a methodological contribution. Past research on ecosystem orchestration has focused mostly on the organizational levels of analysis (Autio, 2022). We add to the field by studying the individuals' sensemaking narratives (e.g. Weick, Sutcliffe & Obstfeld, 2005; Brown et al., 2008). By bringing the individual perspective and narrative approach, we focus on perceptions and experiences and thus provide a novel way of seeing and understanding what ecosystem orchestration means.

5.2 Practical Implications

The findings have implications for individuals, teams, and organizations conducting orchestration. Given the two-fold sensemaking, the abilities to orchestrate innovation ecosystems and their innovation projects necessitate experience, skills to master the practice, and relational as well as social capital.

Individuals need to understand and grow into roles of orchestrating teams, through material, relational, and social practices. The organization can support this knowledge and skill development as well as shared growth and sensemaking between ambiguous and embodied meanings via e.g. providing different roles in the projects

and ecosystems, arranging training in the core skills (like facilitation, leadership, negotiation, and organizational selling) and providing mentoring and opportunities for on-the-job learning. Organizations can recognize, develop, and leverage existing frameworks and models for orchestration and promote such practices in their ecosystems. Importantly, though the role of a third-party orchestrator is often defined contractually, the position needs also to be earned, i.e. trust built via practices with the ecosystem, beyond one's organization.

5.3 Limitations and Future Research

As with any exploratory qualitative research, this study has some inherent limitations related to generalizability. A longitudinal study could provide deeper insights as to how the sensemaking of this practice takes place over time, as well as more insight into how the organization supports individuals in this. Furthermore, since we focus on the perceptions of how individuals see their work, we have no comparison as to what their actual work is. Hence, further empirical studies observing ecosystem orchestration in practice could elucidate new insights, possibly with observation of external actors in the social practices. Finally, this paper has adopted a practice theory lens in the context of ecosystem orchestration, which may provide further interesting research avenues that this research has only begun to discuss i.e. deeper investigation of the cognitive, social, material, and even embodied practices.

6. Ethics and AI Declaration

Ethical clearance was not required for the research. All participants gave recorded informed consent to participate in the study. With regards to AI use, Copilot was used in the early stages of this study to support ideation of research framing and paper titles. These were ultimately iterated and improved with co-author discussion and deeper consultation of the literature and data, with the current title and research framing coming from the authors. For spelling and grammar purposes, Grammarly integration is used on the Word document, with any suggestions from the tool being checked and implemented manually by the author.

Acknowledgements

This research has received funding from the EU's Horizon 2020 research and innovation program under grant agreement no. 956745, EINST4INE: The European Training Network for Industry Digital Transformation across Innovation Ecosystems. The content of this publication does not reflect the official opinion of the EU. Responsibility for the information and views expressed in the publication lies entirely with the authors.

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Design and Implementation of Automated Documentation Management System Prototype Using ChatGPT

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Abstract: Nowadays, effective document management is crucial for enhancing organizational productivity, efficiency, and adaptability, but traditional document management systems often struggle with retrieval, accessibility, and workflow automation. Thus, the present research introduces an Automated Document Management System (ADMS) prototype that integrates ChatGPT as an intelligent assistant to enhance document processing. By using natural language processing (NLP) and machine learning, the system enables users to interact with documents through conversational queries, analysis, retrieval, and summarisation requests. The ChatGPT-powered assistant operates by creating small context sessions to dynamically analyse document content. These sessions extract key insights, highlight relevant sections, and generate summaries according to user queries. By maintaining context within each session, the assistant delivers accurate and relevant responses while ensuring continuity in the conversation. This approach not only improves document accessibility and usability but also enables the integration of other knowledge domains within an organization. To evaluate its effectiveness, the prototype is validated by 30 IT experts, who identify essential functionalities, strengths, and potential challenges. Their feedback provides key insights into areas such as accuracy, scalability, and security, guiding future improvements. This research aims to demonstrate how ChatGPT can optimise information handling and support decision-making, highlighting the revolutionary potential of AI-driven document management. By automating process and project definition and enhancing search capabilities, the system offers a scalable and intelligent solution for modern document workflows. Thus, Knowledge Management (KM) evolves to focus on contextual understanding, emphasises cohesive data integration, and expands the scope of knowledge creation and sharing and their influence on knowledge domains.

Keywords: Knowledge management, Document management, Prototype, Research, ChatGPT, AI

1. Introduction

Effective documentation is essential for knowledge management and knowledge sharing in organizations, as it ensures the secure storage and access to critical information and acts as a strategic tool in decision-making. Employees are an essential asset to any organization, accumulating knowledge and skills that must be documented to avoid loss upon their departure (Navidi et al., 2019). Well-structured documentation management (DM) supports the transformation of tacit knowledge into explicit knowledge, facilitating the sharing of experience and best practices within the organization. However, various studies highlight challenges related to knowledge documentation, including the lack of detail about methodologies and errors, which limits the ability to learn from experience, and the need for having a Documentation Management System (DMS) as a technological approach to categorizing and providing analysis of different organizational assets (Nilekar, 2024).

The present research aims to investigate the specifics of KM in software processes and to propose an Automated Documentation Management System that integrates tools based on artificial intelligence (AI). The integration of AI into corporate documentation processes has the potential to substantially improve the efficiency of knowledge management. This advancement aligns with and can be further reinforced by the established paradigm of conversational agents, such as chatbots, which facilitate interactive access to document content and organizational knowledge (Tin et al., 2024). By documenting business processes and projects, a clear model for understanding and transferring knowledge can be created, facilitating the training of new employees and optimizing company workflows (Haddadpoor et al., 2015). AI tools can facilitate multiple DM processes, providing automation of analysis, categorization, and linking information, providing access, and improving the knowledge flow within the organization. AI-based systems can support technology integration through intelligent search engines, automated summaries, and process analysis, thereby facilitating business process reengineering. AI-enriched documentation ensures quick access to relevant information and improves an organization's adaptability to new requirements and challenges.

The paper is structured as follows. The background part describes the main theoretical foundations, serving as a starting point in the system design. Next, the prototype of the ADMS system is presented, exploring first the system requirements and then outlining the layers of the prototype design. Implementation and validation sections provide relevant insights about the users' perceptions of the ADMS system. Finally, the conclusion outlines the perspectives and future directions for implementing AI tools in document management systems.

2. Background

Document management systems play a crucial role in optimizing organizational processes and promoting collaboration. Documentation management is often perceived as a challenging task due to the inaccessibility, unstructured nature, and complexity of the company information. This results in difficulties integrating new employees, reduced workflow efficiency, and slower innovation adoption. By implementing standardized processes and procedures, company documentation helps ensure compliance with regulatory requirements and industry standards, reducing legal risks and preventing errors. It provides clarity in procedures, ensuring that employees follow established rules. In regulated industries, such as healthcare and finance, documentation demonstrates compliance with legislation and facilitates audits (von der Heyde & Breiter, 2017). In this sense, documentation serves as the backbone of KM in an organization, supporting its ability to absorb new ideas, adapt to change, and improve internal processes. AI can enhance and optimize DM processes. According to several studies, sentiment analysis techniques (such as text classification and recurrent neural networks (RNN)) significantly improve the processing of textual information (Lim et al., 2020). Features such as document search, messaging, and version control in DMS stand out as key factors for more effective collaboration and workflow improvement (Regla & Marquez, 2020), leading to increased system adoption (Ayaz and Yanartaş, 2020). For example, the design and implementation of an electronic document management system (EDMS), tailored to the specific needs of educational institutions, has a transformative impact on administrative processes and collaboration (Mahmood, 2017).

To respond to these challenges with opportunities provided by AI, the authors propose an Automated Documentation Management System (ADMS) design, aiming to provide a centralized and intelligent approach for managing technical and project documentation. By leveraging AI and using a systematic model of KM in Software Engineering (SE), the system focuses on incorporating functions in the following knowledge domains (Georgiev, 2023):

- Technocratic knowledge – technology portfolio, experience in product development, information systems, and innovations;
- Behavioural knowledge – organizational culture, internal policies, and practices;
- Product knowledge – functionality and features of the developed products;
- Process knowledge – documentation on methodologies, workflows, and best practices.

Various researchers emphasize the essential role of documentation in maintaining human oversight over AI systems and supporting the evaluation of human decision-making impact on business processes. Creating comprehensible documentation through AI ensures compliance with regulatory standards (Königstorfer & Thalmann, 2022). For instance, enhancing the requirements elicitation process can be achieved by bridging the gap between AI strategies (including machine learning and natural language processing) and traditional methods that rely on human interaction and manual procedures (Cheligeer et al., 2022; Chomal et al., 2024). The adoption of AI tools as part of KM initiatives can significantly improve knowledge processes by integrating technological innovation and effective requirements engineering techniques (Cerchione & Esposito, 2017). Examples of AI-based solutions include:

- ChatGPT – provides intelligent search and personalized responses, helping developers quickly locate precise information instead of spending time sifting through bulky documents. AI can also analyse recurring queries and suggest improvements in knowledge management systems.
- GitHub Copilot – offers automatic code snippets that accelerate development and deployment processes while preventing errors.
- DeepCode – analyses the codebase to identify bugs, optimize performance, and detect potential security risks.
- Microsoft Power BI and Google Cloud AutoML – analyse large volumes of data, identifying trends and patterns that support better-informed decision-making and workflow optimization.

Beyond these tools, AI can also be used for automatic test case generation, improving employee onboarding processes, and offering personalized recommendations for training and development.

The implementation of AI solutions leads to more effective KM by not only automating routine tasks but also reducing the risk of losing critical information. In the long run, these technologies will play a central role in transforming workflows, ensuring better connectivity, accessibility, and adaptability of knowledge within an organization.

3. Prototype Design and Main Functionalities

3.1 ADMS Functionalities

The prototype of the ADMS aims to demonstrate the applicability and effectiveness of intelligent agents and AI automation to improve the accessibility, understanding, and management of complex software documentation. Thus, the ADMS prototype proposes structured, accessible, and automated mechanisms for storing, analysing, and utilizing documentation derived from the main knowledge domains (Georgiev & Antonova, 2024). It employs AI tools to recognise key concepts, extract new knowledge, and improve navigation across information repositories.

The core ADMS modules support the following key capabilities:

- "My Documents" module provides users with a personal space for storing, uploading, downloading, organizing, and analysing documents using an intelligent assistant, capable of generating summaries and classifying files.
- "Processes" module enables the definition of various workflows, including operational, procedural, and project-related processes, to support software development and organizational governance. It introduces the definition of multiple steps, each with an associated template file that users can download, complete, and submit as part of the process.
- "Projects" module allows users to initiate and manage projects by setting parameters such as budget and timeline, linking them to predefined processes for consistency, managing project documentation with a folder tree, and using an AI assistant for document summarization and content analysis.

Among the most important non-functional requirements for the ADMS are security, performance, an intuitive user interface, and the models of integration with intelligent assistants. The authorization modules ensure that only authorized users have access to sensitive documents, processes, and project information. The system supports common file formats (PDF, DOCX, TXT, XLSX, CSV) to allow text data extraction, analysis, and integration with the intelligent assistant. This is essential, as various business processes involve working with text documents, forms, and structured files.

The intuitive interface of the ADMS enables easy navigation, reducing onboarding time and increasing user efficiency. The integration of an intelligent assistant is ensured by implementing the following key conditions:

- The assistant must be integrated via an API, providing standardized communication between the prototype and the external AI model.
- The system must send and receive data in structured formats (JSON/XML), with support for validation and result processing.

When considering the need for training the assistant and storing the history of uploaded documents, the following aspects must be considered (Table 1):

- Security and Usage Policies: Security measures include data encryption, regulatory compliance, and access restrictions to sensitive data (Goel et al., 2024; Sebastian, 2023).

Table 1: Comparative Analysis of Intelligent Assistants

Parameter	ChatGPT	IBM Watson Assistant	Google Gemini (Bard)	Microsoft Copilot
API Integration	*OpenAI API, RESTful, GraphQL*	*API for cloud and on-prem solutions*	*Gemini Developer API*	*Integration via Microsoft Graph API*
Security Policies	*AES-256 encryption, GDPR, SOC 2, HIPAA (business)*	*SOC 2, GDPR, HIPAA, ISO 27001*	*Google Cloud Security, GDPR, CCPA*	*Microsoft Security, GDPR, ISO 27001, SOC 2*
AI Model	*GPT-4 (GPT-3.5 free)*	*IBM Watson NLP & ML*	*Gemini Ultra, Gemini Pro*	*GPT-4, optimized for Office 365*
Fine-tuning	*via OpenAI API*	*via Watson Discovery*	*Supported by Gemini API*	*In the Microsoft environment only*
File Uploads	*In ChatGPT Enterprise & API*	*Watson Discovery supports document analysis*	*Supports file upload*	*Integrated with SharePoint and OneDrive*

Parameter	ChatGPT	IBM Watson Assistant	Google Gemini (Bard)	Microsoft Copilot
Ecosystem Integration	*OpenAI API for Slack, Notion, Zapier, etc.*	*IBM Cloud, ERP systems*	*Google Workspace (Docs, Sheets, Drive)*	*Microsoft 365 (Teams, Word, Excel)*

ChatGPT is an appropriate model for developing an ADMS prototype due to its powerful GPT-4 engine, flexible API integration, and strong data security policies, including AES-256 encryption and GDPR compliance. It supports fine-tuning and file uploads, enabling custom document analysis and adaptive learning from organizational data. This provides a solid foundation to develop further functionalities, considering the assistants' specialisation. Unlike more limited ecosystem-bound models like Microsoft Copilot, ChatGPT offers broad compatibility with platforms, ensuring seamless integration into diverse workflows. This versatility, combined with its high-quality natural language capabilities, makes ChatGPT especially suitable for intelligent document categorisation, summarization across project management environments.

3.2 Prototype Design

The ADMS prototype is designed as a scalable and secure web-based solution that facilitates the management of documents, processes, and projects within an organization. Its architecture follows a multi-layered approach, with the main components including the client side (Client), server side (API), and database.

The client side is a dynamic Single Page Application (SPA) developed with Angular. It provides a responsive and user-friendly interface that allows access to the system's main modules. Each user action is sent to the server side via RESTful APIs. Access to the various modules depends on the user's role, and sessions are managed using JSON Web Tokens (JWT) for enhanced security.

The server side is implemented as a .NET API component, which provides the business logic and data management. The system exposes RESTful API endpoints that allow operations related to user, role, process, and project management with their associated documents. This layer handles authentication and authorization mechanisms.

When an access request is made, the user is authenticated via a username and password. Upon successful validation, the system generates a token containing information about the user's role. Based on this role, access levels and permitted operations are determined.

The service layer defines how operations are performed and how data is validated within the system. It provides functionalities for creating, reading, editing, and deleting users, roles, processes, projects, and documents. This layer also handles operations related to managing tree structures, which are essential for organizing documents into personalized spaces and project repositories.

The domain Layer defines the abstractions that describe the various classes and objects corresponding to the tables in the database. It is accessible by all other layers of the system, providing a unified structure for working with data.

Microsoft SQL Server (MSSQL) is used for data management. The database is designed to support:

- Hierarchical structures for organizing documents and processes;
- Related tables for storing users, roles, access rights, and project parameters;
- Indexed structure for fast data search and retrieval.

4. Prototype Implementation and Validation

The developed ADMS prototype implements a limited but functionally significant scope of the capabilities of the DMS (Document Management System), focusing on the key knowledge areas essential to the domain of Software engineering. The main components of the user interface include:

- **Home Page** – serves as the entry point to the system, providing users with access to different modules. Navigation is structured around the core functional areas.
- **User Management** – allows for viewing existing users and creating new ones. This implies the presence of role-based access control (RBAC) and administrative authority over system access.
- **User Document Management –** offers the ability to create folders, upload, and organize documents. This functionality supports structured storage and quick access to content according to individual user needs.

- **Process Management** – includes viewing and creating processes, showcasing the system's ability to define and manage operational, organizational, and project workflows. This supports standardization and traceability of actions.
- **Project Management** – enables the creation and viewing of projects, with the ability to attach documents and link them to predefined processes. Such functionality demonstrates the DMS's orientation toward a project-based approach to knowledge and documentation management.

4.1 UI Components

4.1.1 Main views

The administrator interface includes an "Administration" module for managing users, roles, and access rights across the system (Figure 1). The administrator can view detailed system status information, manage a personal file workspace, and configure or edit processes, marking whether they are system-wide (accessible to other users). Additionally, administrators can oversee project structures, attach relevant documentation, and ensure consistency in workflow execution.

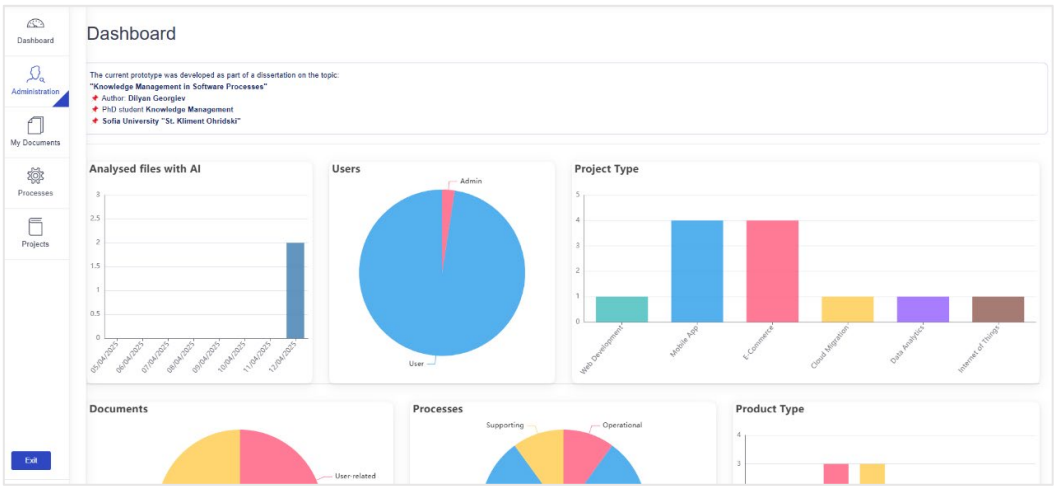


Figure 1: Administrator View

Regular users have access to similar core functionalities, including managing their own file workspaces and editing processes, with the option to indicate system-wide availability. They can also manage individual projects, upload or attach related files, and collaborate with team members throughout the project lifecycle.

4.1.2 Documentation management component

Documentation management is a critical functionality supporting both the "My Documents" and "Projects" modules, acting as a central hub for organizing, accessing, and leveraging content throughout the system. It merges the advantages of traditional document management – covering essential CRUDD operations (Create, Read, Update, Delete, Download) – with advanced AI-driven capabilities for document understanding and analysis, powered by OpenAI technologies.

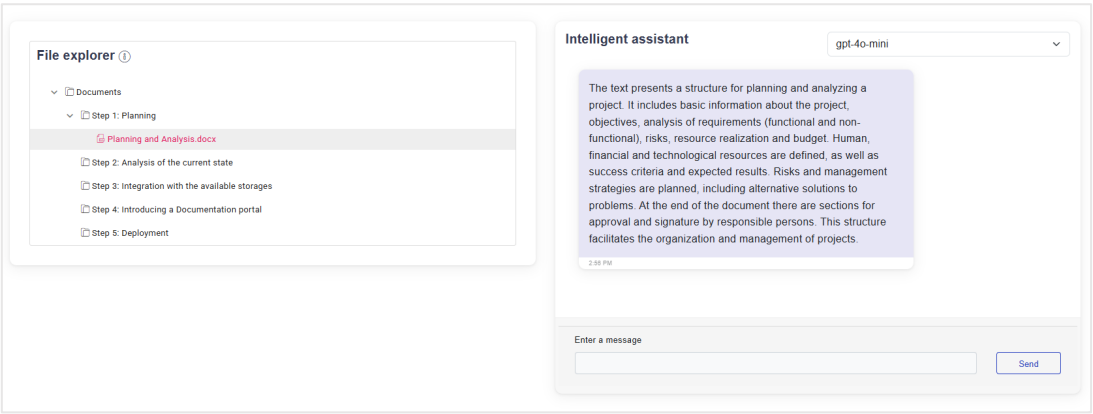


Figure 2. File Explorer and ChatGPT

On the one hand is a robust file explorer, which enables users to create folders, upload and download files, and seamlessly interact with an intelligent assistant via “Summarise” and “Analyse” commands. This assistant, integrated directly into the file tree, can be triggered to perform operations and answer user queries. Through a conversational interface, users can ask specific questions or issue commands, enabling dynamic exploration of document content and extracting meaningful insights in real time.

Furthermore, the module offers the flexibility to choose between different OpenAI models, allowing users to tailor the assistant’s capabilities based on performance needs or context. This integration of AI within a user-friendly document interface significantly enhances productivity, supports knowledge discovery, and positions the documentation management module as a powerful, intelligent feature across both personal and collaborative project spaces (Figure 2).

4.1.3 Wizard Component for Defining Process/Project Steps

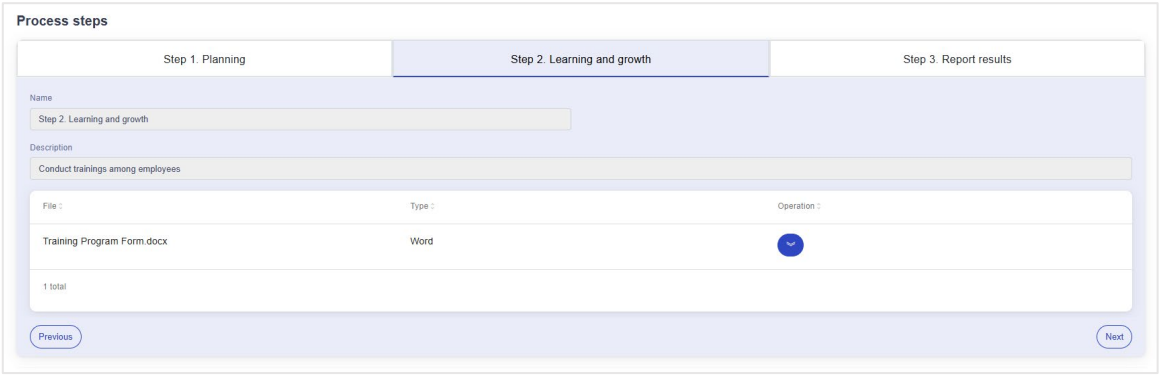


Figure 3: Wizard component for Process management

The wizard component is a key element used to define process steps and automatically generate corresponding project steps based on predefined workflows (Figure 3). It provides a user-friendly interface that allows intuitive configuration and customization of each step’s view, ensuring consistency and reusability even after a project has been initiated. This modular approach supports dynamic adaptation to different project needs and encourages process standardization across teams.

Project information is organized into three main sections for better clarity and navigation:

- “Project Information”, which contains key metadata and configurations.
- “Gantt Chart”, offering a visual representation of the timeline and dependencies between steps.
- “Attached Documents”, which consolidates all relevant files and resources associated with the project.

4.2 ADMS Validation

The study followed a three-stage research methodology to evaluate the prototype. First, a set of testing scenarios is designed to simulate typical user interactions with the system. In the second stage, the respondents execute these scenarios to assess the system's functionality and usability. Finally, participants complete a structured feedback document and a survey, providing both qualitative impressions and quantitative ratings of their experience.

Several of the survey questions are based on a 5-point Likert scale, enabling further statistical analysis. For selected items, one-sample Student's t-tests are conducted by setting up a null hypothesis (H_0: $\mu = 3$), which represents a neutral position, suggesting the statement is not statistically supported. An alternative hypothesis (H_1: $\mu > 3$) is defined to test whether respondents’ ratings significantly leaned in favour of the statement, indicating positive user alignment.

A total of 30 specialists from diverse professional backgrounds within the software industry participate in the ADMS prototype validation experiment. They test the system by executing several scenarios for document management and completing a short survey. The largest share of respondents (70%) are software developers, which adds additional expertise in terms of efficiency, performance, and design. The inclusion of project managers (23%), team leaders (17%), DevOps (10%), and Quality Assurance (7%) specialists contributes to a multifaceted assessment of the applicability of the ADMS in the knowledge areas.

The respondents have different levels of professional experience, with the largest share being specialists with between 5 and 10 years. They make up 50% of the participants, which suggests that the feedback is based on in-depth practical knowledge and experience in document, process, and project management.

The largest percentage of participants work in companies with 100 to 500 employees, which is indicative of medium-sized organizations with well-established processes. Respondents from small teams with less than 20 people, as well as from large enterprises with over 500 employees, are also included, which provides diverse perspectives on the usability of the ADMS in different corporate structures.

During the testing phase, respondents rate the various functionalities of the ADMS in terms of their usefulness. The results show that the intelligent assistant for document analysis has the highest value for users (83%). This highlights the importance of automated document analysis and summarization as a key functionality of the system. Next comes the Intelligent Project Assistant, as 70% of the users see value in supporting document management within projects. Both Project documentation and Project creation are ranked by 57% of the respondents as especially useful, highlighting the importance of effective document organization in the context of project activities and being significant for workflow management. The possibility to upload forms and define processes is useful for 37%, but the results show that they tend to be more specific to certain user groups.

The results of the survey show a high level of acceptance and positive attitude towards the implementation of the system. The numerical data are analysed by applying t-tests, which reject the null hypothesis H_0: $\mu = 3$ and accept the alternative hypothesis H_1: $\mu > 3$ (Table 2).

Table 2: Statistical evaluation of the prototype (t-tests)

Question	Average	t-value	p-value	Result
How do you assess the usability of the system?	3.66	6.02	7.5224E-07	μ>3
How intuitive was the system in terms of navigation?	3.86	5.06	1.0571E-05	μ>3
Was it straightforward to obtain the required information from the provided documents?	4.23	7.86	5.5734E-09	μ>3
To what degree could the intelligent assistant enhance information management in a software company?	3.56	3.08	0.00222541	μ>3

Respondents' feedback identifies key functionalities that would contribute to improving the system and its effectiveness in a real-world environment:

- Automatic report generation (73%) – would save significant time and reduce human error by compiling data and insights instantly. It ensures consistency in documentation, supports decision-making, and improves transparency across projects.
- Integration with external systems (70%) – tools like version control, ticketing systems, or HR platforms would allow seamless data exchange. This would increase the overall productivity, avoid data duplication, and create a unified workflow across different organizational tools.
- Automatic document categorization (57%) – would help with organizing knowledge efficiently, improve navigation, and enable faster retrieval of relevant content. It would enhance structure and reduce the cognitive load on users managing large repositories.
- Access control and rights (63%) – role-based access ensures sensitive information is protected while maintaining operational flexibility. The administrator module would be expanded with collaboration functionalities – sending invitations or dedicating roles for a given project. It minimizes security risks, ensures compliance with data policies, and supports tailored user experiences.
- Advanced search capabilities (50%) – powered by metadata and AI, advanced search would allow users to quickly find precise information. It boosts efficiency, reduces downtime, and supports better knowledge reuse and onboarding.
- Integrated collaborative chat (47%) – would enhance real-time collaboration, enabling users to discuss documents directly within the platform. This fosters faster feedback loops, improves decision-making, and captures knowledge from informal exchanges.

These results demonstrate that the implementation of the system is perceived as a positive step towards process optimization, although some users may have reservations about its long-term impact. The feedback confirms that the prototype successfully performs its main functions – document analysis, process and project management, and integration with the intelligent assistant. Users appreciate the extracted information, the lack of hallucinations, and the intuitive UX/UI interface.

5. Conclusion

The integration of AI is becoming a mandatory element of any knowledge management system that supports the implementation of software processes. In the context of documentation management, ADMS could facilitate access to various types of documentation by integrating intelligent agents within its functionalities.

The presented prototype of the ADMS enables validation of the system's key functionalities, such as documentation management across different knowledge domains, intelligent search and content analysis, and user access control. It will also verify the integration with intelligent agents and the available configuration options. This prototype provides a solid foundation for the further development of the ADMS and implementation of AI into a real-world technological solution supporting effective KM in SE.

Considering that the ADMS prototype demonstrates the potential influence of AI on the efficiency of various professionals in the software industry by supporting documentation storage, application insights, and the sharing of information. Thus, the model could be developed and deployed as a strategic tool that facilitates KM for improving knowledge storage and communication within the organisations.

Acknowledgements

The authors gratefully acknowledge the support provided by the project UNITe BG16RFPR002-1.014-0004 funded by PRIDST.

Ethics Declaration: This study involved a voluntary survey of 30 participants, collecting only non-identifiable opinion-based responses. No personal or sensitive data was gathered. Participants were informed about the purpose of the research, and their consent was implied through participation. As such, formal ethical clearance was not required under the relevant institutional guidelines.

AI Declaration: Artificial intelligence tools were used solely for editing and language polishing. No AI tools were used for data generation, analysis, or interpretation.

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Conceptualizing the Media Ecosystem: Addressing Misinformation, Disinformation, Fake News, and Deepfakes — Key Insights from Interviews with Professional Journalists

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Abstract: As technology continues to evolve rapidly and online content—particularly on social media—is widely consumed, the spread of misinformation, disinformation, fake news, and deepfakes has become a critical concern. While numerous studies recognize the severity of these phenomena and their negative societal impact, significant conceptual ambiguities persist. To address these gaps, this research integrates insights from relevant scholarly literature and in-depth interviews with professional journalists to refine the conceptual frameworks of misinformation, disinformation, fake news, and deepfakes, clarifying their distinctions. It may contribute to communication research by enhancing the conceptual understanding of key media ecosystem concepts and guiding strategies for media management and literacy development.

Keywords: Fake news, Deepfakes, Misinformation, Disinformation, Social media, Journalism

1. Introduction

The contemporary media ecosystem is marked by the widespread presence of false and misleading content. The dissemination of such information is exacerbated by the widespread accessibility of digital devices, the absence of effective mechanisms to detect and constrain the circulation of inaccurate data on the Internet, and the relatively low level of media literacy among users. This issue is further intensified by escalating international conflicts and crises in diplomatic relations, where false or incorrect narratives are used as a tool to discredit adversaries and manipulate public opinion. Significant attention is devoted to misinformation and disinformation (e.g., fake news, deepfakes), which can harm individuals and society overall (Shinde & Sathyaprakash, 2023). For this, the amount of research regarding mis- and disinformation has experienced exponential growth. “At the same time, when research in a particular area increases significantly within a short time frame, there is a great risk of a lack of overview, fragmentation and research cumulativity. This holds particularly true when research is simultaneously carried out in many otherwise rather disconnected disciplines” (Broda & Strömbäck, 2024). This concern is particularly relevant to misinformation and disinformation studies, including fake news and deepfakes, as these phenomena are examined across various disciplines (e.g., computer science, political science, sociology, journalism, and mass communications). Consequently, there is an absence of widely accepted conceptual frameworks to define ‘disinformation,’ ‘misinformation,’ ‘fake news,’ and ‘deepfakes’ in contemporary social and humanitarian sciences. To address these gaps, this study aims to systematize these definitions and develop conceptual models for these terms.

2. Data Collection

This research was designed as a qualitative study, with semi-structured interviews to explore professional journalists' perspectives on such key concepts as ‘disinformation,’ ‘misinformation,’ ‘fake news,’ and ‘deepfakes’. Data gathering was carried out between September and December 2024 in Italy. Twelve respondents were selected based on purposive sampling, with the selection criteria focusing on their professional experience across different types of media. While the primary strategy was purposive sampling, the process also involved some degree of convenience sampling. The journalists were selected from diverse media outlets, aligning with established media studies classifications: public service media (PSM), private television and radio, print media (leading dailies), digital-native news media, local/regional media, and community/non-profit media (see Table 1). Semi-structured interviews were conducted online via Google Meet. Interviews, conducted in Italian, the participants' native language, were audio-recorded and subsequently transcribed using automated software (Microsoft Word). During the interviews, a structured questionnaire served as a guide, ensuring consistency across interviews while permitting participants to elaborate on their experiences and opinions. The collected data were compiled into a single Word document. The following thematic areas were covered during the interviews: the concept of fact and truth, understanding fake news, characteristics and indicators of fake news, reasons for the creation and spread of fake news, principles of journalism and fact-checking, core principles of journalism (e.g., objectivity), a detailed description of the fact-checking process, and journalism ethics and challenges. Then, the analysis followed a rigorous thematic analysis approach, as outlined by Zúñiga et al. (2023). This process involved six distinct phases: (1) familiarization with the data through repeated listening

to and reading of transcripts; (2) generation of initial codes to identify key concepts; (3) identification of overarching themes emerging from the coded data; (4) review and refinement of themes to ensure coherence and validity; (5) definition and naming of final themes; and (6) production of the research report, integrating empirical findings with relevant scholarly literature. This study specifically focused on the differentiation of key terms related to information disorder: 'disinformation,' 'misinformation,' 'fake news,' and 'deepfakes'.

Table 1: Sample of Italian media outlets

Type of media outlet	Media outlet	Position
Press (leading dailies)	La Repubblica	Editor-in-chief
	Corriere della Sera	Journalist
Private TV	Mediaset	Editor-in-chief
	La 7	Journalist
Public Service Media	RAI	Editor-in-chief
	RAI	Journalist
Digital native news media	Follow Up News	Editor-in-chief
	Valigia Blu	Journalist, editor
Local/regional media	Nord Est Multimedia S.p.A. (NEM)	Editor
	Milano Free, Musica 361, 7 Giorni	Journalist Freelance
	Milano today	Journalist
Community, non-profit media	Internazionale	Journalist Freelance

3. Results of Analysis

3.1 Misinformation VS Disinformation

In academic research, the key difference between 'misinformation' and 'disinformation' lies in the intention behind sharing the information. Misinformation refers to the accidental sharing of incorrect or misleading information (Wardle, 2017; Li & Chang, 2022), whereas disinformation involves the intentional creation and dissemination of false information or distorted stories to deceive or harm others (Pennycook & Rand, 2021; Rodrigo et al., 2022). Jack (2017, p. 15) notes, "While both terms refer to misleading information, misinformation usually implies no intent to mislead, while disinformation suggests knowing deception." Disinformation is a broad term encompassing intentionally false content, such as hoaxes, rumors, or clickbait, aimed at provoking reactions (like likes or comments) or serving a specific agenda. Conversely, misinformation involves the sharing of incorrect information without any intention to mislead the public or pursue personal goals.

These findings align with the insights gathered during the interviews, as media experts distinguished between these terms. For instance, an editor from "RAI" explained: "*The term misinformation is used, but it hasn't become part of our vocabulary yet. Disinformation means spreading false news to influence or harm someone. I engage in disinformation when I knowingly share false news to cause harm. Misinformation occurs when I share false news without realizing it. I don't intend to harm anyone, but the news might seem believable to me, and I share it*" (editor, public TV, "RAI"). The journalist from "Valigia Blu" added, "*There are subtle distinctions to make. Disinformation means intentionally creating and sharing false news to mislead or harm someone, while misinformation occurs when we accidentally spread false news because we didn't know it was false. In this case, fake news spreads without any malicious intent*" (journalist, digital native news media, "Valigia Blu").

3.2 Fake News: Key Definitions

A significant challenge in both academic and public discourse is defining 'fake news,' as this concept is often conflated with other related concepts such as deepfakes, clickbait, rumors, and various types of disinformation. Oremus (2016) suggests that we should avoid labeling everything as "fake news." To understand what "fake news" means, it's essential to consider various definitions. For instance, Sutu (2019) describes fake news as "real content used in the wrong context or news shared on websites that spread false information, often designed to

look like real media" (p. 83). Bakir and McStay (2017) note that a key feature of modern fake news is its widespread online dissemination (p. 1). Rini (2017) points out that while fake news can spread through other means, such as emails or posters, it is particularly linked to social media, especially during the 2016 election (p. 45). In recent years, social media has transformed how news is structured and shared (Berkowitz & Schwartz, 2016; Copeland, 2007). Many definitions focus on the format of fake news, which often mimics real news. For example, Levy (2017) states that fake news copies the look and feel of credible news outlets. Brennen (2017) defines fake news as "fabricated content made to look like real journalism designed to deceive" (p. 180). Thus, fake news often follows traditional media conventions, presenting itself as accurate and trustworthy (Han et al., 2017; Kim & Dennis, 2019). These definitions emphasize that fake news often imitates real news reporting, making it easy for audiences to mistake it for legitimate information.

To gather journalists' definitions of 'fake news,' we asked selected respondents to share their views on what fake news is. Based on their responses, we identified key categories and grouped them into several themes.

Fabricated or Partially Distorted Content: Fake news can be completely false or based on real events that are manipulated to mislead the audience. Some journalists say fake news includes "*unreal facts that do not match reality*" (editor-in-chief, press, La Repubblica). Others note it can involve real information that is twisted, as an editor from Follow Up News stated, "*It spreads false news that seems true but isn't.*" This manipulation might involve changing the context, misrepresenting facts, or selectively reporting to sway public opinion.

Fake News Resembling Real News: Journalists pointed out that fake news is especially dangerous because it looks like a real journalistic piece. This makes it hard for audiences to tell the difference between fake news and credible news. The journalist from Milano Today said, "*It may seem true, but maybe it isn't.*" The journalist from La7 described fake news as "*manipulated news that seems true but isn't.*" This deceptive format—using professional headlines and visuals—makes it harder to combat fake news, as people often accept it as real.

Unverified or Inaccurate Information: Journalists emphasized that fake news is often unverified and lacks credible sources. The freelance journalist from Milano Free defined fake news as "*information given inaccurately, without checking with reliable sources.*" Similarly, the journalist from Internazionale noted the fast spread of unverified claims: "*News that hasn't been verified or shared too quickly.*" This highlights the difference between professional journalism, which involves thorough fact-checking, and disinformation, which is often spread without verification.

Fake News as a Tool for Manipulation: Some journalists stress that fake news is created to mislead audiences and shape public opinion. The journalist from Valigia Blu explained its main purpose: "*To make people believe something that isn't true.*" Fake news aims to provoke specific reactions, such as social media engagement or public outrage. It is often spread strategically to achieve social, economic, or political goals.

Overall, from the authors' perspective, fake news is a type of disinformation that can be entirely or partially false, often based on real events but created to mislead or manipulate a target audience. To appear more credible, fake news adopts the style of real journalism, including exaggerated or sensational headlines and a main text that lacks solid evidence, such as official documents or reliable data. While fake news may not always include multimedia elements like photos or videos, these are often used to enhance its impact. The topics chosen for fake news are often selected to resonate with specific audience interests, increasing its chances of going viral. Additionally, fake news often takes advantage of cognitive biases, reinforcing existing beliefs and hindering critical thinking.

3.3 Defining of Deepfakes

While fake news primarily involves textual information, with photos and videos playing a complementary role, deepfakes are primarily based on visual media, such as photos and videos (Westerlund, 2019). The term "deepfake" is a blend of "deep learning" and "fake," referring to images and videos altered or entirely generated through artificial intelligence (AI) and machine learning techniques. Despite the potential positive applications of deepfakes in fields such as education, healthcare, and entertainment—offering opportunities for creativity and harmless amusement—malicious use of deepfakes has raised significant concerns. As Lundberg & Mozelius (2024) observe, "The malicious use of deepfakes creates a social problem and could threaten democratic institutions, social stability, and international security." Deepfakes are characterized by their ability to modify or entirely fabricate images and videos, making them powerful tools for representing both real and fabricated events or situations.

During interviews with professional journalists, emerging threats posed by deepfakes were highlighted. For instance, the editor of a private TV channel noted that the ability to create visual content, especially photos and videos, that appears completely plausible is becoming more widespread and difficult to verify: "*With the help of artificial intelligence or advanced technologies, it is easy to spread fake news. For example, just yesterday, they reported that a man had been killed, and until DNA evidence was available, it was uncertain. Anyone could have created a video with his face showing that he was run over. Until DNA evidence was available, it wasn't certain. Especially with images and the speed at which we consume news, it is much easier to spread false information online*" (editor, private TV, "Mediaset"). Another journalist added, "*… new risks associated with fake news come from technology itself, not just the ability to spread it through social media, but from the new dangers created by artificial intelligence, where fake images and videos can be artificially generated. For those without the tools to interpret and distinguish between truth and falsehood, it becomes much more complicated*." (journalist, private TV, "La7").

Therefore, based on empirical research findings and a review of scientific literature, we have gained new insights into these concepts (see Table 2).

Table 2: Understanding the 'Media Ecosystem': Key Concepts

Concept	Definition
Fake news	constitutes a form of disinformation that may be wholly or partially fabricated, often addressing real events, situations, phenomena, or individuals. It is deliberately created to mislead or manipulate a specific audience. To enhance its perceived credibility, fake news adopts the format of a recognized journalistic genre (e.g., actual news) and adheres to a particular structure. This includes elements such as headlines—typically exaggerated, inaccurate, or sensational—alongside the main text, which generally lacks a systematic, cohesive, and well-founded evidentiary basis, such as official documents, critical data, statistics, or scholarly papers.
Disinformation	involves the deliberate creation and dissemination of misleading information with the explicit intent to deceive or cause harm, aiming to manipulate public opinion or achieve specific objectives.
Misinformation	refers to the unintentional sharing of inaccurate information without the intent to deceive, often occurring when individuals mistakenly believe the content is correct.
Deepfakes	a photo or video product created by artificial intelligence, referring to multimedia materials that are either completely or partially false. It includes a variety of content genres: from entertaining video materials to political and social provocations.

Source: The author's elaboration

4. Conclusion

The research explored key definitions of concepts frequently discussed in academic and public discourse. We identified the differences and similarities among phenomena like misinformation, disinformation, fake news, and deepfakes. Based on empirical research findings and a review of scientific literature, we have gained new insights into these concepts. A potential area for future research could be fact-checking strategies. This might involve analyzing media practices in Italy and comparing journalistic practices in other countries. Such research would help identify commonalities and differences, deepen our understanding of specific contexts (including cultural diversity), identify global trends, and analyze the impact of globalization on the journalism profession.

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Towards Integrating Digital Preparedness into Higher Education

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Abstract: Integrating disaster preparedness education into higher education curricula faces persistent challenges in terms of engagement, relevance, and practical skill development. Recent advancements in digital tools offer promising opportunities to address these gaps through more interactive and experiential learning approaches, fostering disaster preparedness competencies among students, including enhanced risk awareness and improved emergency decision-making. However, embedding such tools into academic curricula requires careful alignment with pedagogical goals, institutional systems, and stakeholder expectations. This paper examines pathways for integrating modern digital preparedness tools into university education through a single case study. Data was collected based on semi-structured questionnaires from educators, students, and first responders at a Norwegian University. Experiences from an EU-funded project that developed an ecosystem (B-Prepared) for preparedness, including four digital products: virtual reality (VR-prepared), mobile technologies (IM-prepared), a learning management system (RU-prepared), and a knowledge management system (Disastropedia), were also considered. The results indicate positive attitudes toward embedding preparedness modules into existing courses. However, to be useful, the Learning Management System (LMS) should include a user flow on emergency preparedness and provide concrete examples on technology integration in a curriculum. The paper further discusses key challenges related to knowledge transfer, pedagogical alignment, and institutional infrastructure.

Keywords: Virtual reality, Emergency preparedness, Training, Education, Knowledge transfer

1. Introduction

Disasters and emergencies continue to pose significant risks to communities worldwide, making it increasingly important to foster disaster preparedness among all sectors of society, including university students (Paton, 2003, Ronan et al., 2015, Becker et al., 2012). Higher education institutions provide an ideal setting for promoting such preparedness, as students often become future community leaders and decision-makers. However, disaster education is not yet a standardized part of university curricula in many countries, and its integration faces both pedagogical and organizational challenges (Shiwaku and Fernandez, 2011, Shaw et al., 2004, Patel et al., 2023).

Traditional disaster education often relies on lecture-based instructions in a classroom situation, which may not sufficiently engage students or promote practical readiness skills (Johnson et al., 2014, Patel et al., 2023). The practical training is typically conducted through training evacuations following a fire alarm at the organization. While several new planning solutions are available, providing regular training at organizations remains challenging (Jalilov, 2025). This is especially true at universities, where there are many students and a variety of different groups. According to our present knowledge, there are no special courses available for evacuation training. There are no responsibilities or structures for this. For this, it would be necessary to align the disaster preparedness course or module with existing curriculum outcomes in the diverse academic disciplines. The motivation behind this paper is to investigate the opinions of the main stakeholders, namely teachers, students, and firefighters, on integrating a digital preparedness module into existing courses.

In general, educators often express uncertainty about how to integrate such new content effectively into an already running curriculum (Shaw et al., 2004, Shiwaku and Fernandez, 2011). For this, both educators and learners prefer a variety of digital tools (Frøland et al., 2020). Emerging technologies, such as Virtual Reality (VR), Augmented Reality (AR), gamification, and serious games, offer promising avenues to enhance engagement and experiential learning in this domain (Allcoat and von Mühlenen, 2018, Boyle et al., 2016, Heldal, 2016). Prior studies have demonstrated that immersive simulations can foster a more profound understanding of hazards and emergency procedures (Allcoat and von Mühlenen, 2018, Wijkmark et al., 2022, Hsu et al., 2013). Gamification techniques can also motivate learners to engage actively with preparedness content (González et al., 2018, Boyle et al., 2016). This paper examined how new technologies can enhance emergency preparedness. The reason for focusing on new technologies is to engage students in their use. An additional motivation is from the ongoing European B-Prepared project context (European_Comission, 2023), which explores civilians'

preparedness by using different technologies. This paper examines how new technologies used in a educational module can contribute to increased preparedness by exploring the possibilities for integrating such modules into higher education curricula at a Norwegian university.

The overall aim is to contribute to a better understanding of possibilities for embedding preparedness modules into existing university courses through investigating attitudes from the involved stakeholders, i.e., educators who need to integrate such modules in their courses, students who need to learn more about emergency preparedness, and firefighters who need to ensure that evacuation procedures and safety instructions are appropriate. The data used in this paper comes from semi-structured questionnaires conducted with key institutional stakeholders, including educators, students, and first responders, and also considering lessons from the B-prepared project (European Commission, 2023).

2. Technological Innovations for Disaster Preparedness Education

2.1 Implementing New Technologies for Disaster Preparedness

Disaster incidents are inherently complex and unpredictable, and traditional training methods for preparedness can be costly and difficult to scale. With the rapid advancement of consumer-grade virtual reality (VR) hardware and mobile technologies, immersive training solutions have become more affordable and accessible at universities (Radianti et al., 2020).



Figure 1: All the Products from B-prepared: a VR game, mobile technology (MT), a knowledge sharing platform 'Disastropedia', and a learning management system (LMS)

Leveraging these technologies to train university students on disaster and emergency preparedness can play a crucial role in mitigating future disaster risks (Zhang et al., 2023, Keya Tasnim et al., 2024). The ongoing European project B-Prepared (European_Comission, 2023) is developing a suite of digital tools aimed at enhancing disaster preparedness education through innovative technologies (see Figure 1). The project's ecosystem consists of several complementary components:

- a mobile-based application, **IM-prepared**, offering geolocation-guided walks (GPS-based), presenting historical disaster scenarios and puzzle-based learning games. The application is being further extended by incorporating augmented reality (AR) games.
- **VR-prepared** is a VR-based serious game platform featuring two separate scenarios: wildfire preparedness and flood preparedness (King Tide). Both scenarios support multiplayer functionality, allowing multiple participants to interact simultaneously within the virtual environment and practice coordinated decision-making and evacuation.
- a dynamic knowledge-sharing platform, **Disastropedia** (Ekon, 2024), designed to allow users to contribute, access, and share information on disasters and preparedness strategies. All newly created content is reviewed and approved by a dedicated curation board to ensure accuracy and reliability.
- an integrated Learning Management System (LMS), **RU-Prepared**, based on Moodle, a widely used open-source LMS platform in higher education, that serves as the central integration point for all project components.

Within the B-Prepared ecosystem, Single Sign-On (SSO) functionality is being planned to implement, allowing students with an account in RU-prepared to access IM-prepared, VR-prepared, and Disastropedia. Progress tracking is also supported within RU-prepared. Full integration with university Learning Management System (LMS) platforms, such as Canvas, is under discussion.



(a) (b)

Figure 2: Figure (a) shows a VR-prepared (King Tide) multiplayer flood preparedness scenario, and (b) shows an IM-prepared AR-based CPR training game

Two example games developed within the B-Prepared project are illustrated in Figure 2. Figure 2(a) shows a VR-prepared scenario that supports multiplayer functionality, allowing participants to collaboratively practice wildfire and flood preparedness in immersive virtual environments. Figure 2(b) presents an AR-based game in which users must correctly identify and position their hands to perform CPR compressions on an unconscious person. The activity is time-constrained, and users must complete the task accurately to succeed in the game.

By combining immersive technologies with gamification strategies (Keya Tasnim et al., 2024), the B-Prepared project aims to create engaging and effective learning experiences that foster greater resilience and preparedness among students.

2.2 Gamification in Learning

Gamification refers to the use of game design elements in non-game contexts and has gained substantial attention in education for its potential to increase learner engagement and motivation (Hamari et al., 2014, Deterding et al., 2011). In disaster preparedness education, where fostering practical skills and risk awareness is critical, gamification can support experiential learning by simulating realistic scenarios and encouraging active participation.

Serious games and immersive technologies such as video (Liu et al., 2023), or VR and AR allow learners to practice responses to hazardous situations in a safe environment (Boyle et al., 2016, Shaw et al., 2004). Prior studies indicate that interactive simulations can improve hazard recognition, decision-making, and procedural knowledge (Shaw et al., 2004, Radianti et al., 2020). Moreover, gamification elements, such as points, feedback, progress tracking, and scenario-based challenges, help sustain learner motivation and promote deeper cognitive engagement (Hamari et al., 2014, Deterding et al., 2011, Subhash and Cudney, 2018). For example, the Gamified Learning Theory (GLT) emphasizes that game attributes (e.g., challenge, rules, interaction) influence learning-related behaviors and attitudes (Landers, 2014). Effective gamification design can foster greater academic participation, enhance intrinsic motivation, and improve retention of preparedness knowledge (Hamari et al., 2014, Landers, 2014).

In the context of the B-Prepared project, gamification is a core pedagogical strategy embedded across the VR-prepared and IM-prepared applications. It utilizes scenario-based challenges, AR interactions, and multiplayer VR experiences to create engaging learning environments that encourage repeated practice and reflection. Integrating such tools into higher education curricula may help address existing gaps in disaster education and better prepare students for real-world emergencies.

3. Methodology

This paper is based on a single-case study, utilizing semi-structured questionnaires, and aims to explore integration pathways for digital disaster preparedness tools and methods in higher education contexts. The paper focuses on the possibility of developing an educational module that includes these components, which

can be integrated into a university curriculum. The technology utilized is inspired by the VR technology for the B-Prepared project.

The stakeholders' feedback was gathered through a small-scale questionnaire distributed to educators, students, and first responders. Three versions of the questionnaire were developed, each including a common core section (20 items for students and teachers, and 18 items for firefighters) focusing on general attitudes toward using VR for evacuation training. In addition to the core items, each stakeholder group answered specific questions related to their own role: educators were asked about their interest in integrating VR modules into curricula, students about their interest in VR-based training in courses, and firefighters about the relevance and validity of VR-based evacuation training. In total, responses were collected from 3 educators, 7 students, and 2 firefighters. The questionnaire included both closed-ended and open-ended questions.

The overall aim of the questionnaires was to capture perceptions of the potential benefits, challenges, and requirements for integrating digital disaster preparedness tools in academic settings as an educational module that can be adopted to different courses.

4. Results

The purpose of the survey was to gather initial feedback from stakeholders on the integration of VR-based fire evacuation training into university curricula. The survey explored three core areas: (1) current knowledge of evacuation procedures, (2) interest in using VR for fire drill training, and (3) preferences for training delivery formats. The following sections present responses from students, educators, and firefighters.

4.1 Student Responses

Students were asked to reflect on their current knowledge of emergency procedures and their interest in VR - based training. When asked about their knowledge of evacuation procedures, most students reported being familiar with evacuation signs; however, many were not fully aware of the location of the designated assembly points.

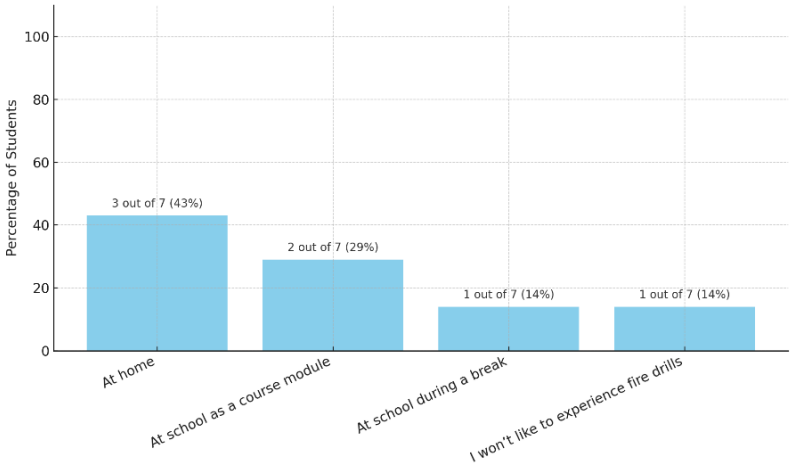


Figure 3: Student preferences for drill locations

When asked how they would respond upon discovering a fire, student responses demonstrated a range of preparedness. One student with a military background responded:

> *"Yell 'Fire!' so that people nearby know it's happening. Pull the fire alarm, then quickly check the nearby rooms. If it's not too intense, I might check the burning room too."*

Another student shared:

> *"Get out, shout in the halls, find the fire alarm. If it's small, I might get an extinguisher first."*

Regarding interest in VR-based fire drill training, six of the seven students expressed enthusiasm. Preferences for drill location varied: 43% preferred doing it at home, while others opted for a break at school or a course module (see Figure 3). The fact that most students favored completing drills at home or as part of a course module directly supports the feasibility of implementing flexible VR-based training scenarios, both for remote home-based practice and for integration as an academic module within university courses.

4.2 Teacher Responses

Educators were asked about their existing knowledge of evacuation, their interest in integrating VR-based training, and their ability to manage such training independently. All three educators reported that they actively look for evacuation signs when entering new buildings and indicated confidence in their basic evacuation knowledge and responsibilities in case of fire alarms.

All educators expressed support for incorporating VR-based fire drills into classroom activities, particularly during breaks, as a flexible alternative to traditional drills. However, when asked about their confidence in managing the VR-based training independently, all three educators reported a need for some form of support:

- One educator indicated that he/she would need personal VR training beforehand to feel confident in instructing students.
- Another educator mentioned that access to necessary VR equipment would be a prerequisite for implementation.
- The third educator highlighted the need for both equipment availability and ongoing technical support.

These findings indicate that while educators are open to adopting VR-based preparedness training, they emphasize the importance of providing adequate training, resources, and technical support to ensure successful integration into classroom teaching.

4.3 Firefighter Responses

Two experienced firefighters (with 7 and 30 years of experience, respectively) participated in the survey. They were asked about their perspectives on fire evacuation procedures and the potential role of VR-based training in supporting preparedness education.

Both firefighters emphasized that regular fire drills are essential for maintaining readiness among students and staff. They suggested that drills should ideally be conducted at least once every two years. Regarding evacuation behavior, they expected that, in the event of an alarm, students and teachers should safely gather at the assembly point and report any missing persons to responders if possible.

When asked about the potential value of VR-based training, both firefighters agreed that VR simulations could serve as a useful supplement to preparedness education. However, when discussing the possibility of officially validating VR-based drills, one firefighter commented:

> *"Yes—to see what is developed and evaluate it from my experience. But not to validate as to assure the quality of a VR application."*

This highlights that while emergency professionals are open to supporting VR-based training efforts, they prefer to contribute as consultants rather than serve as formal validators for the technological or pedagogical accuracy of the VR content.

5. Integration Pathway for Digital Preparedness in Higher Education

5.1 Proposed Integration Approach

Based on the findings of this study, it is evident that stakeholders, students, teachers, and fire safety professionals support the integration of virtual reality into school-based disaster preparedness training, as noted in prior studies (Hsu et al., 2013, Scorgie et al., 2024). However, enthusiasm alone does not guarantee institutional adoption. Practical implementation models are needed to support meaningful policy changes, focusing on knowledge, skills, and abilities (Abich et al., 2021), however, these aspects vary depending on the questioned stakeholders. The products in the B-Prepared ecosystem are designed to work together, offering multiple entry points for both educators and students.

Building on the B-Prepared ecosystem described above, one of the key objectives is to establish effective pathways for integrating these digital preparedness tools within higher education curricula. Rather than positioning the tools as stand-alone training products, the B-prepared project envisions their use as embedded components within existing university courses.

A practical pathway involves linking the RU-Prepared LMS with institutional platforms such as Canvas (a widely adopted LMS in higher education), allowing preparedness modules to be incorporated into standard course structures. This approach aligns with broader trends in the digitalization of higher education (Radianti et al.,

2020), the integration of serious games in the curriculum, and the use of learning analytics to support competency-based education (Ifenthaler and Yau, 2020) and disaster risk awareness (c.f. Calvet et al., 2019).

However, integrating such tools into academic curricula presents several challenges, including aligning them with existing pedagogical frameworks, ensuring institutional support, addressing technical integration with the university's own LMS, and fostering teacher readiness. Prior research highlights that educators often face barriers such as a lack of technical skills, institutional resistance, and uncertainties about pedagogical value when adopting immersive technologies (Calvet et al., 2019, Makransky et al., 2020). Effective implementation requires collaboration between content experts, pedagogical designers, and institutional stakeholders, but also considering the types of emergency (Liu et al., 2023).

The current proposal of this paper is to offer an optional learning module, a short module within existing university courses, rather than as a stand-alone subject. While the learning goals of a course are necessary, the components and ways of using parts of an ecosystem can be aligned with the original learning goals and can be demonstrated and illustrated by using the ecosystem, thereby enhancing learning and emergency preparedness. Examples include demonstrating concrete tool development issues from the B-Prepared products in programming courses, which can be followed by training using the constructed product. Using the concept of creating a knowledge management system through Disastropedia in management or innovation courses can also be followed by training with the B-prepared ecosystem. Since the B-prepared ecosystem encompasses various emergency preparedness issues, such a module can be incorporated into a large number of courses. In this way, digital preparedness can reach a broader student audience, including those in non-technical programs.

Since one of the main issues hindering eventual integration was considering the *User Flow,* from a student perspective, this is outlined as follows (see Figure 4):

- Students register for their regular university courses through the institutional LMS, e.g., Canvas.
- Within the Canvas course, they are offered a learning module on digital preparedness. (For this step, teachers' preparedness is necessary, not illustrated in Figure 4.)
- Ideally, via integration between Canvas and the RU-Prepared LMS, students would gain seamless access to the products, emergency challenges, and rewards in the ecosystem without requiring separate login credentials. (For this, the teachers need to choose suitable emergency management challenges and associated products for achieving their goals.)
- Once inside the RU-Prepared LMS, students access the connected B-Prepared tools via SSO, ensuring a unified learning experience.
- Student progress is tracked within the RU-Prepared LMS, and if the integration is fully implemented, selected progress data (such as module completion status) could be reported back to the Canvas gradebook.

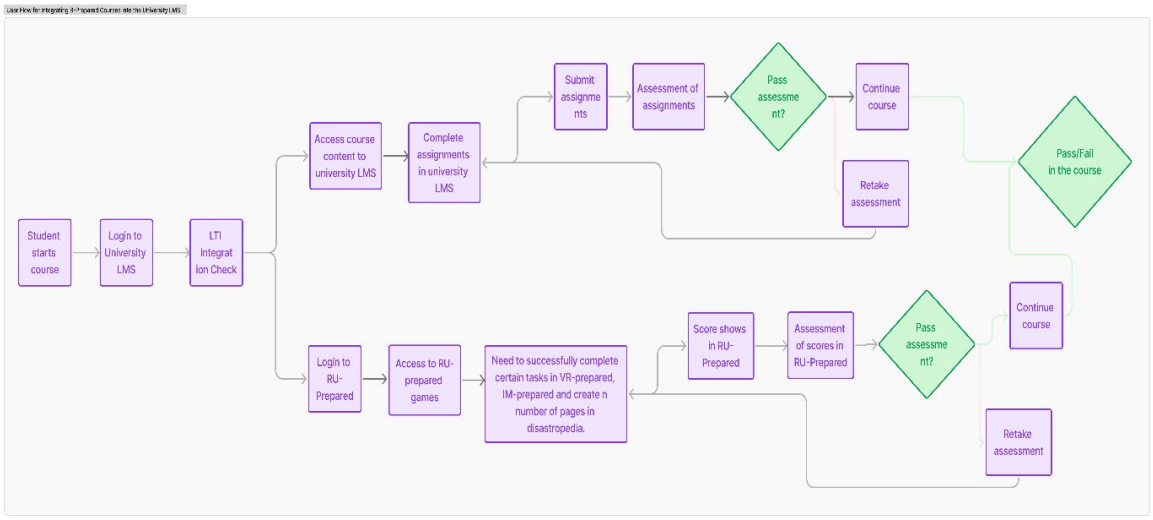


Figure 4: A student User Flow for integrating a B-Prepared module into a course. Full-resolution version available at: [Zenodo DOI link]

5.2 Technical Integration Option: Learning Tools Interoperability (LTI)

A central technical consideration for connecting RU-Prepared with institutional platforms, such as Canvas, involves Learning Tools Interoperability (LTI). LTI is an open standard developed by 1EdTech Consortium (1EdTech, 2025) that allows external learning applications to integrate directly into institutional LMSs.

In this model, the progress of the students could be synchronized back into the Canvas gradebook, provided the RU-Prepared system implements appropriate data mapping and reporting features. Since RU-Prepared already tracks task completions, quiz results, and badge achievements across its connected tools (VR-Prepared, IM-Prepared, Disastropedia), this data could potentially be made available for instructors inside the institutional LMS.

However, the actual implementation of LTI depends on several factors, including institutional policies, data privacy regulations, and long-term administrative support. Universities may hesitate to authorize full data exchange between external systems and internal student records due to concerns about privacy. If LTI integration is not feasible, instructors and students will need to maintain separate RU-Prepared accounts, and instructors may need to track students' progress outside of Canvas manually.

5.3 Challenges and Open Questions for Further use

Currently, the RU-Prepared LMS is based on Moodle. While Moodle–Canvas LTI integration is technically feasible and can offer a stable long-term connection, institutional support is still required for configuration, security updates, version compatibility, and long-term maintenance to ensure the integration remains functional as both systems evolve. This requires institutional support and long-term maintenance. It remains uncertain whether university-level IT services (e.g., HVL's IT department) will support this integration or whether the responsibility will fall to individual course instructors.

- If full LTI-based LMS integration is not implemented, students would need to create separate accounts in RU-Prepared. In this case, mapping student identities between Canvas and Moodle would require additional steps and may add administrative complexity for both students and instructors.
- Similarly, teachers would require teachers/educators accounts in RU-Prepared to monitor student progress. Without full integration, dedicated instructor dashboards would be necessary for teachers to track their students' progress.
- Ideally, if LTI integration is fully implemented, student progress data could be automatically synchronized back to Canvas gradebooks using student institutional IDs. In that scenario, no additional RU-Prepared accounts would be necessary for either students or teachers, thereby greatly simplifying the adoption process. The viability of this solution depends on institutional data privacy regulations, identity management policies, and IT service decisions.

The integration pathway presented here is an initial model that requires further validation and refinement. The next step will be to conduct pilot testing with students and teachers to evaluate both the technical implementation and the pedagogical fit within different university courses. Insights from such pilots will help refine the user flow, identify usability barriers, and inform institutional decisions about long-term adoption. Given that digital emergency preparedness is a relatively new topic in higher education, it is essential to ensure that the integration minimizes additional workload for instructors and supports them in aligning such approaches with curricular objectives. Continuous iterative development and stakeholder involvement will be necessary to achieve sustainable implementation.

6. Discussion

This study examined the feasibility and institutional considerations for integrating digital preparedness training into higher education curricula, incorporating stakeholder feedback and a proposed integration user flow diagram. The proposed integration pathway demonstrates how preparedness training via a module could be embedded into standard university course structures without requiring extensive redesign of existing curricula. By allowing such emergency preparedness modules to operate as optional components across diverse courses, even in non-technical fields, the approach may promote wider student access to resilience education.

In designing effective preparedness training, pedagogical factors remain central. Immersive technologies, such as VR and AR, offer valuable opportunities for experiential learning; however, their effectiveness depends heavily on scenario design and instructional alignment (Radianti et al., 2020; Makransky et al., 2020) and emergency procedures (Liu et al., 2023). Scenario-based learning environments must strike a balance between

realism and cognitive load; overly complex scenarios or excessive novelty may distract learners rather than support knowledge acquisition. Also, for successful curricular integration, the user experience must remain seamless and intuitive for both students and instructors. Fragmented or overly complex system flows can discourage faculty from adopting these modules in their courses (Ifenthaler and Yau, 2020). Long-term institutional commitment, including resource allocation for maintenance and staff development, is necessary to ensure the sustainability of immersive preparedness education (Ebinger et al., 2022).

Beyond the technical integration challenges described in the pathway, practical readiness for immersive technologies such as VR requires additional institutional considerations. Unlike the mobile-based or AR modules, the VR-prepared component demands access to VR headsets and dedicated physical space for safe interaction. Universities must ensure that both hardware resources and student support are available for effective implementation. While teachers may not need to directly operate VR tools themselves, especially if progress data is automatically reported, they still require a basic understanding of the technology to guide students and respond to potential technical or safety issues during training sessions.

Moreover, while the current approach focuses on higher education, similar integration strategies may also be adaptable to vocational schools or lifelong learning programs, broadening access to digital preparedness training across the broader population.

In future iterations, further collaboration between the project team, institutional stakeholders, and teaching staff is needed to refine the integration pathway. Pilot testing with selected courses and continuous feedback loops will help address practical barriers and enhance the value of digital preparedness training within university curricula. Future research should examine how students apply knowledge gained from immersive preparedness training and how institutional processes for integration evolve over time.

7. Conclusions

This paper explored integration pathways and challenges for embedding digital preparedness education into university curricula, focusing on serious games and immersive technologies developed within the B-Prepared project ecosystem. While national and institutional agendas increasingly emphasize digital resilience, effectively integrating it into existing academic structures remains complex, requiring both pedagogical and technical considerations.

The feedback collected from key educational stakeholders, namely educators, students, and fire safety professionals, indicates broad openness to incorporating such modules if challenges related to curriculum alignment, ease of use, and assessment processes are addressed. These actors represent core institutional stakeholders who would directly engage with or facilitate the use of such preparedness modules within their educational contexts.

We presented a concrete integration flow model for embedding B-Prepared tools into existing LMS environments such as Canvas, leveraging single sign-on (SSO) mechanisms to streamline access to multiple learning resources (VR, AR, and knowledge-based tools) for emergency preparedness. Ongoing collaboration with institutional IT services and academic staff is essential to ensure the smooth implementation and long-term sustainability of the project.

Future work should include pilot studies to test both the technical feasibility and pedagogical impact of digital preparedness across diverse courses and disciplines. Additional research is also needed to refine engagement strategies, particularly for less motivated student groups, and to develop robust assessment frameworks for measuring digital preparedness competencies. Broad institutional adoption will ultimately depend not only on technical solutions but also on building organizational capacity and fostering interdisciplinary approaches to digital resilience education.

Acknowledgements

This project has received funding from the European Union's Horizon Europe research and innovation programme under the Grant Agreement No. 101121134. Special thanks from the B-Prepared project to Cecilia Hammar Wijkmark, Zoltán Székely, Orsolya Székely Keresztesi, Attila Lengyel, Gira Szakmár, Espen Kon, Zsolt Márkus, Tibor Szkaliczki.

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GenAI-Assisted Knowledge Generation: A Case Study on Human-Machine Collaboration Through the SECI Model

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Abstract - This paper analyses the impact of Generative Artificial Intelligence (GenAI) on the traditional phases of knowledge creation theorized Nonaka's SECI model. To the purpose, an exploratory single-case study was conducted using semi-structured interviews, direct observation and document analysis within a company operating in the cybersecurity sector and software development. The case company was selected based on its strong innovation orientation, technological culture, and moderate organizational complexity, which are three factors influencing technology adoption in business environments. Interviews were conducted with employees and managers from the R&D and Operations departments, and data were triangulated with secondary sources. Qualitative data were analysed through content analysis methodology, generating an inductive coding tree. The study reveals that GenAI significantly impacts knowledge creation across existing SECI phases. Specifically, while it supports externalization, combination and internalization by facilitating knowledge transformation processes, its impact on socialization presents both opportunities and risks, particularly in the replacement of human interactions. Moreover, results reveal differentiated effects of GenAI across the SECI phases. GenAI enhances externalization, combination, and internalization by supporting the generation of formal templates, code synthesis, report creation and personalized feedback, while its effect on socialization is more ambiguous, raising concerns about critical thinking and the erosion of informal peer learning. These findings suggest that GenAI holds transformative force within knowledge dynamics, offering a unique opportunity to reconsider how human and machine-generated knowledge co-evolve. The paper's novelty and significance reside not only in the analysis of GenAI impact on well-established KM model but also in its capacity to offer organisations interesting insights on effectively integrating it into their workflows.

Keywords Learning organizations, Artificial knowledge management (AKM), Organizational knowledge, SECI, Generative artificial intelligence (GenAI)

1. Introduction

Academic studies define Generative Artificial Intelligence (GenAI) as a technology capable of autonomously generating new content (Dwivedi et al., 2023), including text, images, videos, and audio (S. Singh et al., 2024). This process is made possible through deep learning (DL) models trained on vast datasets, combined with advanced architectures like transformers and fine-tuning techniques that enable AI to generate contextually relevant outputs (Goodfellow et al., 2014). The disruptive nature of GenAI has drawn increasing attention from both public organizations and private companies due to its potential to enhance human efficiency and effectiveness (Felicetti et al., 2024) . As a result, many organizations are making substantial investments in this technology (Lee et al., 2023). Even those that appear uninterested are indirectly influenced by it through the phenomenon of shadow AI, which describes employees' unsanctioned use of this technology (Chin et al., 2025). The literature clearly indicates that the widespread adoption of GenAI will profoundly transform both individuals and organizations in the coming years. From an organizational management perspective, a key consideration is how this technology will reshape business processes and decision-making structures. Knowledge management (KM), the discipline concerned with the collection, sharing, and creation of knowledge within organizations (Gold et al., 2001), plays a crucial role in this transformation. KM is essential for enabling organizations to effectively leverage their informational resources to enhance operational efficiency and drive innovation performance (Darroch, 2005). Until now, knowledge creation mechanisms within organization have been successfully explained through various models, such as Absorptive Capacity Model (Cohen & Levinthal, 1990), Organizational Learning Model (Crossan et al., 1999) and Nonaka's SECI model (Nonaka, 1994). Among these models, Nonaka's SECI framework is particularly relevant to this study as it explicitly captures the dynamic interplay between tacit and explicit knowledge, a process that aligns with how GenAI facilitates knowledge externalization, synthesis, and internalization. This makes SECI a robust foundation for assessing GenAI's impact on knowledge creation. Nevertheless, while many studies have explored the interaction of AI-based applications in organizational contexts and attempted to explain how this technology foster collaboration (Kim, 2024), a notable gap remains in analysing how GenAI contributes to human knowledge generation, specifically in the highly dynamic context of cybersecurity. In this context, the objective of this paper is to build upon the existing SECI model, aiming to examines the impact of GenAI on knowledge creation within organizations, a topic of growing significance in KM research. By presenting a novel insight based on empirical data collected through an exploratory single case study, this research offers novel theoretical insights. Ultimately, it aims to stimulate meaningful discussions

regarding the role of GenAI in KM and provide a structured foundation for future research in this domain. The reminder of the paper is organised as follows. Section 2 presents the theoretical background and foundational KM models. Section 3 outlines the methods and materials used in the case study. Section 4 summarize the findings while section 5 offers a discussion on the empirical results. Finally, Section 6 concludes the paper and highlights potential directions for future research.

2. Theoretical Background

2.1 Knowledge Management Models

Polanyi (1958) was the first to categorize knowledge into tacit and explicit forms. Tacit knowledge consists of ingrained views and values that can only be conveyed by direct interaction and ongoing engagement with the knowledge holder. Conversely, explicit knowledge is documented and readily transferable without the direct participation of the source. Dalkir (2011) asserts that knowledge is a valuable asset inherent in individuals' tacit insights, distinguished by its non-depleting quality. From a pragmatic perspective, knowledge signifies the capacity to actively apply pertinent information(Lin and Ha, 2015) . In this view, it is important to distinguish between what is defined as information and knowledge. Information refers to structured data or facts, while knowledge implies contextualized content that supports action and decision-making. In the context of GenAI, this paper considers its outputs as structured information, which support knowledge creation when interpreted by humans within organizational settings.

Concerning the creation of knowledge, Nonaka (1994) presented the SECI model, which delineates the dynamic transition between tacit and explicit knowledge through four phases that continuously generate new knowledge (Nonaka, 1998). Other academics, such Crossan et al. (1999), propose that knowledge generation is an internal organizational process that utilizes existing knowledge at the individual, group and organizational levels. Cohen & Levinthal (1990) provide a complementary viewpoint by introducing the idea of absorptive capacity, which denotes an organization's capability to identify, assimilate, and utilize new knowledge to achieve a competitive edge.

SECI model

The SECI model is a well-recognized conceptual model that delineates the dynamic process of knowledge generation inside companies via the dynamic interplay between tacit and explicit knowledge. This concept posits that knowledge conversion occurs through four separate phases: Socialization, Externalization, Combination and Internalization (Nonaka, 1994). Each step has a distinct function in the conversion process and contributes to the generation of knowledge inside companies (Nonaka et al., 2006). In contrast to other knowledge management models, such as the Absorptive Capacity Model, which focus on an organization's capacity to acquire and apply external knowledge, and the Organizational Learning Model, which highlights learning across various organizational tiers, the SECI model distinctly encapsulates the ongoing transformation of knowledge between tacit and explicit forms. Considering that GenAI profoundly impacts the externalization, combination, and internalization of knowledge, the SECI model represents the most appropriate theoretical framework for examining how GenAI transforms knowledge generating processes. In this context, it is important to distinguish between information and knowledge.

2.2 Literature Review

An examination of existing literature reveals the transformative potential of GenAI from a Knowledge Management (KM) perspective. Traditional processes of knowledge acquisition, dissemination, and generation are increasingly shaped by this disruptive technology. GenAI contributes to augmenting organizational knowledge bases through the autonomous production of content such as text, images, and scientific insights (Marshall et al., 2024). Across industries, organizations are integrating GenAI to enhance operational efficiency and innovation. In particular, GenAI supports content creation, report writing, and personalization (Islam et al., 2024), while revolutionizing coding and bug detection in software development (Gupta et al., 2023), enabling predictive analytics in decision-making (Menéndez Medina and Heredia Álvaro, 2024) and advancing R&D and product innovation. In cybersecurity, it assists in anomaly detection and proactive defences, while public and customer services benefit from LLMs and chatbots for real-time support and tailored learning (Fraile et al., 2023). Despite its advantages, the literature also highlights ethical concerns, hallucinations, and potential workforce displacement. In this context, human oversight and algorithmic transparency are seen as key enablers of responsible GenAI adoption (Gupta, 2024). Businesses are investing in explainable AI (XAI) and governance protocols to mitigate these risks.

3. Methods and Materials

This study specifically investigates the influence of integrating GenAI technology into the workflow processes of a small cybersecurity firm within the knowledge creation framework outlined by the Nonaka SECI model. Data were obtained through extensive interviews with the company's personnel. The interviews were done individually using computer-assisted methods and were semi-structured, a prevalent methodology in qualitative research (Bryman and Burgess, 1999). Fifteen individuals, comprising managers and staff from the R&D and Operations department, participated in the interviews, with their work experience spanning from two to twenty-five years. The case company was chosen based on (i) the company's inclination towards innovation; (ii) the company's prior technical culture; and (iii) organizational complexity, key factors in technology adoption. The application of these three factors in evaluating the feasibility of adopting a new technology is robustly endorsed by numerous established theories. The diffusion of innovation theory (DOI) (Rogers, 1962) explicitly demonstrates that an organization's innovativeness serve as significant facilitators of the acceptance of new ideas and technologies, whereas organizational complexity acts as an impediment to the adoption of new technologies. The resource-based view (RBV) of the firm (Wernerfelt, 1983) posits that technical expertise and infrastructure, along with dynamic organizational capabilities, are enabling factors, while organizational complexity may pose a risk by diminishing the firm's capacity to adopt new technologies. Finally, Tornatzky et al. (1990) in their technology-organization-environment framework (TOE) assert that current technology use facilitates the adoption of new technology, although organizational scale may serve as an impediment (Tornatzky et al., 1990). The interviews were recorded and transcribed to facilitate comprehensive data gathering. For the whole interview process the authors focus on maintaining a neutral perspective on the topic not to introduce further bias in response collection phase. In the ending part of the interviews, participants had the opportunity for further informal conversation, also included into data gathering procedure. Thereafter, content analysis has been utilized to examine the transcription.

3.1 Data Collection

Computer-assisted semi-structured interviews represent the most relevant source of information of the present work. Before engaging with participants, the authors conducted two pilot tests, not included in the analysis, to confirm the clarity of the questions. The fifteen interviews were conducted in different periods over seven months and lasted between 62 and 120 minutes, with an average duration of 81 minutes. The interview protocol was carefully designed to collect pertinent information aligned with the study's objectives. The initial set of questions was structured to comprehensively address the SECI phases, whilst the subsequent section facilitated a more in-depth exploration of the case company's use of this technology from a general knowledge management perspective. According to prominent research on case study analysis (Eisenhardt, 1989; Yin, 2014), the validity and reliability of interview data can be improved by integrating diverse information sources. Consequently, other secondary materials were examined to augment the data acquired through interviews, including website and project documentation and numerous strategic meetings minutes.

3.2 Data Analysis

The collected data were analysed using content analysis methods, enabling the exploration of complex phenomena through a formally specified coding procedure (Glaser and Strauss, 1967). The empirical data were classified by textual analysis and systematically archived using specialist software. An inductive coding tree was then built, integrating in vivo codes that reflect the participants' precise language and researcher-generated descriptive codes based on analytical interpretations (Glaser & Strauss, 1967). The initial codes were systematically revised and modified through iterative readings of the interview transcripts. Subsequently, topics were systematically categorized in second-order themes, facilitating a heightened degree of abstraction in data analysis (Clark et al., 2010). Ultimately, in the concluding phase, the second-order themes were integrated into overarching dimensions.

3.3 Case

This study focuses on one specific organization (Born, 2004; Pettigrew, 1985). The company in question is a small software house, operating specifically in cybersecurity sector, established in 2013. Its customers include numerous public and private businesses, and it provides a spectrum of services, encompassing cybersecurity solutions and customized software development. The company's distinction from its immediate competitors is in the diversity of its personnel' backgrounds. This strength has facilitated the company's success in numerous innovation initiatives. The company hires experts from a variety of disciplines, such as mathematicians and physicists, in addition to computer science engineers, which enables it to approach data security issues from a

variety of different perspectives. While its heterogeneity is a strength, it also poses potential obstacles due to knowledge asymmetries among team members. This company was chosen based on its alignment with three critical characteristics that affect the incorporation of new technology into organizational processes. The corporation demonstrates significant innovation, as indicated by its substantial history of R&D initiatives, robust technological skills, and minimal organizational complexity. This combination makes the company an exemplary candidate for the current study objective.

4. Results

Figure 1 shows inductive coding tree, which represents the core concepts and their relations, developed from the analysis of the interviews. The integration of GenAI within a cybersecurity startup presents a profound transformation in knowledge conversion processes. Based on the coding tree analysis, the authors identified its impact on four knowledge conversion phases theorized in SECI model.

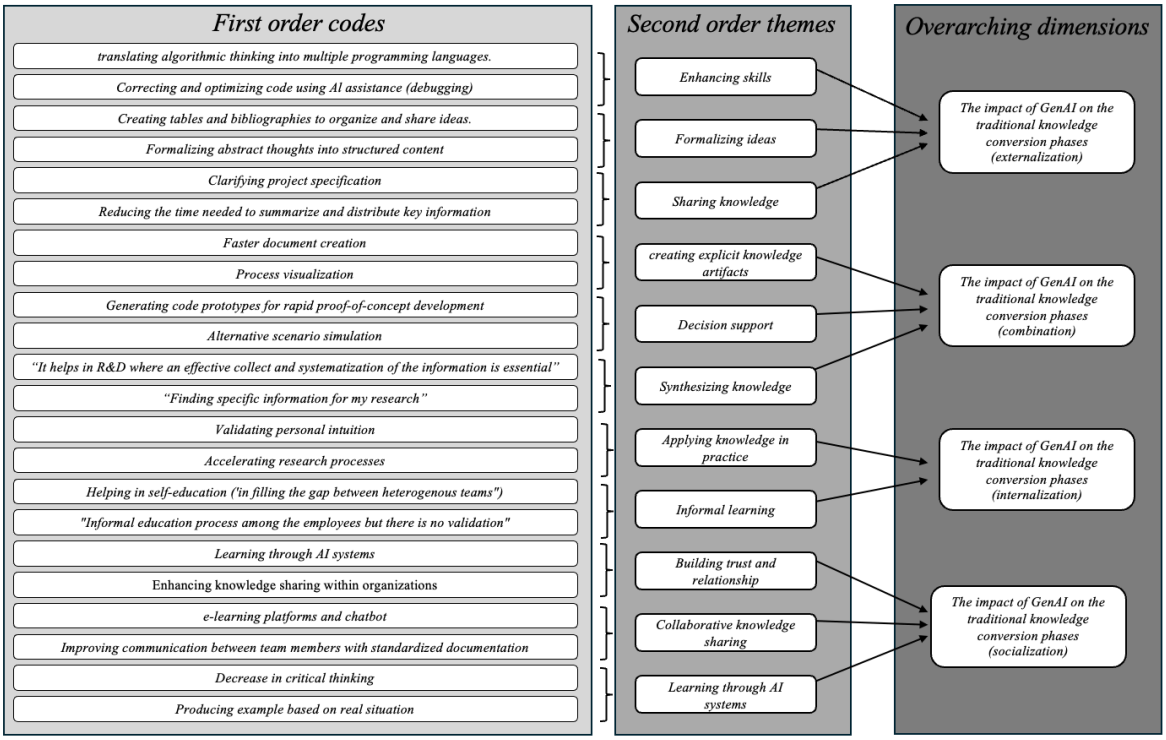


Figure 1*:* Inductive coding tree

4.1 Socialization

The socialisation phase is impacted by GenAI, as it enhances information exchange and collaboration among colleagues in solution development. One participant remarked, "*It assists me in converting my intuitions into more organised content, thereby facilitating their adaptability for sharing*." The overall effect of GenAI on socialisation appears to be primarily detrimental. This is mostly attributed to the misconception of substituting conventional face-to-face conversations with chatbot support. One interviewee remarked, "*You can overcome challenges independently*." Another participant identified a significant issue in the workplace: "*In an environment with stringent deadlines, more seasoned colleagues frequently lack the time to adequately mentor you*." Conversely, they promptly resolve the issue independently, providing you with minimal opportunity to genuinely comprehend or gain insights from the event. The interview with the managers revealed that the gradual replacement of direct socialisation with alternative informal mentorship is resulting in a decline in critical thinking among younger employees. Historically, the capacity for enquiry and reflection was cultivated through in-person contacts, where colleagues engaged in debates that, to some extent, questioned one another's viewpoints. One responder asserted: "*Even in a dynamic environment heavily engaged in innovation, direct experience of the workflow appears to be the most effective method for sharing tacit knowledge*." Nonetheless, technology is regarded as a significant aid in this process, which remains driven by human connections.

4.2 Externalization

The interviews reveal that GenAI is seen as a crucial instrument for converting tacit information into explicit knowledge. This technology assists individuals in organising their thoughts and articulating difficult ideas by producing documents that are broadly comprehensible. From a practical perspective, GenAI assists personnel in efficiently synthesising knowledge into "*written reports*," "*project documentation*," and "*bug detection reports*." A significant benefit is its capacity to standardise workflow procedures via the creation of "*standardised templates*". Developers can utilise GenAI to enhance their efficiency, especially in coding and accessing various programming languages. Simultaneously, managers can leverage GenAI-assisted document synthesis to efficiently generate and disseminate information to staff. In summary, GenAI facilitates information transfer, resulting in a more organised and efficient knowledge-sharing environment within organisations.

4.3 Internalization

The most of participants agree on GenAI's capacity to foster learning application. This is accomplished through the provision of tailored feedback and the simulation of scenarios. Through these interactions, GenAI fosters active learning, allowing users to convert algorithmic concepts into code. Applying information effectively in practical situations is essential for organisations. GenAI enhances the internalisation of new concepts by offering improved access to pertinent information beneficial for future study from diverse sources. Employees are no longer required to focus on whole documents, since GenAI facilitates the extraction of essential insights from them. Furthermore, it assists the R&D department in identifying new research directions to investigate. In addition to enabling organised knowledge acquisition, GenAI contributes to "*organising personal knowledge and enhancing its shareability*." In organisations, informal learning processes are enhanced by GenAI's capacity to recommend pertinent educational trajectories depending on an individual's background, so offering customised learning pathways. Nonetheless, although informal education is frequently beneficial for employees, it lacks formal recognition. The case study company significantly advantages from the systematic incorporation of GenAI into employee training programmes, as it provides the means to address knowledge disparities across its varied workforce. Conversely, as one of the R&D managers observed: "*human fallibility in articulating thoughts and the associated process of enhancement are integral to the human knowledge acquisition process*."

4.4 Combination

Combination is the SECI phase that demonstrates the greatest synergy with this emerging technology. GenAI excels at integrating and synthesising explicit knowledge from diverse formal documents to produce reports, technical documentation, and databases. The case study company recognises the utility of GenAI in facilitating decision-making processes. This technology facilitates the visualisation of intricate workflows by organising the numerous operations in a more logical manner, along with delineating the relationships between distinct tasks. It additionally facilitates the examination of "*alternative scenarios*," enhancing the problem-solving process. Furthermore, GenAI enables experts to interact with extensive datasets by incorporating pertinent information into fundamental concepts and recommending critical areas of documents for examination. One participant remarked, "It aids in research and development, where efficient information collection and organisation are crucial". The potential of GenAI to process and systematise extensive information substantially enhances organisational process optimisation and, once again, offers decision-making help for managers. GenAI enables organisations to enhance knowledge-based decision-making, bolster research and development efforts, and augment efficiency in the creation and distribution of knowledge artefacts.

Figure 2 illustrates the differentiated impact of GenAI across each phase of the SECI model, as emerged from the interview analysis.

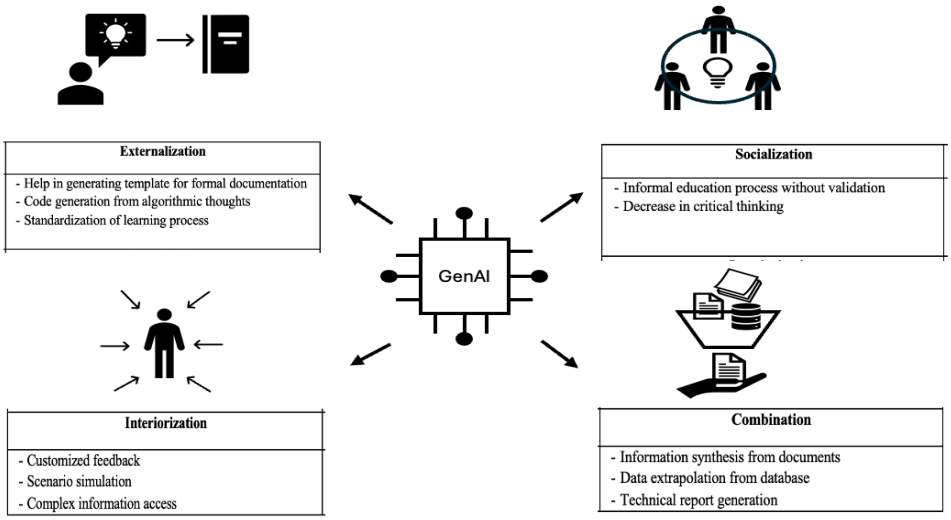


Figure 2*:* The impact of GenAI on SECI model phases

5. Discussion

The company operates in the highly dynamic environment of cybersecurity, where innovation and a strong focus on new technologies are crucial in ensuring operational capability. In this context, the ability to integrate external knowledge and correctly manage internally produced knowledge is a must. The heterogeneity of the workforce presents a significant challenge in training employees who specialize in different sectors. On the other hand, it represents one of the main strengths of the company. This diversity highlights the need for an efficient approach to sharing both explicit and tacit knowledge across the organization. GenAI could represent a potential solution in mitigating information asymmetry and increasing productivity in this complex scenario. As expected, the case study company is actively working to integrate GenAI into their workflow processes and employees' mindset. What emerges from the case study seems to reveal that GenAI rather than just support existing knowledge creation phases activities, it contributes actively in reshaping them. Each phase is impacted differently. Socialization appears to be weakened, as GenAI create the illusion to substitute interpersonal exchanges with chatbot interaction, especially among the youngest. The illusion of self-sufficiency can diminish opportunities for debate and shared reflection, which are essential in developing critical thinking. Interpersonal exchanges, which often involve ambiguity and challenge, represent the setting for critical capabilities development. To Externalize thoughts and intuitions becomes an increasingly automated process, with GenAI supporting the systematization of complex ideas. In practical terms it is done through the production of documentation, code and templates. Combination is the phase which benefits the most from GenAI integration. This novel technology enables the efficient integration of dispersed explicit knowledge into structured outputs, such as technical reports and synthesized analyses. Lastly, internalization requires less time and resource, as users actively absorb new knowledge thanks to adaptive learning pathways and real-world simulations generated by the technology. These findings suggest that GenAI holds transformative force within knowledge dynamics, offering a unique opportunity to reconsider how human and machine-generated knowledge co-evolve. This shift in knowledge creation paradigms underlines the need for a refinement of traditional knowledge management models to better capture the hybrid nature of knowledge creation in this modern context. A noteworthy observation is that, even if most participants agree in GenAI role in formalizing ideas and its ability to allow people externalizing their idea more easily, there is an evident desire to "*maintain power*" over this technology. According to them the risk is to "*leave the right path*" in a sea of fragmented data rather than following a structured research path. Overall, it seems that GenAI has changed the way people work. As one interviewee clearly admitted, "*GenAI will change organizational workflow in a radical way*". However, this transformation seems to be more pronounced among younger employees, while older professionals seem to welcome the great potential of this new tech without necessarily altering (or at least without admitting it) their way of thinking. It remains unclear who is considered the most expose to the phenomenon of losing critical sense due to GenAI dependence. During the study development, while many interviewed were firmly convinced that GenAI would improve working experience and even life, citing various reasons to support their view, an equal number of concerns were raised regarding its negative effect on both its personal use and work-related tasks (Wei et al., 2025; Zhou et al., 2025). Table 1 shows the main benefits and risks emerged for the transcripts.

Table 1*:* Main benefits and risks emerging from integrating GenAI into knowledge creation processes

	Benefits	**Risks**
Individual dimension	Increase in productivity (automation, workflow optimization) Improved work quality (documentation production, data analysis) Facilitating innovation (exploration of new ideas, development of innovative products and services, maintaining competitiveness)	Dependence on technology (reduced internal skills, loss of control over decision-making processes) Ethical issues (bias and discrimination, data privacy, accountability)
Organizational dimension	Development of new skills (work performance, self-learning, complex tasks resolution) Personalized learning (tailored learning experiences) Greater autonomy (access to information)	Reduction in critical thinking (reduced autonomy in problem-solving) Dependence on technology (decreased in critical thinking, difficulties in developing original solution) Ethical issues (responsibility issues for GenAI-assisted decisions)

Concerning the ethical issues summarized in the table 1, they mainly relate to how responsibility is distributed in GenAI-assisted knowledge work. At the individual level, over-reliance may erode foundational human skills. The tendency to defer to GenAI-generated content without questioning its assumptions threatens, not just critical thinking, but also accountability when decisions are based on flawed outputs. At organizational level, ethical issues become more complex and involve accountability of AI-guided decisions which may affect many people. The main concern is that the risk of a systemic shift toward automation in such decisions could marginalize informal mentorship and peer feedback loops, consequently weakening organizational learning culture. These concerns suggest the need for safeguards, such as transparent usage policies, specific ethical awareness for employees and a real integration of GenAI within collaborative rather than isolated workflows.

6. Conclusion

This study aims to examine the influence of GenAI on knowledge generation within organisations, utilising the SECI model as a conceptual framework. By analysing the impacts of GenAI across the SECI phases through an exploratory single case study undertaken on a small enterprise in the highly technological sector of cybersecurity, this study contributes to improving the understanding of human-machine collaboration in knowledge management. The findings underline how each phase is impacted by GenAI, pointing to the need for revisiting and possibly extending the SECI model to better describe this powerful technology transformative impact. The paper's novelty and significance reside not only in an extensive analysis of GenAI impact on well-established KM model but also in its capacity to offer empirical grounding for theorizing an evolved SECI logic fit for AI-augmented organizations.

Limitations and future research

This research, like every study, has several limitations. Initially, as the conclusions originate from a singular case study, even if the chosen organisation is highly representative, there may be concerns regarding generalizability. Regarding this issue, the case study company has been selected as it exemplifies a low-resistance environment for the assimilation of new technology into organisational processes. However, the authors acknowledge that a multiple case study has to be set in order to further validate the results. Secondly, like to all qualitative research, the findings of this study are susceptible to both observer bias and participant bias which poses, on the one hand, a danger of data misinterpretation or erroneous conceptual aggregation via inductive reasoning, and on the other hand differing degrees of comprehension of the concepts outlined in the questions, perhaps resulting in the exclusion of crucial insights. To mitigate this second issue, the authors rely on the rigorous implementation of scientifically verified research methodologies. By exercising strict control over the data collecting and processing processes, it has been feasible to extrapolate findings with scientific rigour while minimising potential biases.

Ethical declaration: All participants were informed about the nature of the study and participated voluntarily. Clearance was not required for the research.

AI declaration: Generative AI tools were not used in the production or analysis of the empirical data. All interpretations and findings are the result of the authors' critical analysis and are not generated by AI.

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Data on Immigrants to Finland: The Case Behind Missing Data

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Abstract: This case-based research studies and presents the processes of data- and information gathering to national registers by Finnish authorities from immigrants to Finland. The focus is on understanding and modeling how data is accumulated, on the problems that remain, and the time-lags involved in data accrual within the Finnish system. We look at the actors, resources and the legislation involved and discuss the benefits of having good data and the importance of data renewal. A real-world case of Ukrainians with residence permits based on temporary protection is presented. The data accumulation process is a secondary process when a migrant is received, which makes it essential to pay separate attention to it. During escalating phases of immigration, the performance of the data accumulation process can be estimated. Improvements to data gathering processes, interorganizational collaboration, and data sharing and consolidation are proposed. If processes the immigrants go through, starting from the earliest possible (arrival) stage, do not integrate data collection and data updating, it will be both costly and often difficult to fill data-gaps later. Common and transparent data related processes and a data-collection plan with definition of core variables would provide a solid base for creating a comprehensive data-based profile for every entrant and reliable information on immigrants in general. Data on educational background of immigrants is an example of the type of data that is now collected (mostly) separately and typically remains incomplete. Missing information may give rise to incorrect assumptions and lead, e.g., to actions and assistance being offered at an individual or national level, not being justified by reliable information. Immigration issues are a timely topic that requires reliable data to be understood correctly and researched reliably.

Keywords: Immigration, Data-accumulation, Interorganizational collaboration, Data-sharing, National intellectual capital, Public administration

1. Introduction

In this research we study the Finnish immigration processes and how data of an individual immigrant accumulates during the various administrative processes that face the newcomer to Finland. We are interested in how data is collected and stored into national data registers in general during immigration and specifically during the process, when it is based on temporary protection status. We study why some important data may be left missing or why collection is delayed. The data accumulation process is a "secondary process" when a migrant is received, which makes it essential to pay separate attention to it. In addition to looking at these issues from the point of view of a single individual, we are interested in how the data is aggregated and becomes a part of the national knowledge capital that is usable in data-based decision-support for public decision-making. It can be said that the success of the governmental data processes from the perspective of secondary use of data is evaluated. The availability of high-quality statistical information and research data are features of a high-level knowledge / intellectual capital of a nation.

Migration has been an important field of study for decades and data and statistics on immigrants and the phenomenon generally offer a credible starting point for research. In this vein, the role of different data actors and data collection process is important (Levine, Hill and Warren, 1985). Although immigration data matters (Batalova, Shymonyak and Mittelstadt, 2018), the data is typically a basis for research, not a "target" of research – here we focus on data and data collection processes. To the best of our knowledge, Finnish immigration related data accumulation questions have not been studied in academic literature previously. This is not saying that there has not been discussion and that there would not be any understanding around these issues among researchers and statistics providers. There is a research gap with regards to these questions.

Figure 1 is an illustration of how data accumulates during and after the process of immigration in the case of immigration to Finland, based on temporary protection. Data is collected in bits and pieces and the accumulation of data starts at the boarder by the Finnish Boarder Guard/Police, followed by data collected from contacts with the Finnish Immigration Service. This first part of the process collects basic information on an immigrant. After settling to Finland data is accumulated to registers from different administrative sources via a "sign of life" method during encounters related to different life events and may include supplementary data collections targeted at obtaining missing data. Data starts to accumulate via meetings with governmental actors, but there are inconsistencies and delays in basic data accumulation that sometimes lead to incomplete data that may be relevant to other than direct decision-making related to an individual immigrant (relevant to, e.g., research).

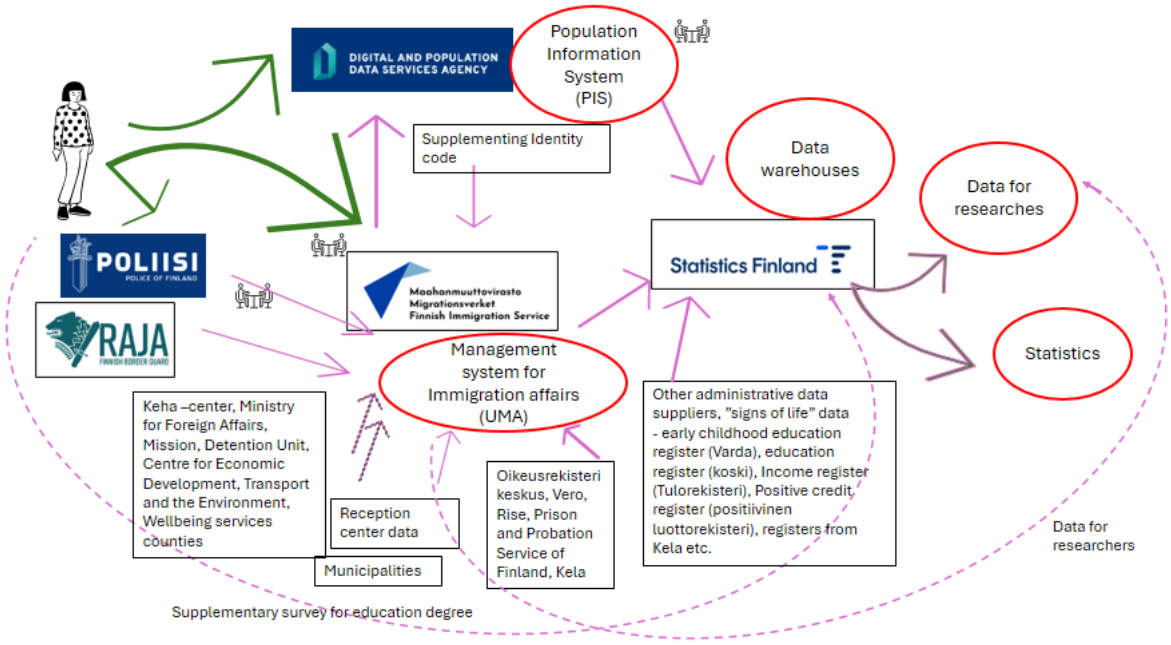


Figure 1: Data accumulation process of temporary protection with the participating organizations

Data accumulation questions are beyond the capacity and scope of any single governmental actor and thus it makes sense to study and focus also on the interorganizational cooperation around data accumulation. Different tasks and responsibilities lead to high levels of autonomy in individual public organizations´ operations (Provan, Fish, and Sydow, 2007) that may ignore interdependence on and collaboration with others (Borgonovi, Anessi-Pessina and Bianchi, 2018; Rajala, Laihonen and Vakkuri, 2018). Here the different tasks and responsibilities are studied from the point-of-view of three actors, i.e., the pool of joint data controllers for the Management System of Immigration affairs (UMA, incl. Finnish Immigration Service (Migri)), the Population Information System (Population Data Services Agency (DVV)), and the Statistical institute (Statistics Finland).

Collaborative governance literature is influenced by the cooperation, coordination, and collaboration (3Cs) theoretical framework (Costumato, 2021). Especially collaboration, which implies comprehensive planning, sets common missions, formulates joint strategies and measures and often establishes a new organizational structure, separate from the individual organizations, with sharing risks, pooling resources, and allocating benefits evenly is important (Costumato, 2021). In our context, we see horizontal collaboration mainly as bilateral or equal with common goals between governmental agencies. Vertical collaboration occurs at national level or between actors at different levels, such as between the ministries and governmental agencies. We identify and propose some points for development of the Finnish system, e.g., creating common and transparent data-related processes and a data-collection plan, including a definition of core variables to ensure the collection of relevant and accurate basic information on immigrants to Finland for statistics and research purposes.

In the next section we present our methodology and then a data accumulation case for temporary protection concerning Ukrainian immigrants to Finland. Then we discuss some challenges observed with data collection, shortly analyze inter-organizational collaboration in this context and close with a discussion and draw some conclusions.

2. On Methodology

The method here is to describe reality by presenting a case of data-driven value creation of knowledge capital at a national level in the case of data collection on immigrants to Finland (see Figure 2). The study is based on the findings of the national statistical production process. We look at the process of data accumulation and data accumulation from the beginning of immigration to the merging of data from various data providers and data processes into statistics and research use of data. In addition to presenting the observed 'story of figures', we also use public material from the institutions involved, information available to the immigrants and the legislation in force: the overall picture presented is based on multiple published sources. Furthermore, these issues have been discussed with domain experts of statistics production process to corroborate the findings. The effects of EU legislation have also been taken into consideration.

This research connects to the knowledge economy framework that includes research of institutions that stimulate efficient creation, dissemination, and use of existing knowledge. This includes innovative actions that promote knowledge accumulation and a modern and adequate information infrastructure that facilitates effective communication, dissemination, and processing of information and knowledge (cf. Marcin, 2013). The presented case presents multi-institution processes and tries to highlight, where the processes need more support. In national intellectual capital research, the public sector as a data collector is often not highlighted, but the importance of relevant and quality data is acknowledged. Quality of data is pivotal for the applicability and credibility of results from data analysis and decisions taken based on low-quality data may be suboptimal or misleading (Orjala, 2021). This public decision-making aspect of data collection issues is a justification for the importance of this research.

In the context of national data management this research shows the value of the structures in place (structural capital) that can produce (collect) intellectual capital and ties this research to knowledge management research. The interoperability of institutions, technological structures in place, legislation, the relational capital as cooperation enabler, financial capital and human capital used all contribute to what essentially is a cross-organizational knowledge gathering and management operation.

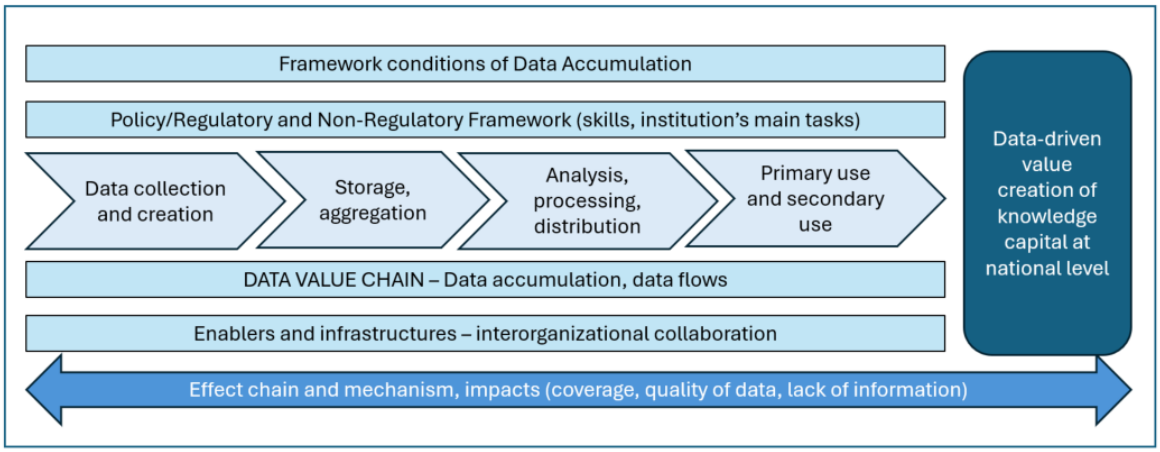


Figure 2: The Data-driven value creation of knowledge capital at national level – case data on immigrants to Finland

Käpylä et al. (2012) mention that a renewal capital perspective is built in all the intellectual capital sectors and refer to a nation´s ability to innovate (see Lee et al., 2017), this perspective is related to this research in that keeping data collected publicly up to date enables decision-support to keep up with the status quo and as such enables informed reactions to changes (redeciding). Figure 2 gives an overall picture of the environment of data-driven value creation for public decision-making. Data accumulation on migration passes through the practices and infrastructures of multiple organizations and includes several obstacles that can be (only) partially resolved through inter-organizational collaboration.

3. Case: Temporary Protection of Ukrainians

This case is about accumulation of data on Ukrainian immigrants to Finnish registers and concerns the immigration after the Russian invasion to Ukraine in 2022. We present a short background data on immigration and then focus on data collection and accumulation related issues. According to the registered population, the number of immigrants from Ukraine was (in 2023) 21 137 persons (Statistics Finland, 2024). The registered population includes individuals with permanent residence information, as the right to municipality of residence is a current condition for a person to be counted in the official population. Compared to the data from Finnish Immigration Service (Migri) the official statistics underestimate the number of Ukrainian immigrants in Finland, as 78 083 Ukrainians had applied for temporary protection during 2022-2024 and 66 726 during 2022-2023. In September 2024, more than 46 000 Ukrainians live in Finland under the temporary protection status (EU 2022/382). The Ukrainians that do not yet have permanent residence, belong to the responsibility of 68 reception centers. During 2023-2024, 28 600 Ukrainians have applied for a placement in a municipality and in the end of 2024 approximately 8 000 Ukrainians live in reception centers, despite the possibility to apply for a placing in a municipality. (Migri, 2025)

Table 1: Immigration from Ukraine 2022-2024

Immigration from Ukraine/Years	2022	2023	2024	Total
Immigration, official statistics[1]	1 533	19 604	13 378	34 515
Temporary protection, applications/permissions [2]	46 641/ 44 939	18 825/ 18 550	12 617 / 12 210	78 083/ 75 699
- applied for municipality placement		13 500	15 100	28 600
-of which temporary protection status, in the end of the year, cumul. % appr.	100	79	62	
-of which living in the reception center in the end of the year			8 000	

[1]Statistics Finland, [2]Migri, European Migration Network, EMN

This data regarding Ukrainians in Finland is indicative but looking at it one can draw some key points. Firstly, the official population stock depends on the registration of the municipality of residence. Secondly, after 12 months of stay the registration is voluntary for an immigrant and requires the immigrant´s own activity. A data collection process that is based on the personal decisions of the targets of data collection weakens data accumulation and lowers the number of migrants and the size of migration peaks in the official statistics. Thirdly, data from different sources differs from each other and a coherent credible picture of the population stock is difficult to form. When looking through the migration figures and statistics, one must be aware of the (data collection) process and of the metadata, as there exists a cohort of residence permit grantees, staying in Finland, who are not included in the annual data, even though they may have migrated to Finland years ago. There is, and will be, delay for more than one year in official statistics regarding the number of Ukrainians in Finland. For example, in 2023 the population living "under-cover" in Finland was nearly 42 000 persons, of which the proportion of Ukrainians was 71 % (Statistics Finland, 2024). The delay in "showing up" in data is a permanent problem and concerns all immigrant groups and becomes more visible when immigration is growing.

Alastalo et. al (2016) pointed out that register-based population statistics leave room for the "illusion of coverage" and accuracy, as they present an exact population figure, even if there is a cohort of resident population not included in the count. While there is a place for criticism, the reasons behind the issue are complex (voluntariness, legislation, imperfections in the data collection). We concentrate on the main (governmental) actors involved in the primary data collection process, i.e., the Finnish Immigration Service (Migri) and the Population Data Services Agency (DVV) and from the secondary use of data point-of-view we concentrate on the Statistics Finland. Migri maintains the management system for immigration affairs (UMA), a large database for immigration data, updated by several other actors in joint data controllership as presented in Figure 3.

UMA is a case management system with several parallel register holders, who can record data and use it via this system in their own processes. The data of Ukrainians starts to accumulate at the border (border guard / police), when the basic information of an arriving migrant is stored. Reception centers take care of the place of stay information and Migri grants the resident permit and stores the data in UMA. Data from the processes of different joint data controllership holders includes data, e.g., on sex, citizenship, date and place of birth , family relations, marital status, location, reception center info and reception allowances. The identification of an immigrant is followed by a separate customer number and a Finnish Identity Code, if one exists. The data is stored temporary in UMA, and it is deleted, e.g., when one obtains Finnish citizenship. (legislation 615/2020).

From UMA (see Figure 3) the data flow to Population Information System is restricted to few data according to the legislation (1330/2019). The Finnish Immigration Service are authorized to record in the Population Information System the surname and first names, sex, personal identification number, foreign personal number, mother tongue, nationality, profession, address abroad, address in Finland, and the start and end dates of temporary residence of a foreign citizen. The same rights have been given also to the Tax Administration (Vero).

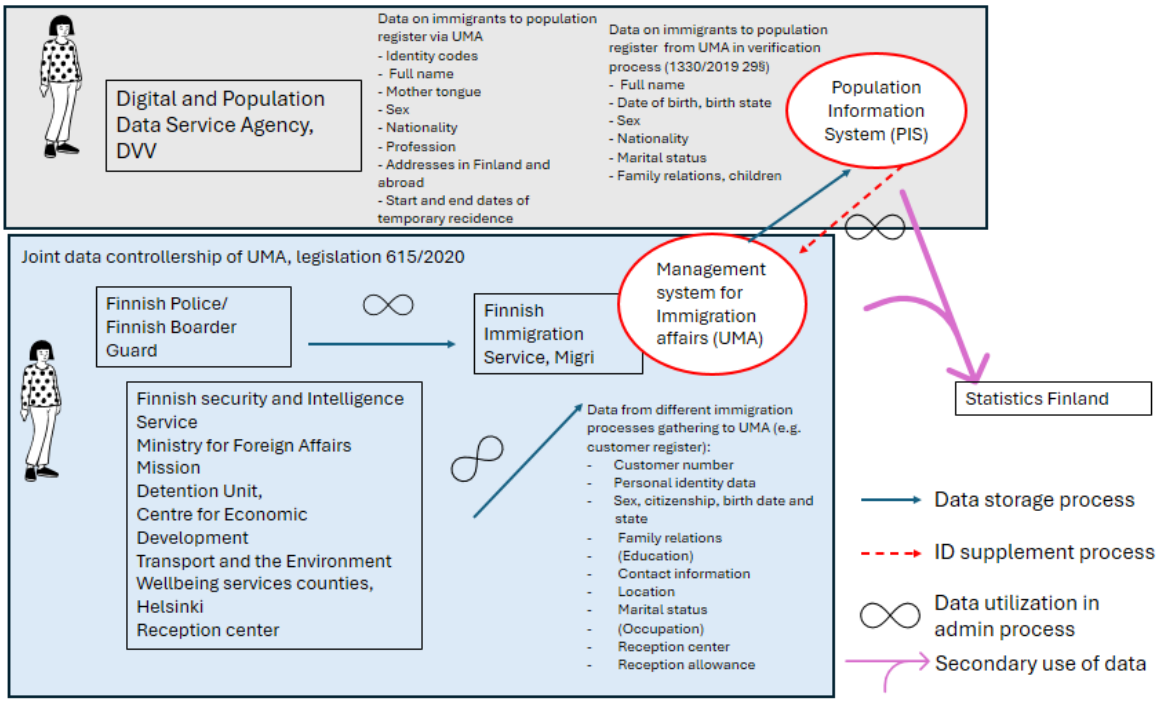


Figure 3: First data flow of Ukrainians – data accumulation to the UMA and the Population Information System

The data recorded in the Finnish Population Information System by DVV echo the powers of Migri despite that DVV has a mandate to record "the other information, the person has given to DVV" (2019/1330). It remains unclear to what extent "the other information" is stored in the Population Information System and to what extent the data of UMA is stored to Population Information System by Migri or supplemented by DVV. One thing to note is that entering information, verification and supplementing processes take resources, which are scarce. The reliability of information on an immigrant is to be ensured with translated and verified documents and in some cases by comparing the data with UMA (661/2009). As a specific detail: data stored into registers cannot be based on an "illegal situation" according to the Finnish law, such as marriage abroad under the age of 18. This means that even if such information were to be obtained, it would not be entered into the system.

It is clear that problems still exist from the data perspective as the data collection on immigration process of the temporary protection persons is fragmented and there are many public sector actors in this process. Many bits of information (variables) are collected or stored partially for specific reasons only and even when collected, they are not included in the data flow, which has impacted the quality of total data. Examples of data on marital status, state of birth, education, municipality of residence and family relations are presented later. Data obtained from the migrants is stored to the Population Information System only partially as the data storage is done based on information backed up by official documents only.

From the data process presented in Figure 3 data is shared for statistical and research purposes. In this data accumulation process the data is enriched by data from other registers and over time, "sign of life" data is accumulated for also for statistical and research purposes to Statistics Finland and UMA. The life events come from other registers such as the early childhood education register (Varda), the education register (Koski), the income register (Tulorekisteri), Population Information System (Väestötietojärjestelmä), the positive credit register or registers from, e.g., the judiciary branch and Kela (welfare, pensions). Researchers can also get data directly from Migri and DVV, but that is not efficient due to created duplicate work (e.g. in data value chain, see figure 2) and increased costs and burden.

4. Observed Challenges With Data

We discuss the challenges in governmental data process from the perspective of the secondary use of data, i.e., statistical and research use. As indicators or examples, we discuss the cases of personal identity code (FI ID), municipality of residence, education, marital status, state of birth and family relations data.

Finnish personal identity code (FI ID) can be given by three authorities Tax authority Vero, DVV, and Migri. In the case of temporary protection, the code is given by Migri. Migri is allowed to admit the status of temporary resident permit without verified documents and without a FI ID code. DVV can supplement codes to UMA. The normal duration of the process for FI ID after immigration is short, as immigrants must finalize their application to Migri within 3 months of immigration. In rare cases a missing FI ID at the time the residence permit is admitted can delay the receipt of the ID until renewal of the resident permit. From the data perspective, the personal identity code is of utmost importance, because it is the common key, when data from different registers and "signs of life" data is merged. Automatic data update flows from different registers cannot be utilized without the personal identity code.

In general, it should be possible to provide a personal identity code immediately at the beginning of the migration process to create an unbroken history of an individual´s stay in Finland from the time of arrival in the country. This is not the case at the moment, and the first data entered for an immigrant at the border by the police (e.g., identity, place of residence and family members) is not tied to a FI ID.

Municipality of residence information is connected legally to the right to use the services provided by a municipality of residence (1994/2001). After receiving municipality of residence, one can get a Finnish identity card and a driving license, use services provided by authorities, and/or receive financial benefits and subsidies. An immigrant can apply for a municipality of residence, when the conditions are met. One main condition is that the person intends to live in Finland for at least one year. Legal stay in Finland is mandatory for this right . Generally, only persons who have right to the municipality of residence include in the population base of official statistics. The statistics on the immigrants and their location, at least during their first year of stay in Finland, are therefore incomplete.

If a person already has a Finnish personal identity code, it is possible to register a temporary address voluntarily in Finland by submitting a notification of a temporary address in Finland via the post office to the Population Information System. In general, temporary address is not comprehensive and as such not valid data to determine the location of an individual but can partly help this data issue. It has been recently suggested (not accepted) that temporary address data is removed from the Municipality of Residence Act, making the use of this information less promising. Addresses in UMA can partly supplement gaps in data, but questions about data validity remain.

One main piece of data (variable) which is not collected during the immigration process is *data on education*. This information is not collected even in the case of work-related immigration. For immigrants who have studied and received their degrees in Finland, the data is automatically transferred to Statistics Finland education register. The register contains degrees received from Finnish education providers via the national databases KOSKI and Virta. Data from education providers not included in these databases is collected through surveys.

If an immigrant has graduated abroad, the data on education is received through governmental processes only if recognition of a foreign qualification is awarded by Finnish national agency for education (Opetushallitus) or the National Supervisory Authority for Welfare and Health (Valvira). Data on degrees awarded in Sweden is received biannually from Statistics Sweden in exchange for the same data from Finland. This exchange of data has extended the number of degrees in the Finnish education register by about 15 000 degrees since 2016. In 2019 and 2023, separate supplementary collections of degree data for the immigrant population aged 18-64 were carried out as a cooperation of relevant agencies and ministries. The data on new degrees received from these supplementary collections included 45 000 degrees (Witting, 2024). The primary option, i.e., the collection of data in connection with the immigration process, cannot yet be implemented. Supplemental collection does not solve the data gap or the basic problem as it may not reach everyone. The education data remains currently incomplete.



Figure 4: Educational structure of the population aged 18-59 by origin, year 2023 (Witting, 2025)

Figure 4 illustrates the situation after supplementary collections. Even after these data collections data on persons with foreign background born abroad was available for only ca. 50% (ca. 290 000 people) of this population. 7.3% of these persons are Ukrainians. Nearly 80% of Ukrainian speakers age over 18 have no entry for education (Witting, 2024). All in all, in the end of the year when a person immigrates to Finland, the lack of education information is nearly 100 % (year 2022 98.3%). Although there are many different data flows, most degrees completed abroad are missing from Statistics Finland degree register. The lack of education information makes it difficult to monitor integration and employment.

One of the basic data points that is missing is *marital status*. Approximately 27 % of this data is missing for the population born abroad 2024 (157 000 persons). This information gap has been growing dramatically since 2004, when the gap was moderate and was (only) 3 800 people (2%).

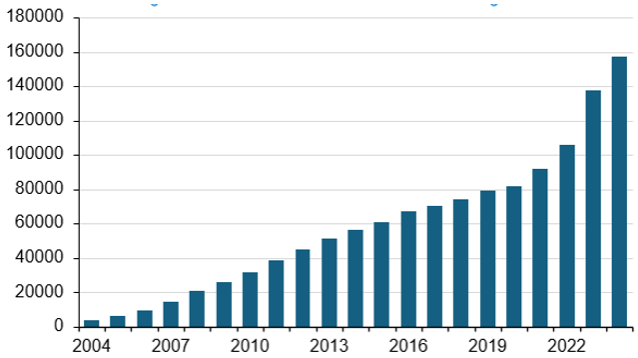


Figure 5: Marital status unknown, population born abroad, development 2004-2024*

Main reason of this lack of data is that provision of this information is (again) voluntary and legalized documents are needed for persons over 18 years in the registration (of data) process. Only for people under the age of 18 is the data stored without documents. If an immigrant is under 18 years and married and even has the legalized documents to prove it, this information is not stored, because it is illegal to be married in Finland under the age of 18. This is a clear “glitch” in the system. A person can make an application to supplement the data later.

State of birth -information is missing for more than 52 000 people in 2024. This information gap is growing fast as the figure was 6000 in 2019. The proportion of people without data on place of birth is almost 9 % of the population born abroad. Most of the gap has accumulated after the year 2022 and 44 % of the individuals with no information are citizens of Ukraine (23 000 persons).

In addition, data on *family connections* is mostly incomplete, even though this information is to some degree available in UMA. Producing statistics or credible information on these relationships is impossible and supplementing it afterwards is very difficult.

In immigration processes, personal contact and physical meetings with governmental actors are obligatory. These meetings could possibly be also used to further the data accumulation concerning core data needed for immigrants. Some data is not recorded as the legislation restricts the storage of the data. In addition, the need for official, legalized and translated documents leads to data gaps. It is also remarkable that even though the migration process accumulates basic data from immigrants into the UMA, the data is not stored permanently nor transmitted to Population Information System. Generally, the utilization of all data sources available should be increased to improve the population base coverage in official statistics.

5. Building Inter-Organizational Collaboration for all Data Needs

The data process of immigrants is a complex and between several public actors with different tasks and priorities. Bilateral cooperation is often insufficient and vertical collaboration is needed to support the accumulation of data from the earliest possible arrival stage. Inter-organizational collaboration can effectively build national knowledge on what is known about immigrants in short and long term, enable renewal of legislation, processes and ICT solutions when needed, i.e., when the actors together observe that a change is needed.

The main actors in the case above, i.e., pool of joint data controllers of UMA (incl. Migri), Population Information System holder (DVV) and Statistics Finland have differing main tasks, data collection roles and filters on data accumulation, i.e., different legislative boundaries. To overcome the negative effects of different priorities on

data collection, collaboration is needed at a national level between the governmental data actors. Collaboration areas include, e.g.:

- Common knowledge of the basic data needs for primary and secondary use of data on immigrants. The lack of data can be long-lasting, in some cases permanent, if the first phases in immigration process are not utilized for data accumulation. If this is not widely known, there may be no "good will" in working to obtain the data.
- During escalating phases of immigration, all data structures should be ready and available. Core indicators and data-related processes must be built in advance and be ready for urgent situations.
- Evaluation of data accumulation and sharing processes are important.
- Common goals, visions, scenarios, joint projects and close cooperation are shared with data actors.
- National Data Policy (Ministry of Finance, 2017), data governance structures and data-oriented renewal of legislation is needed.

Data accumulation in the immigration process is typically not a major issue as a collaboration target, however, it is important to recognize that for a solid picture of immigrants, we need to define the core data that society should have and to form a comprehensive data vision for the basis of actions. The data process and accumulation, the content of the registers, and the needs of all parties in the data process should be considered. We need to ensure that the lack of data is not affecting the holistic picture and clouding the understanding about these issues at a national level.

Putting the above in perspective of previous research, in the knowledge society the need for flexible, open and interconnected organizations is demanded (see Campos et al, 2006). Joie has pointed out the need to ensure that agencies are linked so that they share their intangible assets (Joia, 2008). Chen, Lin and Yen have pointed (2014) that inter-organizational collaborative relationships influence knowledge sharing positively. In addition, in the context of continuous improvements through collaboration structures, some thoughts of rethinking institutional structures have recently been raised, as a solution to design more future oriented institutions (Acemoglu, Egorov and Sonin, 2021; Mulgan 2024). Data governance structures at a national level could be one of the interesting topics in this discussion.

6. Discussion and Conclusions

The aim of this paper is to introduce data accumulation as an important issue in the formation of the knowledge-capital of a society. The collection of primary data has a higher priority in the immigration process, while secondary use of data is needed to bring understanding of the phenomenon of migration and to analyze the background of the immigrants. Both should be considered, when renewal of data collection processes is planned. For fact-based decision-making relevant and complete data is important, also on a personal level for individual immigrants.

The success of inter-organizational collaboration in this context can be approached by looking at what is the quality of the data that is accumulated for secondary data use, i.e., for statistics and research. Inter-organizational cooperation supports the value creation and building the knowledge-capital of the nation, and we need to pay (more) attention to the data accumulation, storage and data exchange in governmental processes. This issue is accentuated by the fact that the world is becoming more and more digitalized and the reliance on digital information within systems demands complete and trustable record-keeping. Organizations easily optimize their actions by focusing on their own needs within the restricted legislation boundaries, such actions looked comprehensively result in inefficiencies.

Immigration is a very complicated phenomenon due to the diversity of different reasons and ways to immigrate. Various public sector administrative bodies have different roles in immigration processes depending on the reasons for immigration. Primary data processes are out of reach of secondary actors. They need collaboration with first-line actors to capture the whole picture of different needs in this complex operating environment. We have made some suggestions for the future. The minimum mandatory data (variables), i.e., core data on immigration for secondary use of data should be defined on a national level and collected starting from the first encounters with of immigrants. The accumulation of minimum core data enables higher register data quality and high-quality information for the entire population. Due to scarce resources, data prioritization should be done in collaboration, considering the responsibilities of all data actors.

Data processes should be ready, tested and available. If processes are not in place, the primary needs of immigration run over data questions, especially in situations of immigration escalation. It is almost impossible

to fill in data gaps later. The gaps may remain for decades, as there is no comprehensive way to supplement data later. Common scenarios and assessment can be tools for improvement. Legislation guides data processes and storage of data. What data can be collected, and stored is strictly legislated, data verification is based on legal and translated documentation, and own announcement is not allowed to be recorded. Some verified data is even "illegal" as the mirror is Finnish legislation. The renewal processes of legislation are not usually optimal for data process needs, as changes to legislation normally have different drivers. We see that in legislation processes, assessment of data process could be useful, in similar ways as impact assessment and cost/benefit assessment.

Some processes don't start without immigrants' own application. This has serious impacts on the population stock, on some data variables and on the validity of statistics. Too strict connection of a variable to administrative decision-making should be avoided in registers. Municipality of residence information is the main example of this kind of data. Despite of that, official statistics should append the population base with immigrants staying over 12 months with, e.g., UMA data when enriching data for research purposes. In addition, only primary data needs are utilized individual meetings with immigrants. Secondary data actors don't have these kinds of natural contacts with immigrants. Physical meetings should be utilized better to the advantage of the whole data process and for all data actors, for example for cross-cutting data-need of the secondary data actors should be considered and data appended in the meetings. The research community should ideally be able to operate with only one public register counterpart for all their data needs.

We want to point out some limitations to this work. The case presented is restricted to temporary protection of Ukrainians which is only a part of immigration and supported by the directive 2001/55/EC and council implementing decision (EU) 2022/382. The data processes in different immigration types vary, which means that part of the data accumulation challenges is not covered in this paper. Another limitation that we point out is that data processes are studied mainly using material, which is available on-line, more information could be gathered through interviews of experts within the studied organizations. This might leave room for open questions such as how prioritization within the main actor organization influences data accumulation and what are the impacts of resource shortfalls in data processes.

We find that future research opportunities within data question are numerous and there is room for integration of research and policy actions to strengthen data processes and utilization of data nationally.

Ethics and AI statement: We, the authors, declare that ethical clearance is not required for the research. We, the authors, confirm that AI tools were not used in the creation of this paper.

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Employee Withdrawal and its Potential Link With Knowledge Risks

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Abstract: This conceptual paper aims to identify and present the potential impact of employee withdrawal on knowledge risks in organizations. Employee withdrawal is a subtype of counterproductive work behaviour and a critical issue for organisations. Employees who are no longer committed to their organizations may engage in various types of withdrawal behaviours. Employee withdrawal may begin with small actions like being late, or daydreaming, but they might culminate in more serious and significant behaviours like absenteeism, missing meetings, or quitting that can be detrimental to the organization. Since a large proportion of organizational knowledge is personalized and resides in individuals' heads researching employee withdrawal behaviours is particularly critical in the context of knowledge risks. Employee withdrawal in the context of knowledge management has begun to be examined only recently. To the best knowledge of the authors, there are no publications that describe the link between employee withdrawal behaviours and various knowledge risks. To fill this gap, the authors of this paper have analysed the literature both on withdrawal behaviours and knowledge risks and created a matrix that illustrates the potential impact of different employee withdrawal behaviours on various knowledge risks in an organization. This study is based on the analysis of the literature related to employee withdrawal and knowledge risks. The paper lays the ground for a better understanding of knowledge risks and their relation with employee withdrawal, and provides food for thought for managers and owners on how the withdrawal behaviours of their employees might potentially generate various knowledge risks in their workplace.

Keywords: Employee withdrawal,Kknowledge risks, Knowledge management

1. Introduction

Retaining experienced and committed employees remains a constant challenge for organisations in a competitive global environment. Unattached to organisations and institutions, employees born between 1980 and 1996 - move freely from company to company, more than any other generation (Adkins, 2023). Therefore, organisations should pay special attention to organisational commitment - the employee's willingness to remain a member of the organisation (Colquitt, Lepine and Wesson, 2013). Organisational commitment influences whether an employee remains a member of the organisation (retention) or leaves in search of another job (turnover). However, the matter is not always clear and obvious; an employee who is no longer committed may refrain from choosing one of these options and instead manifest an intermediate approach, which is withdrawal. Specifically, withdrawal refers to a set of attitudes and behaviours used by employees when they stay at the job but for some reasons decide to be less participative in their duty engagement (Kaplan *et al.*, 2009). Those attitudes and behaviours might take either psychological or physical forms.

The withdrawal of employees can be particularly dangerous due it contagious character. Withdrawing employees, whose morale and motivation to work decrease can also demotivate others, which in turn can cause serious damage to the organisation and hinder its long-term development (Zhang *et al.*, 2023). Employee withdrawal behaviours are recognized as negative behaviours from the organizational point of view, mostly due to the costs or disruptions they cause (Johns, 2002). Additionally, they can also result in several knowledge-related risks. Knowledge risks are a term used to describe a measure of the likelihood and severity of the negative impact of any knowledge-related activity that may negatively affect the functioning of an organisation (Durst and Zieba, 2019).

Despite the high importance of employee commitment for the success of effective knowledge management in organisations (Stankiewicz and Moczulska, 2015), little is known about how employee withdrawal might influence human and organizational knowledge risks. Therefore, it is fundamental to investigate how psychological and physical employee withdrawal behaviours are associated with human and operational knowledge risks. To fill this knowledge gap, this paper aims to present the potential link between employee withdrawal and various knowledge risks.

The paper develops in the following way. The second part presents the concept of employee withdrawal. In the third section, knowledge risks are described. In the fourth section, the potential impact of psychological and physical withdrawal behaviours on various knowledge risks is presented. The last section concludes the paper.

2. Employee Withdrawal

Arriving late and leaving early for no reason, being negative about the content of work, and thinking about leaving work - these negative ways of dealing with obstacles at work can be examples of withdrawal behaviours (Zhang *et al.*, 2023). This refers to the intentional behaviour of an employee in an attempt to avoid work, including physically withdrawing from the workplace or psychologically disengaging from work (Hanisch and Hulin, 1990). Employee withdrawal refers to a range of negative behaviours that distance the employee from the organisation and weaken ties (Liao *et al.*, 2022). Employee withdrawal from an organization can take many behavioural forms, including turnover, absenteeism, and lateness. It may also be of psychological character, i.e., loss of job involvement (Beehr and Gupta, 1978). According to Allen, Bryant and Vardaman (2010), the employee withdrawal process typically involves thoughts of quitting, job search, evaluation and comparison of alternative opportunities, turnover intentions, and this all can eventually lead to turnover behaviour. It can have severe consequences for organisations owing to replacement costs, loss of knowledge, and lowered morale in the workforce (Allen et al., 2010).

The most common taxonomy of employee withdrawal behaviours divides them into two main categories: physical withdrawal behaviours and psychological withdrawal behaviours (Colquitt, Lepine and Wesson, 2013). In Table 1 there are presented some forms of withdrawal behaviours identified in the literature , together with their definitions.

Table 1: Definitions of selected forms of employee withdrawal behaviours

Physical withdrawal behaviours	
Tardiness	"The act of failing to report for duty or return to duty at the scheduled time." (Sliter, Sliter & Jex, 2012)
Long breaks	"Involve longer-than-normal lunches, soda breaks, coffee breaks, and so forth that provide a physical escape from work." (Colquitt, Lepine and Wesson, 2013)
Absenteeism	"Occurs when employees miss an entire day of work." (Muchinsky, 1977)
Psychological withdrawal behaviours	
Daydreaming	"When employees appear to be working but are distracted by random thoughts or concerns." (Colquitt, Lepine and Wesson, 2013)
Cyberloafing	"Any voluntary act of employees' using their companies' internet access during office hours to surf non-job related Web sites for personal purposes and to check (including receiving and sending) personal e-mail." (Lim, 2002)
Moonlighting	"They use work time and resources to complete something other than their job duties, such as assignments for another job." (Colquitt, Lepine and Wesson, 2013)
Employee silence	"Deliberate intention to withhold ideas, information, opinions, or questions about the job or organizational possible issues and improvements." (Dyne, Ang and Botero, 2003)
Turnover intention	"Voluntary, conscious and intentional wilfulness to leave the present employer" (Tett and Meyer, 1993).

Source: Own compilation, based on the sources provided in the table.

The above-described behaviours may be uncorrelated with one another, employees who distance themselves mentally – may not need to distance themselves physically by being absent. However, the behaviours may also be positively correlated, meaning the tendency to daydream leads to the tendency to come in late or take long breaks, which leads to the tendency to be absent or quit (Colquitt, Lepine and Wesson, 2013). The classic progression-of-withdrawal model specifies sequential causal links from lateness to absence to turnover (Rosse, 1988). According to Colquitt and Lepine (2013), withdrawal behaviours may begin with tiny and insignificant actions but can culminate in more significant behaviours that can be harmful to the organisations. Usually, studies on employee withdrawal characterise this phenomenon as negative and counter-productive because of the costs or disruption (Johns, 2002) and also the spreading character of this phenomenon. When some employees withdraw from their duties (either mentally or physically), it sends negative psychological signals to others, consequently, the morale and motivation of other employees also decrease (Zhang *et al.*, 2023). Since

every knowledge management activity requires the involvement of employees, their focus, and motivation (Stankiewicz and Moczulska, 2015), it is probable that employee withdrawal behaviours may harm knowledge processes and thus, also affect knowledge risks.

3. Knowledge Risks

The concept of knowledge risk has emerged through the integration of two areas, i.e. risk management, and knowledge management. Knowledge risks encompass a broad range of threats associated with knowledge that an organization may encounter. Knowledge risk might be defined as "a measure of the probability and severity of adverse effects of any activities engaging or related somehow to knowledge that can affect the functioning of an organization on any level" (Durst and Zieba, 2019).

Human knowledge risks are connected with an individual´s personal, social, cultural, psychological factors and thus human resources management. For example, the risks of knowledge hiding, knowledge hoarding, unlearning, or forgetting are related to this category of knowledge risks (Durst and Zieba, 2019). Technological knowledge risks are related to the application of various technologies in organizations, hacker attacks and social media-related threats fall under this category. These risks are also relevant to knowledge management. Finally, there are operational knowledge risks - the largest category of the three. Those risks encompass the ones resulting from the day-to-day operation of the company, such as the risk of using wrong or obsolete knowledge, knowledge transfer risks, knowledge waste, and others (Durst and Zieba, 2019). In Table 2, particular types of knowledge risks are presented, together with their definitions. The table shows the risks selected by the authors from two categories – human and operational, ones. The rationale for this choice is that these types of risks are most likely to be influenced by withdrawal behaviours, as they are related to employees and their behaviours. Therefore, the following section describes the potential impact of employee withdrawal behaviours on these types of risks.

Table 2: Definitions of selected types of knowledge risks

Human knowledge risks	
Knowledge hiding	An intentional attempt to withhold or conceal knowledge that has been requested by another person. (Connelly et al., 2012, p.65)
Knowledge hoarding	The act of accumulating knowledge that may or may not be shared at a later date (Connelly et al., 2012) and this knowledge has not been asked for by another individual (Webster et al., 2008).
Operational knowledge risks	
Risk of using obsolete/unreliable knowledge	Risks occur when out-of-date knowledge is applied in the organizational context/inter-organizational settings or when a company applies unreliable knowledge, for example, received from a malicious source. (Zieba and Durst, 2019)
Risk of improper application of knowledge	Risks that occur when a company does not have the right skills and abilities to analyseand apply knowledge properly (Zieba & Durst, 2019).
Continuity risks	Risks relate to an organization's ability to maintain its core capabilities over time and to its ability to continue to perform and compete at consistent levels as people come and go (Lambe, 2013).
Knowledge transfer risks	Risks related to all the potential interruptions in the process of transferring knowledge, e.g., lacking willingness to share knowledge, knowledge stickiness, etc. (Durst and Zieba, 2017).
Communication risks	Risks that appear in the process by which information is exchanged between individuals through a common system of symbols, signs, or behaviour, such as misinterpretation, broken communication flow, etc. (Zieba et al., 2021)

Source: (Zieba *et al.*, 2021)

As it can be seen in the table above, organisations may face a variety of knowledge-related risks that can influence their operational continuity, innovation potential, and decision-making process. Among these, knowledge hiding and knowledge hoarding are particularly threating for collaboration and organizational learning, as they destroy trust and reduce overall knowledge accessibility (Connelly et al., 2012; Serenko &

Bontis, 2016). Operational knowledge risks appear when key procedural knowledge is undocumented or fragmented, leading to inefficiencies and problems during transitions or disruptions (Durst & Zieba, 2019). The use of obsolete or unreliable knowledge is also threatening, as decisions based on outdated or incorrect knowledge can result in strategic mistakes or operational failure (Dalkir, 2017). Similarly, the improper application of knowledge that results from poor understanding or lack of appropriate training can cause errors, especially in complex environments (Nonaka & Takeuchi, 1995). Continuity risks, including the loss of institutional memory through employee turnover, challenge long-term sustainability and require robust knowledge retention strategies (Levallet & Chan, 2019). Additionally, knowledge transfer risks and communication risks, such as unclear messages or silos mentality, make the dissemination of critical insights across teams and departments more complicated (Raub & Wittich, 2004). Addressing these interrelated risks requires an appropriate knowledge management approach that supports openness, ensures knowledge quality, and integrates knowledge sharing into daily operations. It is necessary to handle these risks in organisations and to be able to identify the factors that can cause them or increase their intensity. That is why, the potential link between those knowledge risks and employee withdrawal will be examined in the following section.

4. Employee Withdrawal and Knowledge Risks

Taking into account the characteristics of various employee withdrawal behaviours and knowledge risks, one can expect a link between these concepts for several reasons. All knowledge activities require the involvement of employees, their focus on work, organization, and environment, and the effectiveness of knowledge activity depends on employees' behaviours and their skills (Stankiewicz and Moczulska, 2015). Moreover, an engaged workforce constitutes a competitive advantage and brings additional value to the organization (Kont, 2022). Employees who are withdrawing can potentially influence negatively individuals, job performance, innovativeness, and whole businesses, including posing knowledge-related risks.

Human knowledge risks, especially in the form of knowledge hiding or knowledge hoarding can appear when an employee is angry (Zieba, 2023) or discontent and frustrated (Leonard, 2014). These emotions can contribute to an employee's withdrawal (in any form) from the organisation. Therefore, it is likely that an employee who for example psychologically withdraws from work may intentionally conceal the knowledge after someone has already asked for it (Connelly *et al.*, 2012), or hoard their knowledge. Physical withdrawal (e.g., absenteeism, tardiness, long breaks) will not directly impact knowledge hiding, or hoarding based on the nature of these behaviours, but the effect will be the same (knowledge will not be shared/revealed). However, when an employee voluntarily leaves an organisation and psychologically distances himself or herself, he or she may hide and hoard knowledge for weeks or months before their actual physical leave. It may manifests itself for example through behaviours like reluctance to collaborate, or withholding ideas, and information (employee silence). Employees who are distracted during work (daydreaming) will probably not pay attention to organisational issues, and they may pretend during meetings or workshops that they are unaware of knowledge, in other words, they may play dumb and manifest ignorance to avoid sharing information. Therefore, psychological withdrawal will probably have a potentially high impact on both knowledge hiding and hoarding.

Operational knowledge risks can be a result of various employee withdrawal behaviours. First of all, physical withdrawal of an employee - not being present during important meetings, coming to work late or leaving early, may increase the risk of using obsolete/unreliable knowledge by this employee and also his or her colleagues (e.g. in case when this employee possesses some new or reliable knowledge not shared with their peers). Knowledge may quickly become obsolete or irrelevant (Tan *et al.*, 2006) and therefore, if employees miss a meeting or entire day or days of work, there is a risk that they will apply outdated knowledge in their daily operations once back at work. Secondly, also some forms of psychological withdrawal like daydreaming (i.e. “when employees appear to be working but are distracted by random thoughts or concerns” (Colquitt, Lepine and Wesson, 2013) may potentially lead to people not paying attention, and not listen to some important messages. The consequence can be using obsolete or unreliable knowledge. The next risk - improperly applying knowledge can be also impacted by employee psychological withdrawal. When an employee is cyberloafing, daydreaming or using work time or resources to complete something other than their job duties (moonlighting) he or she remains deconcentrated, and he or she can apply knowledge improperly. Physical withdrawal will not directly jeopardise the misapplication of knowledge, as the absent employee, whether for a short or long period during the absence, is not performing any knowledge-related duties.

Knowledge transfer risks are related to all the potential interruptions in the process of transferring knowledge (Durst and Zieba, 2017). Knowledge transfer is a people-to-people process (Tangaraja *et al.*, 2016), therefore, one can expect a direct negative impact of employee withdrawal on knowledge transfer. Frequent absenteeism,

tardiness, and missing meetings mean less opportunity for knowledge transfer, which may for example cause delays in projects where knowledge transfer is crucial. Considering the psychological withdrawal of an employee, it seems that its impact on knowledge transfer may be less severe than in the case of physical withdrawal. Knowledge transfer involves formalised training programmes, which the psychological withdrawer may not be able to opt out of. However, the quality of the training may be inferior, causing fragmentation and potential loss of critical organisational knowledge. In the context of learning and knowledge management, communication is critical, as it is needed to make knowledge practices possible (Durst and Zieba, 2019). If an employee is physically withdrawing from work, there is no communication. However, once an employee is psychologically withdrawing (like in the case of cyberloafing or daydreaming), it impacts the communication process between a knowledge provider and knowledge recipient. Moreover, employee silence (i.e. withholding ideas, information, opinions, or questions (Dyne et al., 2003) makes the information exchange process even more difficult - it may result in misinterpretation or even broken communication flow. Disrupted communication can directly increase the risk of knowledge waste, and threaten knowledge continuity. This risk concerns the ability of the organization to continue its operations, stay competitive and maintain core capabilities (Lambe, 2013). Withdrawal of employees may hinder organisational continuity, since tacit knowledge is kept in people's heads and comes from their experience. Therefore, as long as people psychologically or physically distance themselves from the organization, core knowledge (to a greater or lesser extent depending on the type of withdrawal) can be lost and as a result, threaten organisational ability to continue its performance. These potential relations between selected knowledge risks and employee withdrawal behaviours are depicted in the table below.

Table 3: The possible impact of employee withdrawal on various human and organisational knowledge risks

	Knowledge hiding & hoarding	**Risk of using obsolete/unreliable knowledge**	**Improper applying knowledge**	**Knowledge transfer**	**Communication risk**	**Continuity risks**
Physical withdrawal	No impact	Potential high impact	No impact	Potential high impact	No impact	Potential high impact
Psychological withdrawal	Potential high impact	Potential impact	Potential impact	Potential impact	Potential impact	Potential high impact

Source: Own elaboration

5. Discussion

This paper contributes to the literature on knowledge risk management, which is an emerging field of research. Identifying employee withdrawal as a key risk factor might be used once developing further taxonomies and frameworks of knowledge risks. Moreover, the paper adds to the existing literature on employee withdrawal as it sheds light on its possible negative consequences from a knowledge management perspective, which is novel. Previous studies mainly identified costs and disruption as consequences of employee withdrawal. Finally, this study contributes to the research on the involvement of employees in knowledge management processes. Researchers could use this paper to build upon existing engagement theories and develop new models that explain the intricate relationships between employee withdrawal and knowledge management.

6. Conclusions

To sum up, the impact of various types of withdrawal behaviours on knowledge risks can be diversified. It can be noticed that psychological withdrawal is potentially more severe in implications, as it can be done by an employee even if he or she is at work and is expected to conduct their duties. This kind of withdrawal is more challenging to be noticed by other peers or supervisors and at the same time, it potentially impacts all the selected types of knowledge risks. In a sense, physical withdrawal is easier to manage, as there are no expectations from an employee who is not present at work or a meeting, while it would be natural to expect a present employee to perform at their best. An employee who is psychologically withdrawing can intentionally generate more knowledge risks related to organisational functioning (e.g. by knowledge hiding or hoarding or lack of knowledge transfer).

The article contributes to the existing state of knowledge in both management and psychology. On the one hand, it presents knowledge risk and the phenomenon of employee withdrawal, and on the other hand, it identifies the potential link between these two concepts - the potential impact of physical and psychological withdrawal behaviours on various knowledge risks. It presents how interdisciplinary the work of managers or leaders has become – they need to focus on employees and their behaviours, as their withdrawal not only causes financial

losses to the company, reduces their productivity, but also harms knowledge-related processes, which in turn can lead to various human and operational knowledge risks.

The main limitation of this study is that it is theoretical in nature. By combining knowledge from psychology and management, it has been possible to outline some potential relationships between employee withdrawal behaviours and various knowledge risks. This relationship needs to be further explored both from a theoretical and practical perspective. Employee withdrawal is still an under-researched theme in the context of knowledge management. It is necessary to examine in empirical studies the relation between knowledge risks and employee withdrawal behaviours with the use of qualitative research methods.

All in all, the paper has established the basis for a better understanding of the potential impact of employee withdrawal on knowledge risks that organizations may face nowadays. As such, the paper offers food for thought for researchers dealing with the topic of knowledge risks, employee withdrawal, and knowledge management in general.

Ethics declaration: Ethical clearance was not required for the research.

AI declaration: Artificial intelligence tools were not used to create this paper.

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Leaders' Technology Adoption in Digital Collaboration: An Affordance Perspective

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Abstract: As digital collaboration platforms and advanced technologies such as artificial intelligence can help large teams' work, this article examines the experiences of leaders in embracing technology for digital online collaboration. Understanding how leaders adopt technology for temporary digital knowledge co-creation on digital collaboration platforms with AI-enabled tools enables us to identify how technology adoption affects digital leadership in collaborative working processes in temporary groups. While digital leadership's impact on working has been explored in the fields of educational technologies and online customer service, amongst others, the understanding of its impact on digital knowledge co-creation on AI-supported digital collaboration platforms and affordances for leaders' rapid technology adoption remains scarce. By drawing on affordance theory and the perception of potential usages of the technologies available, I examine what digital collaboration platforms with AI-enabled tools afford for leaders of digital knowledge co-creation. For this a narrative inquiry method is employed and leaders' own perceptions of their adoption of technology is studied, thus helping to uncover the reasoning behind their technology use. Based on qualitative data generated during a four-week case study, I suggest that the adoption of technology can emerge and develop quickly among the leaders of temporary digital groups. The findings of this study reveal that collaboration technology afforded fostering transparency, communication, idea generating and innovative thinking for those in leadership roles, while limited time and lack of prior use hindered technology adoption. My study contributes to the research and practice of leaders' technology adoption in collaborative working processes.

Keywords: Technology adoption, Affordances, Digital knowledge co-creation, Artificial intelligence (AI), Digital leadership

1. Introduction

Digital collaboration platforms have become common for knowledge work in various collaborative online settings (Leonardi, 2021). In contexts of temporary collaboration, such platforms support flexible organising more efficiently than face-to-face meetings. However, when digital knowledge co-creation occurs in a temporary setting, collaboration technologies must be rapidly adopted by participants. Advanced technologies, such as artificial intelligence (AI), aid knowledge processes (e.g., knowledge co-creation) also in temporary network collaboration, and the opportunities they offer change the way of working, especially when time is limited, and cross-sectoral knowledge is to be combined. Hence, digital technologies can potentially enhance technology-enabled, large-scale organising for knowledge co-creation (Makarius et al, 2020; Malhotra et al, 2021). Crucially, leaders can support individuals' learning (Edmondson and Harvey, 2018), and such support is essential for those unfamiliar with collaboration technologies. While leaders themselves adapt to using novel ways of working with digital tools, they are expected to set an example for others in their use of technology. When leaders employ technologies it supports technology adoption by group members, which is important for successful knowledge co-creation. Although prior studies on technology adoption have been conducted in online customer contexts and in the use of educational technologies, to date we lack understandings of this type of knowledge work by large teams (Gefen et al, 2003; Kim and Kang, 2023). Moreover, the experience behind digital leadership's impact on digital knowledge co-creation remains an underexplored theme.

The flow of knowledge plays a key role in interactions and reaching the goals of digital collaboration efforts: digital knowledge co-creation requires individuals to transform tacit knowledge into explicit knowledge, and technology mediates interactions in working via digital collaboration tools. Knowledge flows emerge during collaboration in online communities, for example as chains of comments. Due to digital technologies, these knowledge flows are not restricted by time and space but are asynchronously available when each participant in online interactions has time to read, work, or other ways contribute. As tacit knowledge flows in online communities differ from those observed in face-to-face communication, understanding technology adoption in online collaboration becomes crucial (Faraj et al, 2016). Typically, the effects of technology adoption and quantitative study of relevant factors have been explored via the technology acceptance model TAM and its applications, including the more sophisticated versions like Unified Theory of Acceptance and Use of Technology UTAUT (Zhou et. al, 2024) However, the aim here is to understand the experiences that occur prior to technology use, and I therefore turn to affordance theory, applying this to narrative inquiry that is employed to analyse the data. Before the study presented in this paper, a pilot study on technology adoption in large-scale digital collaboration was conducted – the pilot study's findings about technology adoption and roles motivated this study. While participants recognised potential for action provided by AI, they chose not to adopt it for their own

use. Some of the participants further revealed that they would have wished for help—for example with summarising, which would have been possible by using the AI-enabled tools on the digital collaboration platform—as they failed to recognise such potential during the collaboration. Such missed opportunities in using AI observed from the pilot study resulted in questions revolving around the technology adoption in emergent technology-mediated collaboration. Also, regardless of their role, participants in the pilot discussed the possibilities of technology in a similar fashion, yet those in leadership roles were more proactive in utilising AI.

Debate in studies on digital leadership's impact and collaboration, including on the effect of AI on knowledge co-creation (Sarker, Susarla, Gopal, et al. 2024) has revolved around effectiveness, employee engagement, leadership and digital tools, various leadership styles in digital surroundings, and the effects of digital leadership on organisational culture. For instance, Abbu (2022) finds that digital leadership needs to build trust to achieve a more open and innovative organisational culture. Musaigwa and Kalitanyi (2024) argue that studying digital leadership centres on leadership styles and technology usage, and Crisp and Jarvenpaa (2013) discuss how the development and formation of trust by leaders are crucial in virtual teams. Despite conflicting insights into the impact of digital leadership on employee engagement, studies largely agree on the importance of leadership in temporary organisational contexts (Lin, 2024; Sacavém, et al, 2025).

This, then, leads me to ask how leaders' technology adoption that influences other participants as well as the knowledge processes – happens. Thus, the research question is as follows *What is the perceived technology-based potential for action as recognised by the leaders within emergent digital network collaboration?*

2. Theoretical Approach

2.1 Leadership and Digital Platform Collaboration

Jarvenpaa and Keating (2012) have highlighted that leaders play a key role in technology acceptance and adoption. Leaders must develop strategies for fostering trust and consistently clarifying project goals and guidelines within digital teams (Zuofa and Ochieng, 2021). Yet to do this, leaders themselves first face the challenge of adopting technology. In large-scale collaboration, experts jointly generate knowledge to tackle challenging, open-ended tasks (Blomqvist, 2022; Mikalsen et al. 2021) and successful project delivery by digital teams requires efforts to achieve objectives through effective communication and adopting the appropriate technology. Leaders' actions based on technology affordances impact collaboration participants' technology usage. These actions are based on perceived affordances, which can be either digital or social in nature and exist in physical and phenomenal realities (Gibson, 1979; Leonardi 2013). In digital contexts, the physical technology and phenomena of organising and social conventions are also those dimensions studied by scholars utilising affordance theory in digital environments. New social and digital affordances emerge when working practices with new technologies are created (Gaver, 1996).

2.2 Affordances as the Basis for Digital Leadership

To study digital collaboration and the leaders' technology adoption in a collaboration initiative, this study draws on affordance theory, which helps to reveal how the potential of technology is perceived (Fromm et al, 2020, p. 8): "The affordance concept is considered a promising concept for theorizing IT-associated organizational change that acknowledges both the materiality of IT artifacts and their human interpretation". To date, however, insufficient understandings exist in the prior literature that clarifies the impact of digital leadership in cross-boundary collaboration, its affordances for digital ways of working, and how the affordances of a digital collaboration platform and digital working practices are perceived by collaboration leaders (Tigre et al 2025).

Affordance theory explicates actions based on perceptions and has been applied to study the use of information systems, as well as for theorising how the perceived action potential of a given technology is linked to interaction and organisational processes (Majchrzak and Markus, 2012; Volkoff and Strong, 2013). This study focuses on the perceived action potential as recognised by the leaders of digital collaboration. Importantly, affordances are not the functionalities of the technology itself but the perceptions of action potential (Fromm et al, 2020).

Treem and Leonardi (2012) recognise four digital affordances commonly used in the literature: visibility, editability, persistence, and association. However, these affordances stem not only from technology but also from a leader's exemplary usage, i.e., and leaders' actions further afford action potentials for participants. Beyond this, the dynamism of digital network environments affects how leadership in a digital network of experts differs from that in less dynamic forms of working (Schreyögg and Sydow, 2010; Treem and Leonardi, 2012). Leaders have fewer permanent structures upon which to draw, and the nature of their interactions differs

from experiences generated in more familiar settings. However, before leaders can provide an example for technology use their own technology adoption needs to take place.

2.3 Approaches to Technology Adoption

Zhou et al. (2024) conclude that the most widely used approach to the adoption of new technologies are the TAM and the more sophisticated version, the UTAUT, which are well suited for generating insights into the usage and acceptance of technology. UTAUT provides a more comprehensive model than TAM for understanding technology acceptance and usage in various contexts, elaborating the factors that influence technology adoption as psychological, social, facilitating conditions, and system. TAM, on the other hand, can be employed to gain insight into perceived ease of use and the perceived usefulness of a technology. In terms of technology adoption's quality and efficiency, findings in the literature have been mixed when studied in an educational setting, that is, a setting close to digital collaboration and knowledge co-creation in the context of work (Zhou et al, 2024). Additionally, specific information systems are perceived as related to other experiences when using technology (Venkatesh and Bala, 2008). "Not unlike numerous technologies before AI that came with extraordinary promise, the ground reality tends to be far different. A major hurdle to garnering benefits is the adoption and use of any technology. AI tools are and will continue to be no different." (Venkatesh, 2022, p. 642)

3. Methods and Data Analysis

3.1 Context

This study builds on observations made in the context of a collaborative effort between seven organisations building a consortium for a research project that was based on work and research proposals in a pre-existing group, which the collaboration sought to develop further. Work was conducted as a temporary online network and aimed at building a robust application for research funding. Collaboration unfolded within a limited time frame on a digital platform equipped with functions supportive of knowledge co-creation, several of which were AI-enabled. This study's main informants were the two individuals who led the collaboration. A working model for a community to tackle challenging and open-ended tasks was applied and adjusted to enable collaboration amongst the consortium's builders. The model has four main phases according to specific weeks: problem formation (Week 1), ideation and focusing (Week 2), synthesis (Week 3), and finalisation of the concept (Week 4) (Blomqvist, 2022).

3.2 Narrative Inquiry

To understand the way the coordinator and principal of the collaboration perceived their own technology adoption, narrative analysis was engaged. By conducting an in-depth analysis of network leaders' experience, I became able to recognise their experiences and form narratives on their technology adoption. The approach here assumed that individuals' understandings of reality are constructed through language and that narratives are recollections of events that reflect the way in which individuals experienced these (Davis, 2023; Eriksson and Kovalainen, 2008; Pentland, 1999).

The data were analysed by using the inquiry narrative method (Eriksson and Kovalainen, 2008, p. 210-226), a qualitative research approach that focuses on "the stories and experiences of individuals to understand complex phenomena". This method is used to uncover meanings, and I aimed at forming narratives based on what emerged from the data, recognising the various themes mentioned by the informants in various sequences of the collaboration process. For the analysis, four data types were utilised: interview data, focus team discussions, recorded meetings, and field notes (see Table 1). When using affordances in empirical studies, the optimal approach is to conceptualise how the features of a specific type of technology changes organisational practices—and these features provide the action potential that constitute affordances. The actual usage of a given technology is termed 'affordance actualisation', and the outcomes of such actualisations are the leaders' technology adoption. The analytical power of affordances lies in optimally explaining technology in organisational processes (e.g., knowledge co-creation) that leads to change in that technology's specific areas of application (Fromm et al, 2020; Strong et al, 2014). The data analysis was conducted by coding those actions and potentials related to technology usage that were discussed by the principal lead and coordinator; and these thematic codes formed the basis for understanding what the various collaboration technologies on the digital platform had generated for them. Narratives were constructed based on the codes. Additionally, based on the data, I recognized which phase of the collaboration each code belonged to.

Table 1: Data types in the study

Interview Data	Recorded Meetings	Field Notes	Focus Group Data
Before and after the collaboration semi-structured interviews (N=4) were conducted via Teams. Data were gathered by focusing on cross-boundary collaboration and collaboration tools to remain sensitive to interviewees' voices and experiences.	Before and during the collaboration, planning meetings were recorded for use in understanding the narratives of both coordinator and principal lead. (N=5)	Observations on how informants discussed collaboration technologies during the knowledge co-creation process were recorded to recognise if their perceptions changed during the 4 weeks.	Focus group discussions between the coordinator, principal lead, and professional facilitator were recorded for reflections after the collaboration.

Platform data and feedback surveys were used as secondary sources and enabled to sequence the time, actions, and events that occurred across the beginning, middle, and end of the collaboration.

4. Narratives on Leaders' Technology Adoption

Two narratives were formed to answer the research question. They highlight those perceived potentials for actions, i.e., affordances, that influence leaders' decisions to choose applications from the range of choices offered by collaboration technologies.

4.1 The Coordinator's Narrative

The coordinator had acquired previous experience in using the collaboration platform at hand. She believed that the combination of her positive experiences with other organisational processes related to the task and working model could be leveraged to work more efficiently with the international cross-boundary group. During collaboration she expressed hesitations about the platform as the best choice due to scepticism amongst participants. However, some participants were enthusiastic and expressed satisfaction over this way of working. Despite finding the AI-enabled features useful, the coordinator found using these was impossible in the given time frame. These hesitations notwithstanding, she was initially enthusiastic and content with the way of working.

In the **problem formation** phase, the coordinator's perceptions of the chosen technology were influenced by conflicting feelings and concerns about the schedule: *"The process is done in parts, and then we compile them one by one. But it would be clearer if we could see that we are progressing here."* Her observations reveal the importance of visibility and structured workflows in collaborative platforms.

In the **ideation and focusing** phase, the coordinator relied on facilitators to manage certain tasks, noticing that, for herself, familiarity with communication methods such as email formed an all-but-automatic choice for her interactions: *"I noticed that although I was involved in the work, it was very different from the usual email-based work."* This reliance on facilitators serves to stress the role played by human support in technology adoption.

In the **synthesis** phase, the coordinator further emphasised the importance of visual elements in communication, saying that *"I always prefer visualised content because people do not necessarily have the patience to read long texts."* This preference for visual communication suggests that platforms should provide diverse content features to meet different users' needs.

When the work was completed—that is, in the **finalisation of the concept** phase—she referred to the AI-enabled features of the platform as being useful, although she noted that using them effectively within the given time frame was challenging: *"Technically, it's very easy once you learn how to do it, but there wasn't enough time to organise everything."* This, then, reflects the need for adequate time and training to utilise advanced technological features fully.

In summary, the coordinator's experiences highlight the complexities of novel technology adoption in cross-boundary collaboration. While the platform afforded valuable potential, the combination of time constraints, a degree of hesitation, and the need for human facilitation influenced the experience of technology adoption. The coordinator's reflections generate valuable insights into the role of technology in facilitating collaboration, as well as the importance of addressing users' needs and preferences.

4.2 The Principal's Narrative

A principal lead who was unfamiliar with the collaboration platform headed the four-week-long collaboration. Being sceptical yet hopeful about the platform's potential, he doubted experienced users' suggestions and preferred technologies they had used earlier, such as a word processor embedded in the platform for writing

together. He expressed a degree of gratitude over the AI-generated summaries of the transcriptions of meetings. By the end of the project, he recognised the significant potential of the platform in terms of collaborative knowledge creation and improving outcomes. This experience transformed his perspective, leading him to identify potential in the collaboration platform for future projects and acknowledge its value for efficient and effective collaboration.

The **problem formation** phase provoked both uncertainty and curiosity in the principal lead, and he described the usage of the platform as initially chaotic: *"All the possibilities were not used because the new platform was not familiar enough."* Despite these challenges, there was a sense of openness to exploring the potential of the new tool. Highlighting the importance of prior familiarity in easing the transition, he said that *"if I knew the platform before, it would have been different—my own experience is important".*

The phase of **ideation and focusing** on the task revolved around becoming acquainted with the collaboration technology. As the network began to use the new technology, some issues emerged that needed addressing. Asynchronous work was meant to take place on the platform, but the principal lead mentioned that *"asynchronous work did not take place on the platform but via email".,* partially due to the lack of time to clarify roles: *"Clear roles and guidelines [were] needed."*

By the **synthesis** phase, he had begun to use the digital collaboration platform, discovering that its transparency was superior to that of other digital collaboration forms. The principal lead appreciated the platform's interactivity, stating that it was *"more interactive than other digital tools used before",* yet he found comments and tracking changes to be too unfamiliar: *"Finding comments was hard." Hence, emails continued to be used for reminders and personal communication".* Despite such challenges, the platform facilitated better transparency and communication within the team, as the principal lead observed: *"Transparency and communication [were] better with this technology."*

The **finalisation of the concept** phase brought about the principal lead's recognition of fresh potential as he grew accustomed to the platform and began to identify its opportunities: *"This platform would have possibilities if it was a familiar tool and could be better prepared in advance."* Furthermore, the platform encouraged new ways of thinking and working, and the collaborative environment fostered creativity and innovation, resulting in valuable outputs. The principal lead repeatedly referred to graphics produced by one team, thus highlighting that this novel way of working was beneficial for a process in which a team's idea could be shared with others for comments and subsequent use: *"Using the novel way of working in digital environment added value."* Nevertheless, he recognised the need for greater facilitation and moderation to activate asynchronous work, "*More facilitation could have activated asynchronous work.*" Following his own familiarisation, he arrived at the same conclusion as the coordinator: *"Dividing big tasks and documents into smaller parts is good."*

4.3 Summary of the Findings

The aim of this study was to understand what novel technology's adoption is like for the leaders of a digital knowledge co-creation process. More importantly the analysis revealed what was the leaders' reasoning of the action potentials, i.e., affordances they perceive while using a collaboration platform. Figure 1 illustrates the phases of the collaboration that took place, as well as how technology use was framed in the narratives of the principal lead and coordinator in each phase. Positive past experiences and openness to new technologies can facilitate technology adoption, while hesitance or scepticism and preference for familiar tools can hamper it. Observing benefits can transform resistance into acceptance, thus highlighting the importance of perceived ease of use during the adoption process. The data reveal that individuals using technology for rapid cross-boundary collaboration, as opposed to the tools they used before, to some extent questioned the practicality of using a collaboration platform with novel technologies (e.g., AI) for knowledge co-creation. However, their understandings of the technology shifted over the course of the knowledge co-creation process. Here, based on the coordinator's narrative I identify the aspects of wishing for technology use, prioritising its ease of use, generating ideas and questions, exploring the platform's potential, and communicating via the platform. These represent the perceptions of the collaboration technology recognised by the coordinator. The technology-related aspects that can be identified in the principal lead's narrative include experiencing uncertainty, fostering curiosity, getting used to collaboration technology, using the collaboration platform, and recognising novel potential. Furthermore, technology use was actualised according to this narrative, although not without contradictory perceptions. Both the coordinator and principal lead reasoned that it may be difficult to use technologies that are new to participants in a technology-mediated collaboration. In this way, our findings align with the notion that familiarity can outweigh novel action potential in the context of technology adoption. This highlights the importance of social and digital affordances for enabling us to perceive the usefulness of a given

technology. Following Venkatesh (2022), when novel technologies emerge, technology adoption in practice does not cleave to all that technology's envisioned opportunities. This became evident in the narratives of the principal lead and coordinator, both of whom mentioned the AI-enabled tools, but their willingness to use them was affected by the lack time available to grow acquainted with them. This notwithstanding, the professional facilitator did make use of many AI-based tools during the collaboration. The coordinator's narrative highlights the actual usage of the collaboration platform in greater detail than the principals: her prior experience with using the platform implies that familiarity plays a key role in persuading individuals to adopt a particular technology and enable them to act (Jarvenpaa and Keating, 2024).

Despite initial challenges, the coordinator and principal lead acknowledged the platform's affordances of *fostering transparency, communication, idea generating and innovative thinking*. The process of affordance actualisation led to a transformative perspective, which highlighted the platform's value in terms of collaborative knowledge creation and improving outcomes.

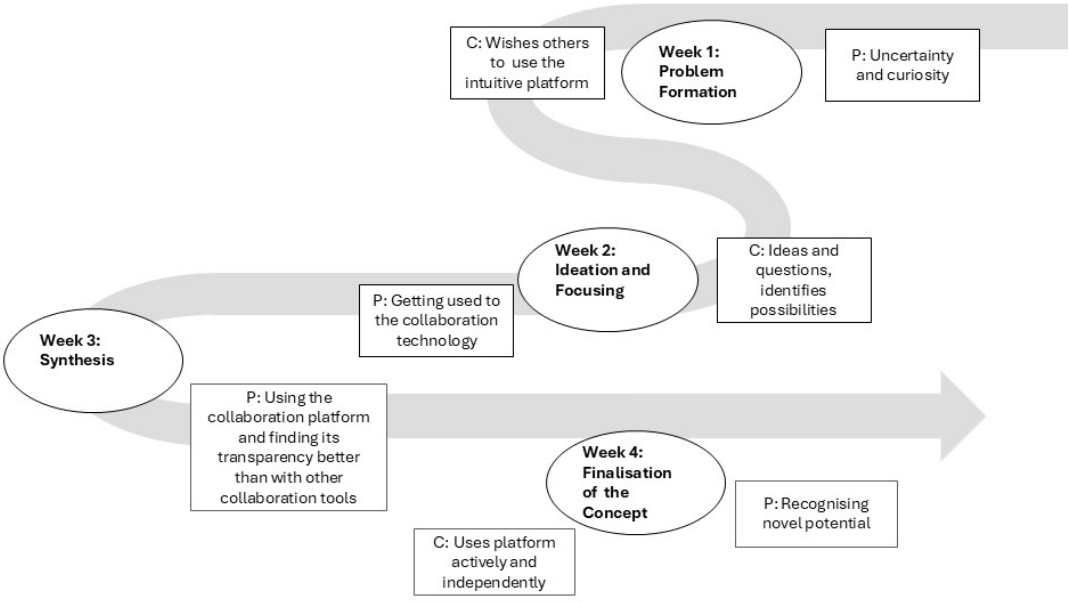


Figure 1: Technology use and perceptions of technology's potential of the coordinator (C) and principal lead (P) in different phases of the collaboration

1. Discussion

Both the affordances identified in the principal's and coordinator's narratives align with extant literature on technology adoption, discussing antecedents and factors influencing it. The findings on technology adoption highlighted similar elements affecting knowledge flows and digital co-creation with collaboration platforms featuring AI-enabled capabilities, as UTAUT's psychological, social, facilitating conditions, and system factors, and TAM's perceived ease of use and perceived usefulness (Zhou et al., 2024). Additionally, digital collaboration participants can also experience technostress caused by excessive technology use and a leader's role can be understood as lying in adjusting the message about technology adoption so that the burden experienced by employees in a community or network of experts can be mitigated (Ertiö et al., 2024). Importantly, this serves to emphasise that the role of a leader in digital collaboration and technology usage differs from that in face-to-face collaboration. Practical implications of this study underscore the importance of ensuring leaders and team members are adequately familiarised with novel digital collaboration platforms through comprehensive training sessions to reduce uncertainty and enhance technology adoption. Moreover, leaders should be encouraged to recognise the affordances of new technologies. Building trust within the team, as highlighted by Abbu (2022) and Crisp and Jarvenpaa (2013), is crucial for knowledge co-creation in digital collaborative environments which was here discussed via hesitations and their potential to hinder technology adoption. Leadership styles, digital fatigue, inclusivity, and potential miscommunication are avenues for future research. Particularly, research is

needed on how AI provokes thoughts and feelings related to an individual's expertise, and how leaders' technology adoption affects affordances for knowledge co-creation in digital environments.

Acknowledgements:

This work was funded by the Jenny and Antti Wihuri Foundation and the Strategic Research Council (SRC) at the Research Council of Finland. I sincerely thank the supervisors of my doctoral thesis: Prof. Kirsimarja Blomqvist (LUT Business School), Prof. Matti Vartiainen (Aalto University), and Dr. Argyro Almpanopoulou (LUT Business School) for their guidance throughout this study.

Ethics declaration: Ethical clearance was not required for the research.

AI declaration: AI tool (Grammarly) was used for drafting text and to ensure correctness in grammar and spelling.

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Lights, Camera, Mentorship: The Role of Mentoring in Film Knowledge Transfer

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Abstract: The main study aim is to identify the forms of tacit and explicit knowledge management used in international film productions and to assess the role of mentoring in the knowledge-sharing process. Several research questions were formulated: (1) What are the common models and practices of mentoring in the film industry? (2) What key factors influence effective mentoring within an international film crew, particularly in the context of the European Film Industry? (3) How does mentoring differ between technical and artistic departments within a film crew? The methodology of this paper is based on qualitative research. It began with an exploratory scoping literature review, followed by a bibliometric analysis. After an in-depth analysis, a survey was selected as the research method, with an interview questionnaire serving as the research instrument. The study presents findings from exploratory data collected from film professionals working in Poland, Germany, Malta, Greece, and Bulgaria between 2023 and 2024. The study indicates that film schools are the most common setting for mentoring in the film industry. However, attending a film school is not a prerequisite for receiving a film education, as many individuals gain their knowledge directly from mentors on set. In production and technical departments, mentoring typically lasts for one to five film projects. In contrast, individuals receiving long-term mentorship are predominantly part of the artistic crew, such as directors and writers. Key factors influencing effective mentoring include talent identification, understanding of the learning process, motivation, communication, and trust. This paper provides a unique analysis of knowledge sharing on film sets and offers valuable insights for film industry professionals aiming to excel in mentoring within multicultural contexts. It examines the role of mentors in contemporary film productions, particularly in setting examples for mentees, identifying talent, and understanding the learning process. Additionally, it describes how knowledge-sharing skills are applied in the demanding and rapidly changing environment of film production.

Keywords: Knowledge sharing, Mentor, Movie, Trust, Communication

1. Introduction

In contemporary academic discourse, knowledge management has emerged as an important area of research. Scientists have noted the important role of knowledge in various areas of technical and social sciences. The term "Knowledge Management" (KM) is often credited to several pioneers who contributed to its early development, but it gained widespread usage through the work of Thomas H. Davenport and Laurence Prusak. The book discusses knowledge management extensively but does not provide a single, compact definition in the sections reviewed. Instead, it frames knowledge management as a deliberate effort to identify, capture, share, and effectively use knowledge within an organization to address business challenges, improve decision-making, and create value. Key components of knowledge management discussed include creating knowledge repositories, improving knowledge access and transfer, fostering a knowledge-oriented culture (Davenport and Prusak, 1998, pp. 5-19). However, the concept had been discussed prior to this in various contexts and disciplines, with earlier references found in the works of individuals like Peter Drucker and Ikujiro Nonaka, particularly in relation to managing information and knowledge within organizations (Drucker, 1990; Senge, 1990; Nonaka 1994; Edvinsson and Malone, 1997). Nonaka, in his pioneering paper, raises critical questions about how organizations process knowledge and how they create new knowledge. He highlights that the society we live in has gradually been transforming into a "knowledge society" (Nonaka, 1994).

An indication can be made to the dynamic growth of publications on knowledge, its acquisition, sharing and the stages of its creation. The social sciences including management and business sciences have conducted research involving theoretical aspects of the phenomena being explained. Numerous empirical studies have been conducted identifying knowledge in various cultural, social, technical and organizational contexts.

Knowledge management, as a young field of management, encompasses the latest methods and techniques to ensure the most effective use of knowledge resources (Kłak, 2020). The basic dimensions of knowledge managemenre acquisition, storage, transfer, development, use and creation (Desmarais *et al.,* 2009, p. 219). The primary objective of cross-cultural knowledge management is to distribute the basic components of knowledge in other areas (e.g. functional areas: marketing, human resources management, production) in an international setting, and ultimately the management of the entire company (Grosskopf and Barmeyer, 2021; Schewe *et al*., 2022). Properly applied, intercultural knowledge should allow other knowledge to be used more fully in situations of contact with other cultures. For this to happen, it is necessary to go beyond recognising,

understanding and accepting cultural differences. People and organisations should strive to treat cultural differences as sources of inspiration, new knowledge and experience. Previous studies suggest that managers should consider cultural differences in management (Luthans and Doh, 2012) and link intercultural management issues to business needs (Chmielnicki and Sulkowski, 2017, p. 51). Within the intercultural realm of film production, mentoring has emerged as the key factor of knowledge management.

2. Mentoring Definitions

In the dynamic and multifaceted world of international film production, mentoring has emerged as a pivotal element in shaping successful careers and achieving success in film production (Hodge, 2009; Bogoni and Michel 2018).

The concept of mentoring used in business originated in Greek mythology. According to Homer, Odysseus, going to war, entrusted the care of his son Telemachus' education to his friend Mentor: Pass on your knowledge and experience to my son," he said (Homer, 2015). The friend did his job well, becoming a symbol of support for the young man for centuries (Boruta-Gojny and Popiołek, 2014). This master-apprentice relationship, which has been known for centuries, is being referred to by an increasing number of modern enterprises, embracing mentoring for their employees (Chyrchel, 2013; Ragins, 2016; Eby and Robertson, 2020). Survey results from The American Society for Training & Development indicate that more than 75 percent of managers consider individual mentoring to be one of the most important factors affecting their professional success (Budzewski, 2016).

The definitions, formulated both in the literature and in meetings of practitioners, are so numerous that E. Parsloe and M. Wray (2002, p. 81) describe the discussions around the concept of mentoring as a "semantic jungle." To avoid delving into this jungle, the author will limit to presenting only two definitions that are relevant to management. Mentoring is a partnership relationship between a master and a student, oriented to creating and developing the student's potential. It is based on inspiration, stimulation and leadership. It relies mainly on the student, through the appropriate interventions of the master, to learn about himself, thus developing self-awareness and not being afraid to follow his chosen path of self-realization (Karwalla, 2009, p. 111). Mentoring is the voluntary assistance given by one person to another, independent of the service hierarchy, so that he or she can make significant progress in knowledge, professional work or way of thinking (Clutterbuck, 2002, p. 13; Eby and Robertson, 2020).

Particularly important seems to be the statement in that mentoring is a relationship independent of the business hierarchy (Sidor-Rządkowska, 2016). This means that the frequently asked question: can the function of mentor be entrusted to a direct superior? - the answer should be negative. Such situations should be avoided even in those enterprises where the relationship between superiors and subordinates (called "co-workers") is a true partnership, based on trust (Budzewski, 2015). Paliszkiewicz (2010) saw trust as the belief that another party will: a) not act in a way that is harmful to the trusting firm; b) act in such a way that it is beneficial to the trusting firm; c) act reliably; and d) will behave or respond in a predictable and mutually acceptable manner.

Much of the current research has examined mentoring programs primarily within corporate or government settings, rather than in the more unstable and less structured environment of creative careers. The conventional mentoring model, where a more seasoned professional mentors a newcomer or less experienced individual (both typically expected to be compensated for their time), may face complications in artistic or creative contexts. A key challenge is the unpredictable employment and income levels of many creative practitioners (Taylor and Luckman, 2024).

Recent research on creative and arts mentoring primarily focuses on the practical advantages mentors provide mentees. For instance, Hope *et al*. (2020) discovered that mentorships offer valuable networking opportunities, recognition, and career entry points. Mentees in the creative sector particularly benefit from expanded professional networks and insights into practical skills like time management and effective communication (Hope *et al*. 2020, 54).

3. Methodology

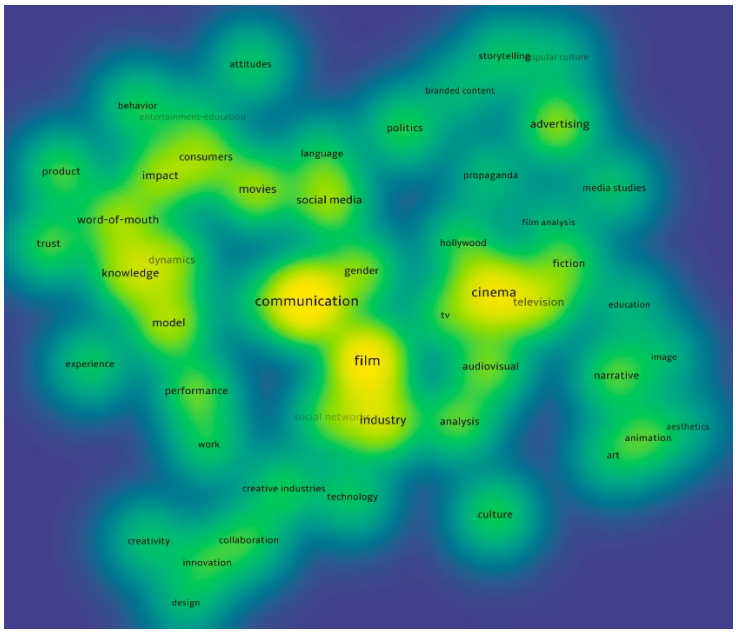
The research was conducted using an explorative, scoping literature review. Initially, the early literature on knowledge management in film industry was analysed to identify the grounding themes of the topic. Later on, a bibliometric analysis was performed on the latest literature on the topic to refine the trends that appeared in the field. Thus, keyword analysis is used to navigate the lead trends in the field. To analyse the scope of

knowledge management and its evolution through the years, a bibliometric analysis was performed with the use of Web of Science database. The used search query was:

(TS=(movie OR film OR cinema OR "film producer" OR "film director" OR "feature film") AND TS=("knowledge management" OR communication OR collaboration OR mentoring OR trust)) AND (OA==("OPEN ACCESS") AND DT==("ARTICLE" OR "PROCEEDINGS PAPER" OR "REVIEW" OR "BOOK CHAPTER") AND TASCA==("FILM RADIO TELEVISION" OR "MANAGEMENT" OR "BUSINESS" OR "ECONOMICS" OR "COMMUNICATION" OR "ART" OR "PSYCHOLOGY SOCIAL" OR "SOCIAL ISSUES" OR "THEATER" OR "BUSINESS FINANCE"))

The database has found a total of 596 articles from the years 2000–2024, later the publication date filter was added, namely years ranging from 2015-2024, so only the most recent articles would be analysed. This resulted in total number of 483 papers.

Later similar query was used for the search in Scopus database. The database has found a total of 942 articles from the years 2015–2024. Later the two CSV documents including the data from Web of Science and Scopus were merged in R Studio software and then the duplicates were deleted. This resulted in the number of 1223 papers, which is sufficient to perform a bibliometric analysis; for instance, Arshad *et al*. (2020) claim that 100 papers are enough for such an analysis, while Abdullah (2022) shows that the minimum threshold should amount to at least 300 papers within a database. Next, a keyword co-occurrence analysis was performed in the software VOS Viewer. The full counting method was used with All Keywords as the unit of analysis. Of the total 2575 keywords in all papers, the threshold of the minimum 5 co-occurrences, as advised by González-Delgado *et al*. (2023), was met by 95 keywords. This number was too big to create readable cluster visualisation, that's why the threshold was changed to 6 co-occurrences. This resulted in the number of 51 keywords. There was Density Visualisation generated with the use of the VOS Viewer software.



Source: own study, generated in the software VOS Viewer.

Figure 1: Density Visualisation Map

As presented on the Density Visualisation Map, the main themes in the field of knowledge management in film industry are concentrated around communication, film, cinema and industry. There were five keyword clusters generated by the software. The main keywords are written in bold.

Table 1: Keyword clusters in the publications on the knowledge management in film industry

Cluster	1	2	3	4	5
Keywords	attitudes behaviour communication consumers dynamics entertainment–education experience impact knowledge language model movies product trust word–of–mouth	aesthetics analysis animation art audiovisual cinema culture education film analysis hollywood image media studies narrative	climate–change collaboration creative industries creativity design film industry innovation performance social networks technology work	fiction gender politics propaganda television tv	advertising branded content popular culture social media storytelling
Number of keywords	15	13	12	6	5

Source: Own study, generated with the use of the software VOS Viewer

The first cluster revolves around human interaction, communication, and knowledge exchange. Key terms like *communication, trust,* and *word-of-mouth* highlight the importance of interpersonal dynamics in driving collaboration and creativity. The second cluster is focused on the artistic and cultural aspects of filmmaking. The third cluster highlights the intersection of creativity, collaboration, and technology within the film industry. The fourth cluster focuses on social narratives and media influence The fifth cluster revolves around marketing, branding, and audience engagement in the film industry. The cluster

For this paper only cluster one, two and three will be taken into the consideration, because cluster four and five are visibly different and do not present similarities with the topic of this paper. The most popular keyword, used in the greatest number of papers was Communication. That's why communication will be one of the main topics of this research. The second keyword "attitudes" in this cluster is also fundamental for this research. Looking at Thesaurus (2025) synonyms to word attitudes are: angle approach, belief, mindset, mood, perspective, point of view, position, viewpoint and motivation. Motivation was a word that occurred many times in conducted interviews, that's why it will replace the keyword "attitudes" in this study.

Based on the bibliometric analysis, three research questions were stated: (1) What are the common models and practices of mentoring in the film industry? (2) What key factors influence effective mentoring within an international film crew, particularly in the context of the European Film Industry? (3) How does mentoring differ between technical and artistic departments within a film crew? The methodology of this paper is based on qualitative research. A survey was used as the research method and the interview questionnaire was chosen as the research instrument (table 2).

Table 2: Interview protocol

No.	Survey question
1	What are the benefits and disadvantages of going to film school?
2	What are the alternative ways to film school to learn filmmaking craft?
2	Did you have a mentor, who would guide you through the intricacies of your film career?
3	Is your mentor permanent during the course of your career?
4	What qualities should mentor have?

No.	Survey question
5	What are the advantages of having a mentor in your film career?
6	What are the benefits of being a mentor?
7	What tools can mentor use to increase his effectiveness in teaching?

Source: Research methodology, own research

The questions for the interview questionnaire were developed based on preliminary exploratory interviews and were informed by the study of Alony, Whymark, and Jones (2007), which explored tacit knowledge sharing in the Australian film industry, as well as by the article by Nuis, Segers, and Beausaert (2024), in which a validated scale for measuring mentoring in employability-oriented higher education programmes was proposed.

The study established a research hypothesis: Efficient management of explicit and tacit knowledge, as well as professional mentoring focused on young filmmaking talents are essential factors in the success of film production. This report examines the data to identify evidence of knowledge sharing and highlights the factors that help or hinder it, based on participants' descriptions during interviews. The interviews were conducted with film industry professionals from November 2023 to February 2025. The list of these interviews is provided in table 3. The selection process for the initial two participants was predicated on recommendations from European film producers.

Table 3: Completed interviews used in this study

No	Name	Profession	Date of record	Film Industry	Pseudonym/ Citation
1	Alex Camilleri	Director	19.01.2024	Malta/USA	(Alex-Director, 2024)
2	Karl Alin Galea	Production Manager	26.01.2024	Malta	(Karl-Production-Manager, 2024)
3	Ioan Banzourkov	First Assistant Director	29.04.2024	Bulgaria/Greece	(Ioan-First-Assistant-Director, 2024)
4	Dr Michael Bickerton	Camera Operator	06.05.2024	UK	(Michael-Camera-Operator, 2024)
5	Ted Gardocki	Production Manager	12.07.2024	Poland/USA	(Ted-Production-Manager, 2024)
6	Ernest Lorek	Film Director	25.07.2024	Poland	(Ernest-Director, 2024)
7	Vangelis Anthimos	Film Director	07.10.2024	Germany/Greece	(Vangelis-Director, 2024)
8	Ilya Gavrilenkov	Editor	07.10.2024	Germany	(Ilya-Editor, 2024)
9	Aleksandra Patoka	Production Designer	13.10.2024	Germany	(Aleksandra-Production-Designer, 2024)
10	Robert Gryka	Editor	19.01.2025	Poland	(Robert-Editor, 2025)
11	Jakub Kosma	Producer	04.02.2025	Poland	(Jakub-Producer, 2025)
12	Katarzyna Próchniak	Production Manager	06.02.2025	Poland	(Katarzyna-Production-Manager, 2025)

Source: Own source

Individuals within specific professions are typically well-positioned to offer comprehensive insights into film management, encompassing associated challenges and procedures, particularly concerning knowledge sharing and collaborative endeavours. The interviews conducted were structured around open-ended questions, facilitating extensive probing and contextualization. A selection of these questions is presented in table II, although variations were introduced across interviews based on the trajectory of discussion, information provided, and the interviewee's role. Furthermore, it was envisaged that the questionnaire would evolve over time to align with emerging data categories (Alony *et al*., 2007).

There are many ways to code qualitative data derived from interviews. One can start with open coding, which involves constructing codes during the process of reading the text (inductive method). The next step is to look for similarities and differences among the codes and reduce their number by grouping them into specific categories (aggregation), assigning them names, and attempting to capture them holistically. This serves to build a data structure (Czakon, 2025). The inductive coding was used in this paper.

4. Results and Discussion

The research results allowed to describe the nature of mentoring in the film industry by exploring how professionals identify talent through real-life experiences, shared artistic vision, and curiosity. It addresses common models and practices of mentoring, highlighting step-by-step guidance and long-term motivation. The discussion also considers key factors influencing effective mentoring within an international film crew, such as determination, persistence, and communication, including patience, clarity, and setting professional boundaries. Additionally, it explores differences in mentoring between technical and artistic departments, emphasizing how mentors tailor their approach based on the specific demands of each role. In recent years, several research results have appeared that show some similarities to the results presented here. Arslantas & Kocagoz (2021) analyzed enduring mentoring relationships in project-based environments, emphasizing their significance for continuous development and engagement. Results obtained by Wong et al. (2022) addresses the challenges and strategies of communication in intercultural mentoring. Finally, mentoring supports the processes of the transition from formal education to professional practice, using informal learning models (Sefton, 2018; Kukkonen, 2021) .

4.1 Identifying Talent

Michael Bickerton, a camera operator, emphasizes that the first step in mentoring is to identify talent. He asserts, "I think, from my perspective, it's really important to identify the talent, identify the skills, identify the areas that they're good at. In order to do it, I need to get them in front of real-life experiences" (Michael, 2024). As a university lecturer, he carefully observes his students during their tasks and encourages them to refine their abilities. This approach allows him to recognize potential, as demonstrated in the case of one student who served as a first assistant director in a film assignment. Similarly, Ernest, a director, highlights the importance of a shared artistic vision as a foundational element of the mentor-mentee relationship. He explains, "I think that the key aspect of being able to call someone a mentor is the shared vision of art and, in general, the understanding of what it means to create" (Ernest-Director, 2024). According to Ernest, without a mutual comprehension of the artistic concept behind a film, establishing a successful mentoring dynamic becomes challenging. Katarzyna, a production manager, underscores curiosity and the willingness to step outside one's comfort zone as crucial characteristics of a mentee. She states, "I do not fully believe in the millennial mindset that one must strictly guard their time and only focus on personal gains. It is not that one should not do so, but I dislike hearing excuses on set such as 'I failed because I didn't know how to do it.' If you don't know how, then come and ask" (Katarzyna-Production-Manager, 2025). Katarzyna emphasizes that determination and persistence in achieving goals are key factors in selecting a mentee. In another instance, Michael Bickerton illustrates how he identified talent in one of his students during a casting process. He recalls, "I was particularly impressed with one student during the casting process. She and the director both liked one actress, but the director thought they could still find someone better. The first AD turned to the director and firmly stated, 'If we don't cast this actress, we don't have a film. If we don't have a film, we don't get a grade for this module.' She really laid it on the line, and I was very impressed by her decisiveness and clarity" (Michael-Camera-Operator, 2024). By analysing her approach to decision-making, Michael identified her strengths and recognized her potential as a leader in the filmmaking process.

4.2 Being an Example

Effective mentors not only recognize potential but also provide structured guidance to help emerging professionals grow in their roles. Michael Bickerton highlights the importance of developing confidence in mentees through discussion and step-by-step guidance. He explains, "Initially, she lacked confidence in this role, but as weeks passed, through our discussions and guidance on her responsibilities, her confidence grew significantly" (Michael, 2024). This statement demonstrates that Michael possesses the qualities of an effective mentor. He identifies talent and understands the role that the new filmmaker is trying to fulfill. By engaging in discussions and clearly outlining responsibilities, he successfully helped a young filmmaker transition from uncertainty to confidence in her role. Another essential aspect of mentorship is providing achievable tasks that mentees can successfully complete. Katarzyna, a production manager, emphasizes this approach by gradually exposing her mentee to challenges that are within her capabilities. She states, "And now with my Ania, when

we work on a project, I throw her into deep water, but only in places where I know she will not drown. There was a situation where a technical person was very demanding, and I knew that this conversation could overwhelm her. So, I led the conversation while Ania accompanied me and listened" (Katarzyna-Production-Manager, 2025). This example illustrates that assigning feasible tasks helps mentees avoid frustration while gradually increasing their confidence and competence. Ted, another production manager, underscores the significance of maintaining enthusiasm and long-term motivation in mentorship. He explains, “I think the other thing that I do for people too, is maintain their enthusiasm to keep their motivation up and helping them understand that, well, okay. One thing I can promise you is that five years will pass now at the end of this five years, do you want to be here or there? And, in order to be where you want to be, it means that you have to make the right choices every day up until that moment and helping people kind of understand that perspective, that it's not just, you know, wishing for Christmas to come a little early" (Ted, 2024). Ted’s mentorship approach encourages mentees to focus on long-term goals by considering their desired future and recognizing that consistent, deliberate choices lead to success. He helps mentees understand that professional growth is a gradual process requiring sustained effort rather than quick, wishful thinking.

4.3 Communication

Effective communication is a fundamental aspect of professional collaboration, particularly in environments where hierarchical structures influence knowledge transfer. Alex Camilleri, in his interview, highlights the critical role of communication within a team dynamic. He emphasizes that patience and clarity are essential when mentoring newer members of a department: "Communication is paramount [...]. I think that's important is to be patient with people and to understand that, especially if you're one of the more senior people in a department that you're constantly going to have newer people and you have to be aware that knowledge trickles in gradually [...]. You have to help them understand what the specific term that you're using means and help them learn that so that next time you can just say that one word and they'll know" (Alex-Director, 2024). This statement underscores the necessity for mentors to communicate their ideas both thoroughly and concisely. Patience is a crucial factor that facilitates the transfer of knowledge, as trainees often require additional time to process information and assimilate the specialized terminology used within a professional setting, such as a film set. Without effective communication, knowledge gaps may persist, hindering the overall efficiency of the team. Another essential dimension of communication is the ability to establish professional boundaries. Katarzyna, a production manager, points out the significance of asserting oneself within a professional hierarchy: "There are moments when you must set boundaries with your superiors. That is what the job of a production manager entails, and someone who is overly nice will find it very difficult. For example, I have an excellent production coordinator who works for me, and I am trying very hard to teach her how to set boundaries. I know that until she learns this, she is not ready to be a production manager" (Katarzyna-Production-Manager, 2015). According to Katarzyna, one of the most critical aspects of communication is the ability to set boundaries with superiors and colleagues. She mentors her mentee to assess situations and develop the confidence to refuse when necessary. The ability to communicate assertively is a fundamental leadership skill that ensures not only personal well-being but also the effectiveness of professional interactions.

Ethics declaration: I didn’t need ethical clearance for the research referred to in this paper.

AI declaration: I didn’t use an AI tool in the development of the paper.

5. Conclusions

The findings of this study provide valuable insights into the role of mentoring in knowledge transfer within the film industry. The research hypothesis: Efficient management of explicit and tacit knowledge, as well as professional mentoring focused on young filmmaking talents are essential factors in the success of film production was confirmed. By analysing the responses from industry professionals, the study addresses the three main research questions posed at the outset.

5.1 Common Models and Practices of Mentoring in the Film Industry

Mentoring in the film industry takes on multiple forms, with both formal and informal approaches playing a significant role in knowledge transfer. According to respondents, film schools provide a structured environment for mentorship, where experienced professionals guide students in developing technical skills and creative approaches. However, an alternative and equally effective pathway is mentorship occurring directly on film sets. Many professionals, including directors, production managers, and cinematographers, highlighted that hands-on experience under the guidance of seasoned mentors is invaluable. Respondents

emphasized that in the production and technical departments, mentorship typically lasts for one to five film projects. In contrast, individuals in artistic roles, such as directors and writers, often receive long-term mentorship. The survey also revealed that mentorship practices vary depending on the region and type of production, with some film industries fostering a strong culture of mentorship, while others rely more on peer-to-peer learning. Notably, several respondents acknowledged that successful mentoring relationships are built on mutual trust and shared artistic vision. Mentors play a crucial role in shaping mentees' professional identities, providing both technical knowledge and creative guidance.

5.2 Key Factors Influencing Effective Mentoring within an International Film Crew

The research findings highlight four key factors that influence effective mentoring within an international film crew: talent identification, leading by example and clear communication. Talent identification is a critical first step in mentoring, as respondents emphasized the importance of recognizing a mentee's strengths and potential. Several interviewees mentioned that they assess young professionals based on their problem-solving skills and ability to handle pressure. Leading by example was another key aspect discussed by respondents. Effective mentors not only provide verbal guidance but also model the behaviours and skills they expect from their mentees, ensuring that they learn by observing real-life applications of industry practices. Effective mentoring involves teaching individuals how to think critically and make informed decisions, rather than just providing direct answers. The last significant finding is the emphasis on communication. Effective communication was identified as a cornerstone of successful mentoring relationships, with mentors needing to convey ideas clearly and patiently.

5.3 Differences Between Mentoring in Technical and Artistic Departments Within a Film Crew

The findings of this study clearly demonstrate that mentoring takes different forms and serves varied purposes across technical and artistic departments within a film crew. These differences stem not only from the nature of the work but also from the length, intensity, and objectives of the mentoring relationship.

In technical departments mentorship is often short-term and task-oriented. Professionals in these areas typically work under intense time pressure and must follow strict procedural guidelines. As such, the mentoring process is usually focused on teaching concrete skills and ensuring that mentees quickly become self-sufficient within the workflow. In these departments, mentoring often lasts for the duration of one to five film projects, during which mentees are expected to gain enough experience to operate independently.

Conversely, artistic departments are characterized by long-term, vision-driven mentorships. Here, the mentor-mentee relationship is deeply rooted in shared artistic values and mutual understanding of creative expression. Artistic mentors often serve not only as teachers but also as sources of inspiration and guidance throughout a mentee's career. The longevity and emotional depth of these relationships reflect the evolving nature of artistic identity and the need for sustained support through various stages of creative development.

This research makes a contribution to both film studies and knowledge management literature by offering a nuanced and empirically grounded understanding of mentoring dynamics within the unique context of the film industry. While film studies often examine artistic output and production processes, this research delves into the human element of skill and talent transmission. It illuminates the often implicit processes by which professionals identify and nurture emerging talent, emphasizing the critical roles of real-life experiences, shared artistic vision, and innate curiosity – factors not always explicitly theorized in existing film pedagogy or production studies. This research contributes to the understanding of tacit knowledge transfer by providing a qualitative case study within a collaborative and creative domain. It illustrates how uncodified expertise, practical wisdom, and artistic intuition are transmitted through mentoring relationships in a complex, project-based industry.

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Masters Research Papers

The SECI-MaP Model: A Human-Machine Integrated Model for Organisational Knowledge Creation

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Abstract: While the human-focused SECI model of Nonaka and his colleagues captures their widely recognised theory of organisational knowledge creation, we live in an era of rapid technological advancements and Artificial Intelligence (AI). AI and in particular Machine Learning (ML), show great potential for organisations to support their learning and to discover and create new knowledge. This leaves the question of how AI and ML impact the SECI model. This study performs a theoretical investigation on integrating human- and machine contributions for organisational knowledge creation. A Design Science Research (DSR) approach is followed to design, develop and propose the conceptual SECI-Machine Partnership (SECI-MaP) model. The SECI-MaP model extends Nonaka's SECI model and captures a human-machine symbiotic and synergistic partnership for enhanced organisational knowledge creation. It implies that sufficiently mediated and applied combined efforts of humans and machines could be greater than the sum of their individual contributions.

Keywords: Knowledge creation, Knowledge-Enriched machine learning, Human-Machine partnership, SECI-MaP model

1. Introduction

Healthy, well-functioning organisations undertake intentional initiatives to create, develop and use knowledge to achieve business success (Davenport and Prusak, 1998). Since the 1990s, the SECI Model and theory of organisational knowledge creation, per Nonaka and Takeuchi (1995), has gained vast popularity and is often referred to as seminal and highly respected. While it has been revised and enhanced several times by introducing additional concepts and dimensions, it remains primarily human focused. The essence of the SECI model illustrates that the spiral of interactions and conversions between tacit and explicit knowledge, facilitated through four knowledge conversion modes (socialisation, externalisation, combination and internalisation), creates new knowledge.

Socialisation is the conversion of tacit knowledge into more tacit knowledge. Since tacit knowledge is embedded in the minds of people and is often context-specific and difficult to formalise, individuals exchange tacit knowledge through social interaction and shared experiences, while trust plays an important role. *Externalisation* is the conversion of tacit knowledge into explicit knowledge. As tacit knowledge is articulated through reflection and dialogue, it becomes crystallised and easier to codify and share and, therefore, tacit knowledge is translated into explicit knowledge. *Combination* is the conversion of explicit knowledge into more explicit knowledge. It involves the gathering, editing, integration and diffusion of explicit knowledge to compose systematic and more complex sets of explicit knowledge. *Internalisation* is the conversion of explicit knowledge into tacit knowledge, which closely resembles the concept of learning. Individuals need to identify within the explicit knowledge what is relevant to them and embody it through practice and action. New knowledge integrates with the person's existing knowledge and could restructure the existing knowledge. Tacit knowledge that becomes part of a person's knowledge base, leads to another spiral of knowledge creation, starting again with socialisation.

From a data-driven technology perspective, we have seen significant advancements since the 1990s. Artificial Intelligence (AI), in particular Machine Learning (ML), is used increasingly and offers significant potential for organisations to support their learning and to discover and uncover knowledge. Advancements in Automated Machine Learning (AutoML) make ML solutions more accessible to organisations, while the impressive results of ML in the form of Generative Artificial Intelligence (GenAI) have taken the world by storm since 2022. However, these technologies present challenges regarding the creation of organisational knowledge.

Firstly, there is the challenge of integration with tacit knowledge that is embedded in the human mind. Secondly, insufficient data and data quality concerns are common. It also became increasingly important to understand, interpret, explain and trust ML models. Research on integrating external knowledge into ML pipelines proved that Knowledge-Enriched Machine Learning (KEML) not only assists in addressing these challenges but could also improve performance and knowledge conformity of models (von Rueden *et al.*, 2021). An interesting perspective is that KEML closely resembles the human KM perspective, where knowledge creation is a product of integrating existing knowledge with newly acquired knowledge (Dasgupta and Gupta,

2009). Since KEML can combine human knowledge (represented for consumption by machines) with machine intelligence to develop new knowledge, this sparks the research question: *"How does KEML impact the SECI model of organisational knowledge creation?"*

To address the main research question, two supporting questions contribute from this background. Firstly, *"How can KEML address limitations of Nonaka's theory of organisational knowledge creation?"*, considers limitations highlighted by critical reviews of Nonaka's theory and the SECI model. The second supporting question, *"How can KEML unlock new potential for enhancing the SECI model?"* provides an opportunity to explore the research problem from a clean basis, uncovering further potential of KEML to enhance the SECI model.

The research aim is to guide and contribute to enhanced organisational knowledge creation in dynamic business environments, by capitalising on the best of both human- and machine contributions, in an era of rapid technological advancements and AI. An intuitive connection between organisational knowledge creation as per traditional Knowledge Management (KM), and ML as part of AI, supports this aim – both are intrinsically concerned with knowledge and the nature of learning.

To this end, the objective of this study is the development of a human-machine integrated model for explaining, understanding and guiding enhanced organisational knowledge creation. Nonaka, Von Krogh and Voelpel (2006) highlight that open boundaries and the evolution of their theory prove to be of great benefit to the field. They encourage different approaches and perspectives and aim to inspire new development around the theory. Considering this open invitation and the prominence of Nonaka's SECI model within the KM field, it is used as springboard for this study. The proposed SECI-Machine Partnership (SECI-MaP) model, therefore, extends the SECI model and enhances it towards supporting organisations in their efforts to create new knowledge in a data- and technology-rich era, contributing towards innovation, organisational agility and prosperity.

2. Methodology

This study follows the Design Science Research (DSR) paradigm. DSR aims to enhance human knowledge via the design and development of artefacts. The output of DSR is both the newly developed artefact(s) and design knowledge (DK). The aim of DK is to provide an understanding of how and why an artefact changes (either enhances or disrupts) the context of where it is applied (Vom Brocke, Hevner and Maedche, 2020).

In this study, the artefact, the SECI-MaP model is designed and developed as a conceptual model. For this study, a conceptual model is regarded as a simplified visual representation that explains and supports the understanding of key elements, their interactions and relationships. Design knowledge includes perspectives of how and why the model explains and guides enhanced organisational knowledge creation.

While several DSR approaches exist, the methodology per Peffers *et al.*, (2007) as illustrated by Figure 1 has been adopted for this study. It provides a well-suited process model, but simultaneously flexibility in execution, such as different possible entry points and iterative possibilities. The following steps summarise the activities followed for this research.

- *Problem Identification*: The research problem is identified, defined and its importance justified. Primary- and supporting research questions are formulated as noted in the Introduction.
- *Objective Definition:* The aim and objective of the study is inferred from the defined problem. Supported by background- and theoretical knowledge, a feasible objective is defined.

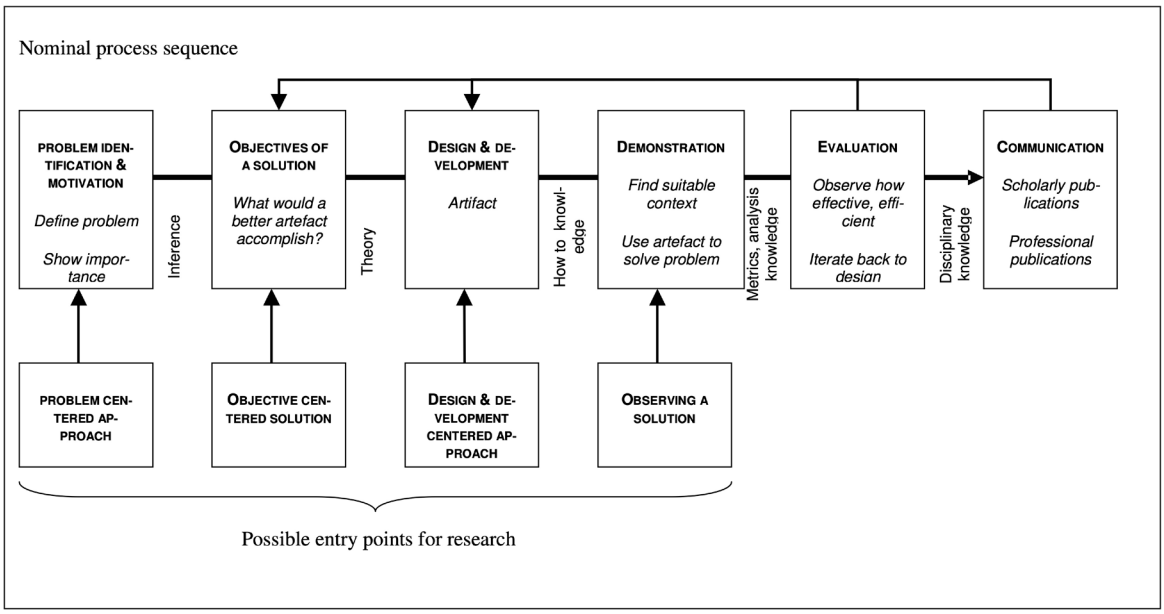


Figure 1: DSR Methodology Process Model (Peffers *et al*., (2007))

- *Design and Development:* The SECI-MaP model (the artefact) is designed and developed. This is supported by a focused literature study, as guided by the scope and the needs of the investigation. Key inferences then guide the development of the SECI-MaP model as summarised in Section 3.
- *Demonstration:* The SECI-MaP model is demonstrated from both a conceptual and an applied perspective. The demonstration which shows how the SECI-MaP model enhances organisational knowledge creation, forms part of the design knowledge.
- *Evaluation:* The SECI-MaP model is evaluated against two diverse use cases. Due to the scope of the study, this is a theoretical and conceptual evaluation. In future projects, this can be advanced in practical organisational settings.
- *Communication:* Key elements of this study are communicated through this paper and more detail pertaining to the full research project through the original Masters thesis (du Plessis, 2025).

3. The SECI-MaP Model for Organisational Knowledge Creation

Organisational knowledge creation, as defined by Nonaka and his colleagues, remains relevant – even decades later in an era where data, technology, and artificial intelligence play prominent roles. In organisations, we are still interested in collective knowledge and expertise, knowledge about the organisation's processes and systems, successes and failures, risks and challenges, potential inefficiencies and areas of improvement, opportunities for growth, customer insights and industry trends – to name a few. We still need the new knowledge to support decisions and, where relevant, distribute it throughout the organisation and embed and embody it in products, services, and systems.

The research question *"How does KEML impact the SECI model of organisational knowledge creation?"* is addressed by designing and developing a human-machine integrated model for organisational knowledge creation. This section, therefore, represents the 'Artefact Design and Development' phase of the DSR Methodology per Peffers et al. (2007).

Leading up to addressing the research question, an overview of key arguments and inferences that guided the development of the proposed SECI-MaP model is presented. These arguments and inferences are based on the focussed literature study, the evaluation of a selection of applications of KEML, and supported by practical experiences in an organisational context. KEML, for this study, is defined as any application of ML where any form of knowledge is integrated into any stage of an ML process to improve the model and/or results. Exploring two supporting questions that further contribute to the SECI-MaP model concludes the section.

3.1 Key Contributing Arguments and Inferences

3.1.1 A partnership between humans and machines capitalises on the best of both.

The main design principle for the SECI-MaP model is a human-machine symbiotic- and synergistic partnership. Both humans and machines have much to offer, but both have strengths as well as weaknesses. The contributions of humans and machines could therefore be complementary, supplementary, sometimes re-enforcing, or even conflicting – in the latter case, serving as a flag that further work is required. The partnership is defined to be symbiotic as it should be mutually beneficial to the contributions of both humans and machines. This means that the strengths of humans should compensate for the weaknesses of machines and vice versa. The partnership is also defined to be synergistic, where humans and machines co-create outcomes that could be greater than the sum of their independent contributions. A few contributing perspectives are summarised below.

From an overarching perspective, the continuously increasing ability of machines to process higher volumes of data at greater speed filters through various attributes. The ability of humans, in comparison, is significantly limited, and without the use of machines, large amounts of data collected by organisations would remain unutilised and potentially wasted. However, human input generally improves the quality of results and outputs produced by machines (von Rueden *et al.*, 2021).

Related to machines' distinguished processing capabilities, are the exceptional levels of complexity that they can deal with. However, the more sophisticated and complex these systems become, the harder it becomes to interpret and explain the inferences generated by them (Calegari, Ciatto and Omicini (2020); Angelov *et al.* (2021)). Human understanding plays a critical role in testing the validity of results and interpreting and deriving contextualised meaning.

On a more specific level, machines have a lot to offer as far as predictive power is concerned. Machines can uncover new (currently unknown) knowledge and information from existing sources and data, based on discovering patterns and making connections. However, due to common challenges such as overfitting, underfitting, data imbalances, dimensionality-, and feature selection issues etc., outcomes can be greatly improved by human judgment and the integration of pre-defined knowledge (von Rueden *et al.*, 2021).

A human-machine integrated model for organisational knowledge creation should, therefore, first provide opportunities to capitalise on the best contributions of both humans and machines. Secondly, it should support the effective balancing of such efforts towards a symbiotic and synergistic partnership to advance optimal knowledge creation outcomes.

3.1.2 Humans remain central and in the driving seat.

While machines provide numerous possibilities, it is ultimately human intelligence that will determine the outcome. While machines can superbly take care of the tasks that they are designed for, and aid, strengthen, and augment human efforts, it frees up humans to focus on tasks that require human general intelligence such as creativity, adaptability and intuition.

This further implies that humans require the skills to interact with their intelligent machine partners. It naturally suggests that traditional roles of humans in an organisation are changing. This prompts organisations to invest in upskilling or hiring to take advantage of an effective human-machine partnership. Yet, the realisation of such a partnership requires organisational foresight and intervention. Humans are therefore not only critical as part of an effective human-machine partnership, but also central and in the driving seat.

3.1.3 A sustainable model should consider continuously evolving technology.

Since the 1990s, the rapid rate of advancements in technology and AI has been transformative in many regards. With ongoing research, development and increasing investment in AI, it is not only expected that the pace of technological advancements will not slow down, but is likely to continue reshaping the world and, therefore, organisations in the future.

Against this backdrop, it is important to consider the continuously evolving role of technology in the design of the model. Process models that generally focus on a sequence of activities might be too restrictive. Process models are also often geared towards goal-oriented processes, while knowledge creation utilising KEML is generally more exploratory in nature. Thus, we steer away from a process model and propose a flexible conceptual model that focuses on the principles and interconnections of concepts.

3.2 From SECI to SECI-MaP

The research question "*How does KEML impact the SECI model of organisational knowledge creation?*", is addressed by extending and enhancing the SECI model towards a human-machine partnership. The resulting SECI-MaP model is visually represented in Figure 2.

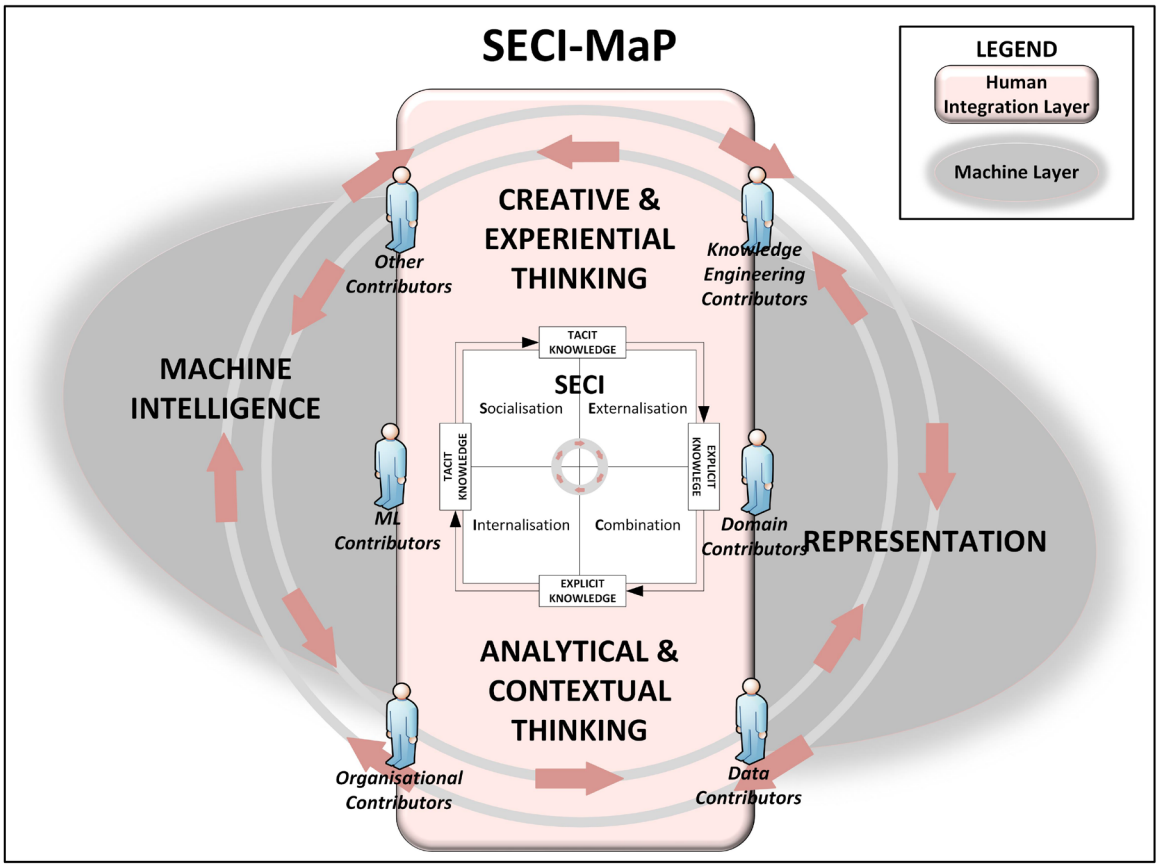


Figure 2: SECI-MaP Model

The SECI-MaP model consists of three layers. At the core, it captures the essence of the human-focused SECI model (Nonaka and Takeuchi, 1995). The spiral of continuous conversions between tacit and explicit knowledge facilitated through the four knowledge conversion modes (socialisation, externalisation, combination and internalisation) remains relevant.

The outer layer is the *Machine Layer*. It capitalises on the strengths and unique contributions of machines. The rounded shape with 'expandable' soft edges symbolises open-endedness and continuously evolving approaches, techniques, and technology. This supports the model's sustainability where continuously evolving technology is the order of the day. Guided by the needs of an organisation, any technique or approach can be used when applying the model in practice. Embedded in the machine layer, are the two key elements *Machine Intelligence* and *Representation*.

Machine Intelligence is loosely positioned towards the tacit side, as it refers to the ability of machines to learn, act, and even 'think' in a way that mimics human cognition. These are done by using algorithms and computational processes and include, recognising and analysing patterns, interpreting and 'understanding' complex data, learning from experience, predicting outcomes, and generating content.

Representation is positioned towards the explicit side and refers to the input into the machine learning process. Explicit input must be represented in some way for it to be consumed by machine intelligence. This could be structured- or unstructured data or formally represented knowledge. Per the taxonomy of informed machine learning (von Rueden *et al.*, 2021), representation can take on various forms such as algebraic- or differential equations, probabilistic relations, simulation results, logic rules, knowledge graphs, formal ontologies, and human feedback. Once represented, knowledge can be integrated into various stages of ML

pipelines and thus be consumed by machine intelligence – an approach that has been proven beneficial by various studies. Benefits have been summarised and classified by Rueden *et al.* (2021) to include better performance, knowledge conformity, better interpretability as well as training with less data.

The *Human Integration Layer* is the middle layer. It does not only serve as the 'glue' that holds the model together, but it also drives the application of the model. The rounded edge of the rectangle symbolises the symbiotic and synergistic partnership between humans (symbolically square) and machines (symbolically rounded). Note that the human integration layer encapsulates the SECI core, implying that the contributions from the machine layer extend the SECI model via the human integration layer. The aspects of thinking incorporated in the human integration layer are derived from Sternberg's theory of adaptive intelligence (Sternberg, 2021). These are simplified from the aspects of creative, analytical and practical (or contextual) thinking, into two broader categories that are loosely aligned with tacit and explicit knowledge, respectively.

Creative and Experiential Thinking in the context of the SECI-MaP model refers to human cognitive processes that typically rely on tacit knowledge. It depends on knowledge gained through practical experience, intuition and judgement, and is a critical mediator to interpret and enhance the output from machine intelligence, or to refine, redirect and mould it towards more reliable, trustworthy, ethical and feasible solutions.

With *Analytical and Contextual Thinking* on the explicit side, humans need to consider the broader environment and context when analysing problems and making decisions. While the machine layer can greatly contribute and support human productivity by dealing with high levels of complexity and processing high levels of data at speed, outcomes must be contextualised, understood and trusted. This form of human mediation includes applying human judgement, ensuring quality, communicating explanations, context and causality, and integrating the machine contributions into human understanding.

Human contributors are represented as broad categories of knowledge and skill. These categories are not intended to be an exhaustive list, but rather a broad indication. Important to note is that these areas of contribution do not imply that people are ringfenced within these areas - the same person could contribute to more than one area.

The circular arrows that span across the human integration layer and the machine layer, are driven by the human role players from the human integration layer. The circular arrows move in both directions and symbolise the integration of human- and machine contributions in the partnership. Note that the positions of human contributors are not absolute or static. Human participants would typically 'move around' and often work closely together.

3.3 Addressing Limitations with Knowledge-Enriched Machine Learning

In response to the supporting question: "*How can KEML address limitations of Nonaka's theory of organisational knowledge creation?*" the potential for KEML as part of a human-machine partnership to address some of the noted limitations of Nonaka's theory and SECI model was investigated. Key findings from the analysis are summarised below.

- *Learning, diversity and bricolage*: Poell and Van Der Krogt (2003), note that the SECI model neglects the contribution of different actors and learning strategies. Furthermore, multiple perspectives that lead to knowledge diversity and better-informed decisions is overlooked (Powell *et al.*, 2007).

A typical KEML project brings (human) diversity when a project team draws together different skills, knowledge and backgrounds e.g. organisational-, domain-, data- and ML- expertise. When AI comes into play, the diversity added by machine 'actors' adds an additional dimension to the potential for knowledge creation.

- *Problem finding*: As highlighted by Engeström (1999), this important success factor for the creation of knowledge for innovation is not included in the SECI model.

Due to the unique way that machines raise questions compared to their human counterparts, machines could identify unnoticed correlations in data and find problems that may be missed by human cognitive processes. Machines could also discover knowledge that is not question-driven (Martinez-Plumed et al., 2021). Due to these differences, humans and machines in a partnership could arrive at different questions from the same context, which further creates more diversity and opportunities.

- *Socialisation challenges*: Employees often resist full participation and share selectively due to caution related to trust issues and fear of judgement (Au and Chan, 2008).

Machines are not human, and hence, they do not judge. Various studies found that trust plays an important role and that humans are more willing to share honestly with machines where the interaction is anonymous or non-judgmental. This opens the door for the human-machine partnership to promote more open and honest sharing during socialisation phases.

- *Externalisation and Internalisation challenges*: Issues related to knowledge hoarding and superficial articulation of knowledge exist due to attempts by employees to be indispensable and thus preserve knowledge for themselves (Au and Chan, 2008). They further highlight the over-reliance on memory compared to understanding as an internalisation challenge.

The playing field changes in an era where AI plays a prominent role. Information and knowledge that individuals would typically try to preserve for themselves are becoming more readily available. Individual competitive advantage is increasingly driven by other factors such as creativity, critical thinking and the ability to discriminate effectively. Interesting to note is that these skills that drive individual competitive advantage are also key human skills required for an effective human-machine partnership.

- *Combination challenges*: Human nature to resist change and stick to old practices, often leads to combination efforts resulting in the 're-inventing of old wheels' (Au and Chan, 2008).

Machines have no preference for the old versus the new. They have no emotions or natural tendency to stick to old habits. This counters and balances combination challenges in the human-machine partnership.

3.4 Unlocking new Potential with Knowledge-Enriched Machine Learning

To address the second supporting question: "*How can KEML unlock new potential for enhancing the SECI model?*", new opportunities and potential for KEML as part of a human-machine partnership towards organisational knowledge creation were investigated.

The first relates to knowledge creation to support organisations to excel in times of rapid change. An organisation needs to be a 'learning organisation' and therefore be adaptable and flexible to survive and thrive in times of rapid change (Senge, 1990). That, while learning from a human perspective is subject to 'Learning Myopia' in the form of the human tendency to overlook distant times, overlook distant places and overlook failure (Leventhal and March, 1993). These challenges are embedded in the organisational challenge to find the appropriate balance between exploration (creation and invention of new knowledge) and exploitation (re-use of existing knowledge in new contexts). The natural human tendency is to favour exploitation over exploration (Lavie, Stettner and Tushman, 2010; Levinthal and March, 1993). Exploration and exploitation in organisations also compete for (human) resources that are often short in supply. Sturm *et al.* (2021) found that machines can reduce the need for human exploration as ML is particularly suitable for exploration. KEML as part of the human-machine partnership, therefore, exhibits great potential in this context.

A second opportunity relates to the codification and subsequent retrieval of knowledge. Knowledge codification is needed to organise knowledge and make it explicit, re-usable and accessible (Davenport and Prusak, 1998) and is also a key component of externalisation in Nonka's SECI model. However, organisations face challenges in achieving these goals. A key challenge is the extensive time required from subject matter experts to codify knowledge. This is due to the volumes, complexities and the need for an iterative process of recodification and refinement (O'Meara and Kelliher, 2021). Knowledge is also context-dependent (Cohendet and Edward Steinmueller, 2000) and a 'phenomenon in motion' (Patriotta, 2004). This is where KEML in the form of genAI applications, customised for the organisation, shows significant potential. Although the use of genAI presents challenges and risks, many of these relate to sociotechnical issues (Fui-Hoon Nah *et al.,* 2023) and can therefore be largely mitigated by the human-driven partnership between humans and machines.

Finally, machines could alleviate pressure on one of the scarcest resources in organisations – time. As per Davenport and Prusak (1998), the lack of adequate time is regarded as the biggest threat to the successful generation of knowledge in organisations. While time is limited and impossible to replicate, machines can take care of tasks that are time-consuming for humans, and hence, 'create' more time for humans to focus on their unique contributions.

4. Evaluation

During the evaluation phase of the DSR process, the artefact was theoretically evaluated using two diverse real-world organisational scenarios. Two scenarios from development areas that capture significant interest from organisations (AutoML and GenAI) were used for the evaluation. Key aspects and findings from the detailed evaluation of the SECI-MaP model (du Plessis, 2025), are summarised below.

The first scenario is summarised from an Amazon Web Services (AWS) 'Online Tech Talk' dated 16 August 2022 (AWS, 2022). KEML in the form of AutoML is used by a mobile phone service provider for insights and predictions on customer churn. The marketing analyst has access to high volumes of tabular data related to customer history, as well as information on customers who left. He uses the user-friendly no-code interface of AWS SageMaker Canvas to interact with his machine partner. Canvas analyses the data by identifying data types, missing and mismatched values, and visually presenting it to the user. The user further interacts with Canvas to select the column to predict and evaluate recommendations on how to deal with anomalies before selecting a model. The promising results from the model in Canvas motivate getting weigh-in from the data science team, where they enrich the model with formally presented knowledge, using AWS SageMaker Studio. The final model results are analysed, refined and communicated by the marketing analyst.

We observe a close interaction between the human and the machine layer. It requires tacit as well as explicit knowledge from the marketing analyst to 'socialise' with his machine counterpart. The machine layer plays an externalisation role as results are presented as user-friendly visualisations. Further human mediation takes place when the data science team feed additional external knowledge to the representation side of the machine layer, for further consumption by the machine intelligence. Both combination and internalisation take place as the marketing analyst gets to understand the relationship between features. As the marketing analyst shares the output of the model with other organisational users, socialisation and internalisation take place as they learn more about their customers and what services are important to them. It takes advantage of the contributions of both humans and machines, saving valuable time towards creating new knowledge about their customers' needs, and enables them to do root cause analysis on potential issues.

The second evaluation is on a genAI tool, developed for conversational guidance to customer support agents. (Business scenario summarised from Brynjofsson *et al.* (2023).) Agents require problem-solving skills, thorough product knowledge and the ability to handle contentious conversations and deal with frustrated customers. The genAI tool was enriched with additional training on a large set of customer-agent conversations from the organisation that have been labelled based on outcomes and customer satisfaction. The tool provides real-time suggestions to agents on how to respond, while agents remain responsible for their conversations and are free to use, amend or ignore suggestions from the tool.

To interpret this scenario in the context of the SECI-MaP model, it is important to note that the human ability to respond 'appropriately' is based on tacit knowledge gained through experience. This underlies the conversations with customers that are integrated into the explicit/representation side of the machine layer. This serves as training input for the machine intelligence that ultimately displays these skills and tacit knowledge when providing conversational guidance and suggestions. We can argue that a form of 'socialisation' takes place between the machine and the humans when suggestions are made. Humans use their judgement (tacit knowledge) to reject, alter, or accept the machine guidance. This could be a particularly effective way of 'socialisation' as machines are not human and do not judge. Humans can therefore freely decide what to do with the machine suggestions without fear of judgement or pressure to use the suggestions.

We can conclude that the evaluation indicate that the SECI-MaP model is generic enough to remain valid for the diverse scenarios. It is also specific enough to explain how enhanced organisational knowledge creation is facilitated through the human-machine partnership in the scenarios.

5. Conclusion and Future Work

Nonaka's widely cited SECI model has attracted considerable interest from researchers in the field of KM. Various studies provide critical assessments, while others aim to integrate varying additional aspects, such as complexity theory, knowledge enablers and sensemaking - to name a few. Several studies also propose alternative models and suggest different focal points regarding organisational knowledge dynamics. More recent studies consider the role of different technologies, each with its unique contribution. This study relates to the latter.

In alignment with the objective, the primary contribution of the study is the proposal of the conceptual SECI-MaP model that explains how machines, as represented by KEML, impact the SECI model of Nonaka and Takeuchi (1995). Extending and enhancing the SECI model in consideration of rapidly advancing technology and AI, advances our understanding of the increased potential that emerges when human- and machine efforts are effectively integrated. It explains the unique strengths of machines versus humans and how they complement and supplement each other to create a partnership that is both symbiotic and synergistic. This feeds into the longer-term aim of the research, which is to guide and contribute to enhanced organisational knowledge creation in dynamic business environments, taking advantage of AI.

The demonstration and evaluation of the SECI-MaP model, indicates theoretical validity and the potential for the model to support the longer-term aim of the study. Since the 'Evaluation' phase of the DSR Methodology of Peffers *et al.* (2007) aims to observe the effectiveness and efficiency of the developed artefact, a limitation of this study is that it does not include empirical validation. While empirical research was beyond the scope of this study, the promising theoretical results justify the need for further empirical research.

While this study serves as a theoretical foundation and merely a starting point to guide, navigate and contribute to enhanced organisational knowledge creation in a partnership between humans and machines, it leaves organisations with promising prospects and opportunities to explore.

Ethics statement: Ethical clearance was not required for the research referred to in this paper.

AI statement: AI tools were not used in the development of this paper.

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Knowledge Management Maturity Analysis in a Finnish NGO's International Programme

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Abstract: While knowledge management (KM) and KM maturity have been widely studied in the private sector, literature on nonprofits remains limited. Consequently, literature on KM maturity in this sector remains limited. In nonprofits, including child rights NGOs, effective KM plays, however, a crucial role in maximizing impact, ensuring accountability and improving programme outcomes. This study assesses KM maturity in a Finnish child rights NGO's International Programme (IP). Objectives include measuring KM maturity, identifying existing practices and challenges, and exploring management's perspectives on improvement needs. A KM Maturity Model developed for the public sector was modified for this study. Interviews were conducted with four IP senior management team members, who rated KM-related statements on a five-point Likert scale and answered open-ended questions related to the statement themes. Responses were transcribed and analysed using thematic grouping, with frequency and median used for quantitative analysis. Findings show that while KM was a relatively new concept for the respondents, several KM practices were already in place. Identified strengths include strategic alignment of indicators with organisational goals, a positive attitude toward KM, and the use of extensive data products from the NGO's international headquarters. Key challenges include limited time for deeper KM integration and a lack of structured knowledge-sharing processes. Respondents emphasised the need to strengthen team-wide KM understanding and proposed improvements like increasing transparency in decision-making, fostering collaborative learning, and systematically developing KM structures. This study provides a foundation for advancing KM within the studied NGO in order to enhance organisational performance. Next steps include developing a detailed KM improvement plan and potentially extending the maturity analysis organisation-wide. The study demonstrates that the use of a suitable KM maturity model can be useful for NGOs and nonprofits. Beyond its implications for the studied NGO, the findings can help other nonprofits to take the step to assess KM processes and implement improvements, ultimately enhancing effectiveness and impact across the sector.

Keywords: Knowledge management, Maturity models, Nonprofits, NGOs

1. Introduction

In today's knowledge-intensive society, knowledge management (KM) plays an increasingly important role in the success of organisations, whether private, governmental or nonprofit. Although often used interchangeably, in this paper, the term nonprofit is used as a wider term referring to any organisation whose purpose is not tied with financial gain, such as those in the sectors of education, social welfare, research or similar. NGO (non-governmental organisation), on the other hand, is used for referring to nonprofits that work independently of governments nationally and often internationally on issues including development, humanitarian and social work. From this follows that all NGOs are nonprofit, but not all nonprofits are NGOs. In NGOs, knowledge management can often be considered quite narrowly to only focus on the access to information for enhanced efficiency and quality of work of employees.

The objective of this study was to assess the KM maturity level in a Finnish non-governmental organisation's (NGO) International Programme (IP). The organisation under study is a politically independent organisation that promotes children's rights in Finland and around the world and is accountable for its effectiveness and impact to both its donors and the children and adults whose lives it seeks to improve. As an organisation working in the development sector, the NGO has a long tradition of monitoring performance, but no actual assessment of knowledge management maturity level had been done prior to this. Assessing KM maturity in the context of child rights NGOs is highly relevant, as these organisations operate in complex and resource-constrained environments, where evidence-based decisions, and effective knowledge use and sharing are critical for improving accountability and achieving and following up long-term impact.

Knowledge management can be defined in different ways depending on the source and context. In literature related to KM in the context of nonprofits, KM is defined, for example, as a set of strategies designed to enable employees to efficiently access essential information, enhance productivity, and minimize errors (Harper and Trees, 2020). In other sources related to organisations' KM generally, KM is defined, for example, as the practice of utilizing an organization's shared knowledge to enhance its competitiveness (Teah, Pee and Kankanhalli, 2006)

and involving at least the processes of generating, storing/retrieving, sharing, and utilizing knowledge (Alavi and Leidner, 2001.)

For the purposes of this paper, KM is defined as a process that comprises two main components as illustrated in Figure 1. First, management with knowledge covers decision-making based on knowledge and presentation of information and conclusions based on data. The second component, management of knowledge, includes the collection, categorisation, sharing and storage of data as well as systems and recording practices.

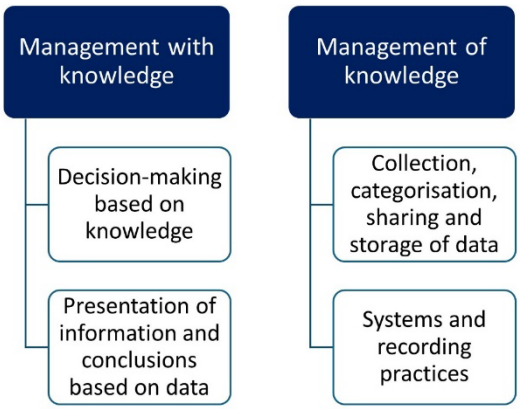


Figure 1: The concept of knowledge management. Adapted from Leskelä et al. 2019

The focus of KM in this paper is on the utilization of knowledge for decision-making and the structures and processes that facilitate this. Knowledge management is seen as a strategic approach to enhance organisations' possibilities of success. Khatibian, Hasan gholoi pour and Abedi Jafari (2010) define KM maturity models (KMMMs) as frameworks that outline the levels of growth an organization undergoes while improving its knowledge management structures and processes. KMMMs offer organisations a tool to systematically document the knowledge management development process by evaluating how it is defined, managed, and regulated (Khatibian, Hasan gholoi pour and Abedi Jafari, 2010, see also Jääskeläinen et al., 2022). Different KMMMs have been proposed, but no one established model exists for assessing an organisation's KM maturity (ibid.) By carrying out a KM maturity analysis, organizations can comprehensively evaluate and understand their KM status quo and obtain an insight into KM areas needing improvement (Akhavan and Philsoophian, 2018).

For NGOs, maturity models can offer a structured approach to identify gaps, enhance learning across programmes and locations, and systematise the use of knowledge for both operational and strategic decision-making. Literature around KM maturity models and analyses in the nonprofit sector or in child rights organisations in particular, is, however, scarce. Gunning (2014) studies information process maturity in the NGO sector from grant writers' perspective, while Mikovic et al. (2019) explore the impact of social capital in NGOs' knowledge and propose a mathematical neural network approach for assessing their KM maturity. Hume and Hume (2008, 2016) suggest that KM frameworks for nonprofits need to be tailored to their unique missions and operational structures as well as to take into account the size of the nonprofit. Akhavan and Philsoophian (2018) report an empirical KM maturity evaluation on a research centre in the electronics sector, while Harper and Trees (2020) explain the benefits of effective knowledge management for nonprofits and offer tools and guidance how nonprofits can start to leverage KM. Cultural and organizational readiness are reported to affect achieving higher KM maturity both in NGOs and corporate-like nonprofit entities (Moreno-Monsalve and Delgado-Ortiz, 2021). Besides the KM maturity analyses mentioned above, the literature review did not reveal any empirical KM maturity analyses focused specifically on child rights NGOs or addressing how KM maturity influences strategic decision-making in nonprofit contexts. This highlights a clear gap that this study seeks to address. In sum, the limited empirical research on KM maturity in nonprofits, and especially in child rights NGOs, demonstrates the need for context-specific insights. By assessing KM maturity in a child rights NGO's International Programme, this study supports evidence-based development of KM practices in a sector, where effective knowledge use can significantly enhance organisational impact.

2. Objectives

The study aimed to assess the current state of KM maturity within the NGO's International Programme team's work. The IP team has 21 members, including four members of the IP management team. The objective was to obtain a numerical assessment of KM across various KM areas, identify existing structures and practices

supporting KM within the IP team, examine challenges in KM, and explore potential improvements proposed by the IP management team. This analysis is intended to provide a basis on which the IP team can further develop its KM practices and to facilitate regular monitoring of the progress within the IP team.

3. Methods

The assessment employed the shorter version of the Information and Knowledge Management Maturity Model published by Finland's State Council in 2019 (Leskelä et al., 2019). Leskelä et al. (2019) consider that their maturity model, compared to previous ones, is a more comprehensive and holistic one and specifically designed for use in the public sector. The model was thus selected for this study due to it being a holistic, tested approach designed for use in public sector-like environments. It offered a structured yet adaptable framework suitable for assessing the KM practices of a child rights NGO. The original, full version of the model assesses KM maturity by means of 102 statements. The full version also includes statements relating to the satisfaction experienced for each area of assessment based on subjective evaluation. As in the original measurement of KM maturity with this model, the statements were designed so as to be rated on a five-point Likert scale from 1 to 5 (1 = strongly disagree, 5 = strongly agree) with "Not able to answer" also provided as an answering option. The shorter version of the analysis model evaluates KM across ten key areas and features twenty statements covering each area. It does not include statements related to satisfaction. (Leskelä et al., 2019.)

The components of KM assessed in the maturity analysis were the following, as described in the shorter version of the maturity model (Jääskeläinen et al., 2019):

- Vision and strategy (3 statements)
- Governance and organisation (3 statements)
- Information needs (2 statements)
- Information acquisition (1 statement)
- Information organisation and storage (3 statements)
- Information products (1 statement)
- Knowledge sharing (1 statement)
- Knowledge usage (2 statements)
- Measures (3 statements)
- Outcomes (1 statement)

The individual statements were tailored to align with the NGO's IP team's operations and tested by conducting one interview, after which the statements were slightly modified further. Data were collected through interviews with all four members of the IP senior management team. The selected four participants collectively oversee the International Programme team's different work streams: Programme Development and Quality, Institutional Portfolio and Institutional Partnerships. The participants were chosen for their comprehensive oversight and direct responsibility for strategic and knowledge-based decisions within the programme. In preparatory discussions with the IP team management, it was assessed that interviews, together with a numerical assessment, would be able to generate a more thorough understanding of the team's KM maturity level compared to a numerical assessment alone. At the same time, the management wanted to limit the interviews to the senior management team, as it was assessed that they would be the ones with sufficient and most relevant knowledge around KM for the purposes of the study. The IP senior management team members interviewed represented different domains of the IP team functions providing equal representation of the different functional domains. It was also considered that carrying out interviews with all team members would have been too time consuming for the purposes of the study. Due to a lack of a common understanding of KM in the organisation, it was felt that having all team members take the numerical assessment might also have been of little value added.

During the interviews, carried out via MS Teams, the researcher read out each KM-related statement. The respondents verbally rated the statements on a five-point Likert scale from 1 to 5 (1 = strongly disagree, 5 = strongly agree), and "Don't know" was also an answering option. Only one "Don't know" response was received, and it was excluded from the calculation of the median values. While the Likert scale allows for capturing participants' attitudes toward KM structures and practices, it is recognised that this method reflects perceptions rather than objective reality. Results should therefore be interpreted as indicative of perceived maturity and used primarily as a basis for qualitative analysis and for identifying areas for developing implications for future development.

During the interviews the respondents also verbally answered open-ended questions, which asked the respondents for their justifications for each rating they had given, as well as for examples of good or bad practice and suggestions for improvement. The responses to the open-ended questions were used for gathering examples of knowledge management practices, challenges, and areas for improvement. The duration of the interviews was between 40 and 53 minutes. The interviews were transcribed and analysed using thematic grouping. For quantitative data analysis of the rating scores, frequency and median scores were used. Given the small sample size, the numerical data primarily serves as a supplementary reference to qualitative insights, providing a concrete baseline against which the organization can track its future progress in KM.

4. Results

The assessment revealed both areas of strength and weaknesses in the organisation's KM structures and practices. Figure 2. shows that the components of *Measures* and *Outcomes* both scored the highest possible median (5), indicating a mature level of KM in those areas. The areas of *Governance and organisation* as well as *Information products* were the ones with the lowest median (2), indicating a relatively weak rating compared with the other areas of assessment. The medians for the rest of the components were between these two extreme ends situated fairly close to each other with the medians being either 3.5 or 4 for all the other KM components.

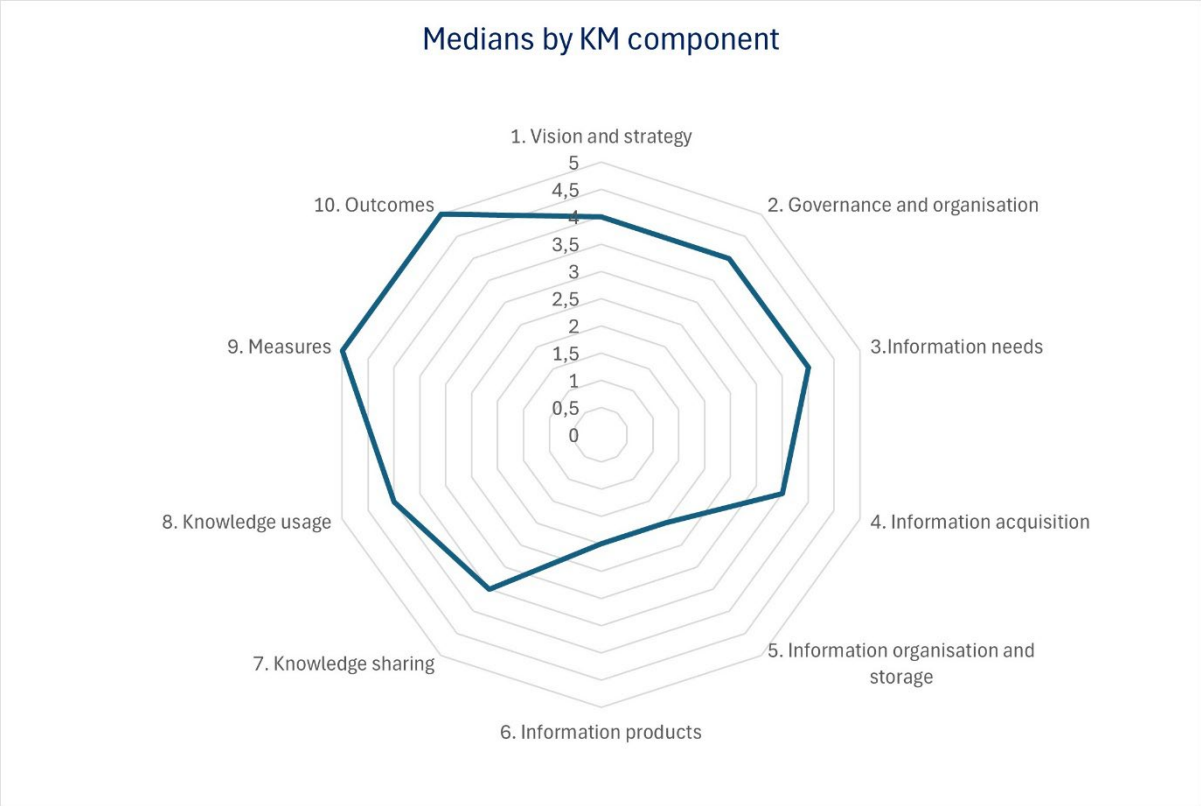


Figure 2: Medians by each KM component assessed

When examining individual statements, there were three statements that were rated unanimously by the respondents with the highest score, 5, see Table 1. below. The statements were related to the positive attitude towards KM in the IP team, indicators being directly linked with the strategy and KM practices increasing the effectiveness of the International Programme.

Table 1: Individual statements with the highest medians.

KM Component	2. Governance and organisation		9. Measures		10. Outcomes	
Statement	There is a positive attitude towards KM in the IP team		Our indicators are directly linked with the strategy as it is linked to the International Programme		KM practices increase the effectiveness of the International Programme	
Median	5		5		5	
	n	%	n	%	n	%
Strongly agree	4	100	4	100	4	100
All	4	100	4	100	4	100

The statements with the lowest median were found under the KM components with the lowest overall medians, see Table 2. All respondents somewhat disagreed with the statement that the IP team has a platform or system in use that integrates KM. The second statement with the lowest median was related to the IP management having a dashboard solution adaptable to its needs. This statement divided the respondents' opinions receiving ratings from somewhat agree to somewhat disagree.

Table 2: Individual statements with the lowest medians

KM Component	5. Information organisation and storage		6. Information products	
Statement	The IP team has a platform or system in use that integrates knowledge management		The IP team has a management dashboard solution adaptable to its needs	
Median	2		2	
	n	%	n	%
Strongly disagree	0	0	2	50
Somewhat disagree	4	100	0	0
Neither agree or disagree	0	0	1	25
Somewhat agree	0	0	1	25
Strongly agree	0	0	0	0
All	4	100	4	100

In open-ended questions interviewees highlighted as key structures supporting KM the availability of the various information products and systems of the organisation's international headquarters and accessible to the Finnish NGO under study. Additionally, interviewees identified as a strength the collection and utilisation of robust data on the effectiveness of different thematic approaches, for example, child protection and child-sensitive social protection. This aligns with the high ratings given by the respondents to the statement assessing the connection between indicators and strategy.

> *"As in many other organisations that work in development cooperation [...] there is a very long tradition of firstly, collecting data on the effectiveness of our work and the results we achieve, and then trying to take it into account in the redefinition of the objectives of our work..." (Translated from Finnish), Respondent 2*

Challenges were identified, for example, in the areas of information sharing and general knowledge and understanding around KM.

> *"Maybe we don't really know, maybe haven't fully internalized [...] that [...] knowledge management, how could it improve our work. We have never discussed this topic, the potential it has." (Translated from Finnish), Respondent 3*

The interviewees also recognised insufficient time available for KM-related tasks as well as the integration of information from different sources as challenging.

The respondents identified several areas for development, including enhancing understanding of KM's possibilities, improving information-sharing processes, and fostering a culture of shared learning. More effective use of the various data products provided by the NGO's international headquarters was also mentioned as a quick and easy way to improve knowledge sharing and use.

5. Discussion and Conclusions

The assessment of KM-related statements from the maturity analysis, along with qualitative data, indicate that KM is still a relatively new concept within the organisation's IP team. The interviewees themselves highlighted this both before and during the discussions. However, while the term "knowledge management" may not be widely used, the IP team already has structures and practices that support KM. One key development need identified by the respondents was to enhance understanding of KM and explore its potential within the team. The respondents also welcomed the topic being addressed through the KM maturity analysis and expressed interest in further efforts to advance KM practices in the organisation.

A comprehensive report detailing the findings of the analysis was prepared for the NGO's IP team to support the continued development and monitoring of KM. The report provides a foundation for creating a concrete action plan to enhance KM practices. Next steps proposed for the NGO include discussing the report findings and recommendations in detail and organising a workshop with the relevant team members for prioritising the KM improvement actions, responsibilities and timelines together with the team. A joint workshop would provide the possibility for the whole team to participate and take ownership of the actions agreed. The recommendations also include setting clear indicators and a monitoring framework for the KM action plan. Key indicators for the organisation to follow up in the implementation of the action plan could include assessing awareness and understanding of KM through periodic pulse surveys, tracking the number and quality of knowledge-sharing activities and events, monitoring relevant user statistics of the key dashboards from the NGO's international headquarters, where possible, and regularly checking in on the perceived value of the KM improvements through team reflections.

The variation in maturity levels across measured KM components suggests that targeted interventions are needed. For instance, the low scores in *information organisation and storage* point to the need for clearer responsibilities, ownership structures, and coordination mechanisms in KM-related processes. Likewise, the low maturity in *information products* reflects a need to enhance the accessibility, integration, and usability of data products to better support decision-making. Concrete first actions could include setting up a process and responsibilities for the analysis, sharing and use of the data products provided by the NGO's international headquarters. Actions could also involve, for example, appointing a KM focal point or integrating KM roles more explicitly into team responsibilities. In order to improve on the *information products,* the organisation could consider taking into use an application or software such as Power BI or other business intelligence application that would allow building meaningful data dashboards. This would require investments in product licences, training and staff time, but would bring with it a potential for highly improved management decision-making.

The emerging awareness of the importance of KM in the organisation can be transformed into tangible actions to strengthen KM practices. The action plan should address gaps in understanding through training and capacity-building activities tailored to the organisation's context. Organisation of trainings and information sessions on KM could help to achieve a common understanding of KM in the team and the organisation as a whole. Short orientation sessions, peer learning, and examples from similar organisations can support the internalisation of KM concepts and practical tools and help to clearly define the benefits of KM for the organisation's daily work. Identifying practical use cases of KM and linking KM activities directly to the team's objectives could help bring KM from the conceptual level to concrete actions in the team.

Fostering a culture that values shared learning is critical to long-term KM success. Encouraging open dialogue about lessons learned, creating regular spaces for exchange, and highlighting examples of good practice within the team are key starting points. Concrete practices may include allocating time in team meetings for reflection, establishing informal "learning hubs" around common themes, or documenting and sharing insights from key projects. Leadership also plays an essential role in modelling knowledge-sharing behaviours and acknowledging contributions that advance organisational learning. By embedding shared learning as a routine part of team practices and reinforcing its value, the organisation can build a more collaborative and adaptive KM culture over time.

Additionally, the maturity model tested in this study could be used in the future for a more extensive baseline analysis of the organisation's overall KM maturity status, serving as a basis for broader improvement efforts.

Much like for this study, which focused on the IP team, the questions can be adapted to suit the different units of the organisation, including projects and development, service provision, and different support functions such as communications, marketing, fund-raising, IT, and HR. Each unit could assess its own KM practices based on relevant dimensions, enabling decentralised yet consistent evaluations across the organisation. By repeating the maturity analysis regularly, teams could track their own development, identify persistent gaps, and reflect on the effects of KM interventions. The results of the analysis could also be used for cross-team benchmarking and could help prioritise organisation-wide support, such as training or system improvements. When embedded into organisational review and planning cycles, the maturity analysis could become a structured feedback mechanism that enables strategic learning, adaptation, and performance improvement across the whole NGO.

The approach used as well as the findings and recommendations of the KM maturity analysis in the IP team could thus serve as a kick-start for an organisation-wide process, leading to the development of a comprehensive organisational KM strategy aligned with the organisation's overall strategy. KM should not be a parallel or separate function, but rather embedded into strategic planning, resource allocation, job descriptions, and objectives setting at the organisational, team and staff member levels. When KM is derived from strategy and integrated in this way, it will directly support the achievement of strategic goals.

Previous research suggests that KM maturity analyses can enhance organisational performance by outlining optimal operational characteristics, which often result in improved satisfaction and performance at the workplace (Jääskeläinen et al., 2022). In the context of the NGO studied, improvements in KM could support clearer coordination of existing knowledge flows, enhanced accessibility of data products, and more consistent application of insights across teams to respond effectively to changing partner or community needs. These changes, in turn, can contribute to more effective programming and increased impact for children and families. Furthermore, having clearly defined knowledge-sharing processes and easier access to relevant information can increase staff motivation, role clarity and team cohesion, which can lead to improved staff satisfaction and retention. Better KM can also reduce duplication of effort, streamline workflows, and improve accountability.

Beyond its implications for the studied NGO, the findings of this study can serve as an example that can encourage other nonprofits to assess their own KM processes, recognise potential gaps, and implement strategies for improvement. It also illustrates that the KMMM used in this study, although targeted towards the public sector, is also suitable and can be adapted for other contexts, such as use in NGOs, encouraging similar organisations to assess their KM practices and begin structured improvements. Sharing these insights more broadly could contribute to a culture of knowledge sharing within the nonprofit sector itself. Ultimately, these insights can contribute to improved effectiveness and greater impact in the nonprofit sector.

Ethics declaration: This study involved human participants but did not require ethical clearance, as it did not involve sensitive data, personal risk, or ethically sensitive topics. Participants were informed of the study's purpose, and participation was entirely voluntary.

AI declaration: After the study and results were ready, an AI tool (ChatGPT 4o) was used to generate ideas for recommendations for the NGO for further developing KM in the organisation. The ideas suggested by the AI were used only as inspiration for formulating the final recommendations presented in the Discussion and conclusions section of the paper. AI was also used for the purposes of language refinement, and to ensure coherence in academic writing. AI was not used for other purposes. All AI-generated content was critically evaluated, revised, and validated by the author to ensure accuracy, relevance, and alignment with the study's objectives.

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Generative AI's Impact on Knowledge Ownership: Ensuring Fair IP Attribution

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Abstract: With the in-depth application of generative artificial intelligence (Gen AI) in the field of knowledge management (KM), the traditional intellectual property (IP) system is facing serious challenges. The AI-driven knowledge production model blurs the clear boundaries of traditional IP ownership, resulting in increased uncertainty in the distribution of rights and an aggravation of the imbalance in the pattern of interests. This dilemma is further amplified by Gen AI's unique "black box" and "autonomous" characteristics, and it is difficult to determine a clear ownership subject for its automatically generated content. These challenges have exposed the fundamental limitations of the traditional IP framework, which is based on an anthropocentric knowledge production paradigm that is difficult to adapt to the characteristics of knowledge innovation in the AI era. By systematically combing the solutions proposed by various countries in the field of KM, combined with the analysis of international typical cases, this study focuses on the mainstream coping strategies, including the separation of moral rights and economic rights, the collective management authorization model, the transformation of the safe harbour principle, and the exploration of patent paths. The results show that the existing schemes have significant limitations: they are insufficient in terms of technical adaptability, legal compatibility and ethical legitimacy. These solutions focus too much on rights segmentation and ignore dynamic collaboration; Emphasis is placed on post-event relief, and there is a lack of source governance. In order to overcome these limitations, this study innovatively proposes an optimization framework of "technology-law-governance": develop an interpretable contribution tracking algorithm at the technical level, and construct a causal mapping of data-model-knowledge assets; At the legal level, a mixed ownership structure is designed to balance private rights protection and public access through hierarchical rights confirmation. At the governance level, a global coordination mechanism has been established to use smart contracts to achieve real-time distribution of cross-border IP rights. This integrated solution aims to reconstruct the IP system in the AI era, promote technological innovation while maintaining the sustainability and fairness of the knowledge ecosystem.

Keywords: Generative AI, Intellectual property, Knowledge management, Technology-Law-governance framework, Hybrid property rights

1. Introduction

The rapid development of the new generation of AI is profoundly changing the paradigm of KM, creating great opportunities and serious challenges. AI technology has become the core driving force for the digital transformation of various industries, but its rapid development has also completely shaken the foundation of the traditional IP system, exposing major shortcomings in the ownership identification and management mechanism of AI-generated content (AIGC). The inherent "black box" nature of AI models leads to the opaque decision-making process, and its self-generation ability makes it difficult for the creator to identify the subject (Rezaei, 2025). This situation has been further exacerbated by the global application of AI, and cross-border data flows and cooperation have had a huge impact on the traditional IP system based on territorial jurisdiction. With the wide application of Gen AI in key knowledge work areas such as legal document drafting and medical research, it is urgent to build flexible and fair IP management solutions. According to Priority Research, the global AIGC market will exceed US$22.12 billion by 2025, with a compound annual growth rate of 27.02%, highlighting the urgency of solving this problem - not only to ensure the innovative development of the digital economy, but also to safeguard the legitimate rights and interests of creators.

Current research on these challenges is still fragmented and in-depth. Although important breakthroughs have been made in technical areas such as explainable AI and contribution tracking algorithms, these advances have not yet been effectively integrated into legal and governance frameworks. The reform plans of the copyright system proposed by academics, including the separation of economic rights and moral rights, the collective management model, and the adjustment of the safe harbour principle, are often difficult to fundamentally deal with the complex network of "human-machine-enterprise" multi-subject collaborative creation in the development of AI systems. Although the blockchain-based ownership recognition system has potential, it is limited by scalability challenges. International policy coordination is also hampered by jurisdictional differences. This fragmentation leads to existing solutions that only address the symptoms and do not get to the root of the problem.

In light of the limitations of current research, this paper will explore ethical issues in the use of Gen AI in KM. By constructing an innovative tripartite framework of technology-law-governance (TLG), it systematically addresses these critical gaps. At the legal level, it proposes a pioneering hybrid ownership structure that balances private incentives with public access through dynamic, hierarchical rights recognition—a significant improvement over the current "all-or-nothing" approach to copyright. The governance pillar automates cross-border IP distribution via smart contracts, addressing long-standing challenges in judicial coordination. Together, these components represent a paradigm shift from a static "rights segmentation" model to an adaptive "responsible coexistence" system. This framework can effectively reduce litigation costs associated with IP while increasing transparency in content creators' compensation. By addressing technical, legal, and governance issues simultaneously, this study provides, for the first time, a comprehensive solution that ensures fairness in the AI-driven knowledge economy while maintaining innovation, which is particularly relevant in industries where knowledge integrity is crucial, such as academic publishing, legal services, and healthcare information systems.

2. Literature Review

Knowledge management, as an important branch of the field of management, is an activity of planning and managing knowledge, knowledge creation process and knowledge application. Early research focused on knowledge classification of explicit and tacit knowledge and knowledge transformation mechanism using Socialization-Externalization-Combination-Internalization (SECI) model (Nonaka & Takeuchi, 1995), emphasizing the culture and process design of knowledge creation and sharing (Alavi & Leidner, 2001). In recent years, research has gradually turned to technology-driven knowledge governance, knowledge ecosystem construction, and the role of knowledge in innovation (Argote & Fahrenkopf, 2016).

With the development of emerging technologies such as the Internet, many researchers have begun to researched the combination of KM and technology, marking that the international research on KM is gradually becoming intelligent (Shi &Tian, 2024). In this context, the breakthrough of Gen AI technology has injected new impetus into KM research and practice. AI consists of human intelligence and intuitive ability to generate creative and novel ideas that drive organizational innovation, which is classified as a competitive advantage because of higher experience-based thinking (Liebowitz, 2006). In the field of KM, AI drives innovation, optimizes business processes, and improves market competitiveness by supporting the sharing and transformation of tacit knowledge (Olan et al., 2022).

The explosive development of Gen AI makes the production and distribution of knowledge face great changes, and the emergence of AI poses unprecedented challenges to the traditional IP system. It is generally believed in the current research that the creation process of Gen AI involves the complex interaction of data input, algorithm iteration and human intervention, resulting in the fuzzy definition of the subject of rights (Lucchi, 2024). Fenwick and Jurcys (2023) revealed the hybrid network characteristics of "human-machine-enterprise" in the process of creation, and the "author-centric" framework in the traditional copyright law is difficult to define the copyright allocation under this mode. In addition, the content generation mechanism of Gen AI is also an impact on the "idea-expression dichotomy", which is a challenge to the theory of copyright system. (Zhang, 2024)

In September 2022, Jason Allen applied for copyright registration for a work created using AIGC: Theatre D 'opera Spatial. Allen believes that his creative input to AI Midjourney involves "inputting a series of prompts, adjusting the scene, choosing the parts to focus on, and determining the tone of the image", which is on a similar level to that expressed by other types of artists, and that the potential AIGC generation works are only the raw materials transformed by his artistic contributions. But the US Copyright Office demanded that the content generated by AIGC be excluded from the registered copyright, while Allen insisted on registering the copyright of the entire work. In the end, the copyright Office refused to register the work because it could not determine that Allen had created the work entirely by hand. Traditional IP law has "human creators" as its core, but as this case shows, AIGC's creative process involves multiple participants, resulting in ambiguous judgment of the subject of rights and difficulty in defining the ownership of rights. At the same time, at the legal level, the current law lacks clear norms for "non-human authors" and cannot determine the degree of human intervention in AIGC.

At the same time, Gen AI lacks legal constraints, and the use of unauthorized training data has led to disputes over the boundary of rights and unbalanced distribution of benefits. Thongmeensuk (2024) compares the text data mining (TDM) exception clauses in the EU, the UK and Japan, and points out that there are significant differences in the applicability of the copyright exception to AI training data in the existing legal system, which may lead to an imbalance of interests between right holders and developers. The 2023 Stability AI lawsuit, in which artists alleged that their AI models were trained on their work without authorization, still dismissed most of the three artist plaintiffs' claims for lack of clarity and specificity. Such disputes highlight the practical problem

that it is difficult to protect the rights and interests of the original works in the commercial application of Gen AI training, which is prone to cause IP disputes and ethical disputes (Alavi et al., 2024).

In the face of these challenges, the academic community has proposed many solutions, but there are still limitations at multiple levels. Although schemes such as the separation of authorship right and property right, can balance the interests of developers and users, but due to the unsynchronization of AI laws in various countries, laws cannot effectively constrain Gen AI in the scenario of transnational cooperation. RAI (Responsible artificial intelligence) principles can reduce ethical issues by reducing bias through explainable AI, but they still focus on "rights cutting", More standardized frameworks and longitudinal studies are lacking (Boege et al., 2024). These limitations indicate that there is a lack of interpretable contribution traceability tools at the technical level.

The current research clearly reveals the impact of Gen AI on the IP system, highlighting the necessity of building a systematic AIGC equity distribution system and mechanism, but fragmented solutions are difficult to cope with the systemic challenge. Although some scholars have begun to discuss its legal and ethical impact, there is still a lack of effective technical support for property rights protection, no clear theory to help identify the ownership of rights, there is a research gap, and theoretical and practical breakthroughs are urgently needed. This paper proposes to build a three-in-one integration TLG framework, which provides a new path for stimulating AI innovation and ensuring the sustainability of knowledge ecology.

3. Research Method

This paper sorted out the solutions of cases collected at home and abroad, found that most of them focused on technology and law. Through sorting out many relevant literatures, it found that there were many similarities in data transaction circulation. An article published in this field introduced the three-way governance method of data transaction circulation, including technology, law and standards. Similarly, the Fair IP Attribution applied to KM in this subject is also applicable to this method, but the formulation of global standards is vague and one-sided. However, they both belong to the new technology, they were virtual and non-physical, and they have similar technical supervision, legal rules and governance mechanisms. Finally, it is determined to adjust this method in terms of statement. constructing a "technology-legal-governance" trinity integration framework.

Through theoretical integration, this study discusses the ethical problems of using Gen AI in KM and feasible solutions from classical cases, analyzing the solutions and features from the aspect of three dimensions in order to provide reference and inspiration for the research and practice of KM and related fields.

4. Technology-Law-Governance Framework

4.1 Technology

At the technical level, interpretable contribution-tracking algorithms need to be developed to establish causal links between data, AI models and the generation of knowledge assets. Solving AIGC intellectual property problems requires deconstructing the whole Gen AI process: from user input data through model decision processing to generating output (text/image/code and other knowledge assets). The data layer contains expert training data and user newly added data, the model layer involves algorithm design, training process and parameter optimization, and the output layer points to the final generated results. To determine the proportion of equity ownership, it is necessary to quantify the information transmission and transformation path in the whole process. In view of excessive intervention may lead to interest game and black-box operation, it is suggested to implement multi-party verification mechanism through third-party platforms and reconstruct causal logic mapping with interpretable algorithms (Xu, 2022). The data dimension should quantify the influence weight of the sample on the output. The model layer needs to record key decision nodes through blockchain technology to achieve multi-party supervision; The output layer needs to track the interaction process between user input and model reasoning, analyse the semantic correlation strength of input prompts and generated results through comparative learning, and embed visual interpretation modules (such as causal heat maps with key contributing factors) in the generated interface to form interpretable AIGC reports with legal effect.

4.2 Law

Employing the traceability algorithm of explainable contributions, it is easy to systematically backtrack to the originated content along with their creators, paving the way for both property right enforcement and benefit distribution. However, that only answers the “who contributed what” question, not how to fairly allocate IP rights among stakeholders. The rights and interests in KM among creators, users, and the public vary and are

continuously evolving. Therefore, it is necessary to develop a hybrid property rights model that blends private rights protection with public access governed by hierarchical authorization.

4.2.1 The core concept of mixed ownership structure

There are many examples of mixed ownership forms organized around private rights and public property, usually with a hierarchy in the positing of powers that pits individual IP interests against those based on social public values. In essence, it sets up a knowledge resources hierarchy to confer rights such that stakeholders (creators, businesses and the public) access varying levels. In this way, it can also ensure that the private rights of creators are protected, while promoting knowledge sharing and popularization.

The goals of mixed property rights architecture are three main protect private rights, promote the sharing of public knowledge, and realize flexible profit distribution. The first is to protect private rights, that is, through the design of clear property rights structure, to ensure that knowledge creators and data providers have clear ownership and use rights. Then, on the premise of not infringing on private rights, it promotes the sharing and circulation of knowledge in the public domain to avoid the monopoly of knowledge resources. Finally, different levels of rights and interests are set according to the use scenarios and needs, which can not only protect the economic interests of the creators, but also make the knowledge benefit the society and realize the flexible benefit distribution.

4.2.2 The design mechanism of hierarchical rights confirmation

The hierarchical rights verification architecture proposes to divide IP into tiers or levels by their implementations and value where each level should have independent rights holders with trial usage grants. Therefore, this paper not only create a more flexible and transparent mechanism for the utilization of knowledge, but also have better alternatives to approach conflicts between safeguarding individual rights with public interests.

Division of Equity Levels

The first step is to recognize what hierarchical right confirmation truly means: demarcate the margins of rights at different tiers. Levels at which to decide on IP rights share.

Knowledge Producers: As human rises higher in the awareness pyramid, a growing percentage of these items become the source of truth. At this level, the creator holds all IP rights and can use, copy, change, or even sell them — totally unrestricted. The creator can also release their IP to the public, share it, or license its use (and profit) to others and institutions (Xu, 2022).

Licensing layer, sharing layer: The knowledge bridge through licensing agreements, creators may license IP to others.

Public Domain Layer: The most open level, aimed primarily at the public and academic research fields. At this level, knowledge sharing, citations and reproductions are free. Yet, it has to be ensured that they are not infringing upon the personal privacy of the creator, trade secrets and other fundamental rights. Additionally, these private rights may be protected via means such as anonymization and de-identification (Xu, 2022).

Rights Flow and Conversion

The hybrid property rights structure needs to build a reasonable rights transfer mechanism to reconcile private rights and public access demands, allowing creators to license part/all of their IP through payment or free, but ensuring their continued control over the work and reasonable benefits. At the same time, a gradual opening path should be designed to make knowledge assets gradually transition from shared use to the public domain. Such a phased opening mechanism can drive innovation iteration while protecting the rights and interests of creators. To prevent the abuse of rights, it is necessary to set the application field and the limitation range of use constraints, and establish a backtracking verification mechanism to ensure the continuous compliance of the license terms.

4.2.3 Balance between private rights protection and public access

Designing a mixed property rights structure requires finding a balance between private rights protection and public access. Transparency is reflected in the legal terms and actual operation, and the standardized license agreement can clearly define the boundary of rights. Moreover, the structure should have the flexibility to adapt to technological development and social needs, not only protect the rights and interests of creators, but also promote the dissemination of knowledge. Finally, it is necessary to establish an effective regulatory mechanism to ensure that the use of knowledge complies with the requirements of the agreement and safeguard the

legitimate rights and interests of all parties. These elements are interrelated and constitute a complete property rights system together.

4.3 Governance

Building a global collaborative governance mechanism is an important way to solve the issue of Gen AI equity distribution, and to achieve fair equity distribution between creators and AI by forming unified equity distribution standards for Gen AI among different countries. However, at present, there is no effective collaborative governance model in the world. Therefore, how to promote policy coordination and unified standards among countries has become a topic that cannot be avoided in building a global collaborative governance mechanism.

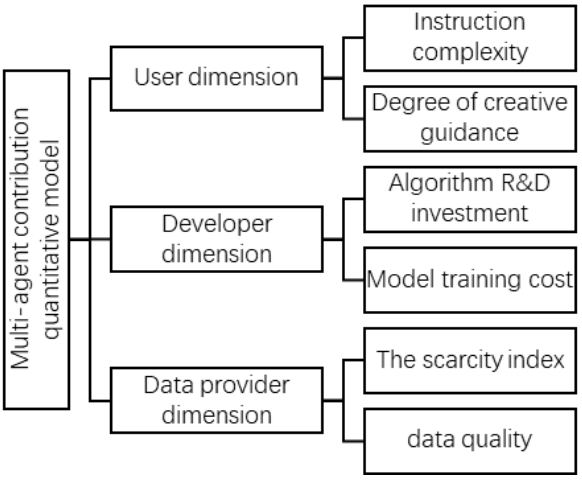
4.3.1 Smart contracts to achieve equity distribution

Smart contracts rely on the decentralized execution and transparent traceability characteristics of blockchain, which can effectively avoid single points of failure and human intervention, ensure the multi-party verification mechanism, and establish a traceable dispute resolution framework while ensuring the transparency of transactions, thus improving the reliability and security of contract execution. Its automated characteristics support the precise allocation of AIGC rights and interests, promote international uniform rights and interests' allocation and implementation standards, and help global governance coordination (Song, 2008). The implementation process needs to be divided into three stages: technical preparation, rule construction and ecological cultivation to promote Gen AI equity allocation system, and uphold the principle of "responsible innovation" to balance technological innovation and intellectual property protection, so as to promote the progress of AI technology and maintain the sustainability of human knowledge ecology.

Period 1: Technical Preparation

In the technical preparation phase, to ensure the accuracy and effectiveness of the smart contract, the development of an international standard for the calculation of AIGC contribution values is a top priority. In order to realize the fair distribution of rights and interests, we construct a scientific multi-agent contribution quantitative model. The model is evaluated from three dimensions: customer, developer and data provider, so that each subject's contribution rate has a basic measurement standard.

The multi-agent contribution quantitative model is constructed as shown in Figure 1.



Note: R&D=Research and Development

Figure 1: Multi-agent contribution quantitative model

In order to realize the fair distribution of Gen AI technical achievements, it is necessary to build a multi-agent contribution quantitative model and establish a scientific equity mapping by systematically evaluating the differentiated inputs of users, developers and data providers. User contribution is measured by instruction complexity and innovation: rigorous instructions generated by deep thinking can guide AI to produce specialized content, and its creativity can trigger breakthrough innovation, which constitutes a core value metric. Developer contribution covers the full cycle investment of algorithm development, including the intellectual resources consumed by research iteration and parameter optimization, as well as the high computing power required for model training and operation and maintenance costs, which need to be converted into assignable equity

weights. Data provider contributions are based on the dual dimensions of data quality (accuracy/completeness) and scarcity: high-quality data lays the foundation for model learning, first-source scarce data reduces training costs and improves output uniqueness, and such resources should be given more weight in allocation. The model realizes the accurate matching of contribution and benefit through dynamic evaluation mechanism, and builds a sustainable cooperative ecology.

Period 2: Rule Formation

In the process of formulating rules, the initiator needs to take the lead in establishing a global smart contract governance cooperation mechanism, jointly establish the basic principles and framework of fairness, transparency and security, form an international consensus, and ensure the equality of rights and obligations of all parties. In the implementation phase, it is necessary to build a transparent supervision system, accept extensive supervision, prevent misconduct, and establish a code protection mechanism to resist the risk of technical attacks and data leaks, and ensure the security of participants' assets and privacy. The whole process should be open and inclusive, take into account the political, economic and cultural differences of various countries, and work together to promote the construction of a global governance system.

Period 3: Ecological Cultivation

During the ecological cultivation period, an incentive system for open-source communities and developers should be established to achieve fair distribution of rights and interests through smart contracts. Build a developer collaboration platform to promote technology sharing and joint research, optimize algorithms and break through technical bottlenecks. Set up a special fund to reward developers with outstanding performance in smart contract and AIGC technology innovation, and attract enterprises and scientific research institutions to participate in open-source projects to jointly promote the progress of research and development, and application of AIGC technology.

4.3.2 Global collaborative governance mechanism through smart contracts

At the technical level, smart contracts can solve the problem of AIGC equity allocation with unique technical characteristics, accurately measure the contribution of users, developers and data providers in the Gen AI creation process, avoid human intervention and disputes, and provide technical guarantee for the realization of global collaborative governance. In terms of system, each country should organize multiple forces to participate in the formulation and revision of the standard, formulate unified international rules, clarify the rights and obligations of each subject, and ensure the sustainable development of human knowledge ecology.

5. Conclusion and Limitations

Traditional IP frameworks have shown many problems under the impact of AI, and many typical cases have appeared around the world. This paper proposes an innovation optimization framework through a case study, and analyses it from the three dimensions of technology, law, and governance, so as to provide a reference for the construction of an AI-driven KM system in China. It is worth noting that the research methods in the field of data transactions provide suitable analytical tools for this topic. The research results have improved the domestic IP system to a certain extent, provided a basis for responding to the demand for legal revision brought about by technological innovation, and helped to maintain the fairness of the knowledge ecology and ensure the sustainability of AI development.

However, there are obvious limitations in this study: the sample size of the case is insufficient in terms of research methodology, and the research content focuses on the theoretical discussion of Gen AI and the traditional IP system rather than practical verification. Nevertheless, this study still provides an innovative solution for the Gen AI IP distribution system.

6. Future Study

Although existing research has deeply explored the impact of KM strategies on organizational performance (Liu et al., 2023) and the complexity of cross-country knowledge transfer (Liu et al., 2022), the rise of Gen AI has posed new challenges to the field of KM. In particular, theoretical breakthrough and practical exploration are urgently needed in IP protection. Future research can combine organizational learning theory (Liu et al., 2022) to explore how to balance the efficiency of Gen AI on knowledge sharing with the infringement risk in the process through dynamic capability construction. In addition, future studies can explore the role of AI agent and top managers, such as chief knowledge officer (CKO) (Liu et al., 2018) in KM and the impacts of AI agent and top managers collaboration on knowledge ownership.

Acknowledgements

The authors appreciate the support from the Guangdong University Engineering Technology Research Center for Precision Components of Intelligent Terminal of Transportation Tools (No.2021GCZX002) and the guidance from Dr. Gang Liu.

Ethics Declaration: This study followed the ethical norms of academic research. The data used in this study were either publicly available or secondary data and all data were collected within a legal and ethical framework. In addition, this study did not involve any experiments, interviews, or surveys that could have had a direct impact on the participants. Therefore, according to the relevant ethical requirements, this study did not require formal ethical approval.

AI Declaration: This study used AI tools in the writing process. This paper uses AI tools to assist with literature search and some text editing. The use of AI tools accounted for less than 13% of the overall content of the paper, and all results and text were thoroughly reviewed and revised by the authors. The main ideas, analyses, and conclusions of the study were done independently by the authors, and the AI tools were only used as an aid and did not have a decisive influence on the final content and conclusions of the study.

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Non Academic Papers

Evaluating Generative AI Technology Choices and Software Frameworks for Developing AI Solutions in Business

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Abstract: Generative AI (GenAI) is being increasingly adopted in business, yet leveraging it effectively remains challenging due to diverse use cases and organizational needs. While generic end-user tools are widely used, they often fall short in addressing domain-specific tasks and integration requirements. This paper reviews the limitations of such tools and emphasizes the need for customized, use-case-specific GenAI solutions. We examine emerging software frameworks for developing tailored GenAI solutions.

Keywords: Generative AI, Technology choices, Generative AI frameworks, Enterprise AI integration, Generic and custom GenAI solutions

1. Introduction

GenAI adoption is increasing worldwide. According to a global survey (McKinsey, 2025), nearly 75% of organizations now use AI in at least one function. However, realizing long-term value remains challenging, particularly as organizations struggle to choose the right tools amid a growing landscape of frameworks and technologies (Deloitte, 2025). Most are still in the experimentation phase, using proof of concepts (PoCs) to test feasibility.

This paper reviews the current state of GenAI adoption, examining the strengths and limitations of popular end-user tools, and the growing need for custom solutions. It also reviews key development frameworks.

2. Generative AI Adoption in Business Context

Our AI consultancy experience in the Finnish AI Region European Digital Innovation Hub (FAIR EDIH) (Finnish AI Region, n.d.) project reveals that both large and small companies belonging to different sectors are adopting AI. The major sectors include healthcare, education, construction, manufacturing, real estate, and logistics, among others (Khan et al., 2025). Businesses are increasingly turning to GenAI to boost productivity, automate labor-intensive tasks, such as content creation and document drafting, reduce operational costs, and gain a competitive advantage (Deloitte, 2025; McKinsey, 2023).

Most companies start their GenAI journey with popular end-user tools such as ChatGPT, MS Copilot, NotebookLM, and Perplexity AI. Microsoft Copilot is integrated with Microsoft 365 applications and supports tasks like email drafting, document summarization, and generating data insights. However, it offers limited flexibility outside the Microsoft ecosystem, lacks transparency, and presents integration challenges with non-Microsoft platforms. In our AI consultancy, several companies have also shown dissatisfaction with its performance for their tailored tasks.

NotebookLM provides summarization, citation generation, and audio guides from uploaded content. However, it struggles with poorly formatted PDFs, limited file support, and strict usage limits. Despite assurances of data privacy, concerns remain regarding content handling.

Conversational agents such as ChatGPT, Gemini, Claude, and Mistral offer natural language interaction with support for various input types and basic web integration. Their ease of use and wide accessibility are clear

advantages. However, they lack organization-specific knowledge, are prone to hallucinations, and cannot be directly embedded into business workflows.

Search engines like Perplexity AI combine web search and AI reasoning, offering real-time, sourced answers with file upload and API options. They excel at information delivery but depend heavily on the quality of external sources and prioritize information retrieval over creative or specialized output. Like other tools, it also raises privacy concerns.

3. Need for Customized GenAI Solutions

Enterprises are increasingly recognizing that one-size-fits-all generative AI tools often fall short for specialized needs and company-specific use-cases. The generic AI solutions suffice for common and recurring cases such as simple content generation, basic data analysis, finding information from internal documents with simple queries, quick internet searches, and simple knowledge extraction. The issues of hallucination and inaccurate answers, lack of transparency, minimal control over the implementation pipelines and model behavior, lack of use case adaptability, lack of data privacy, and lack of integration in organizational workflows warrant the development of custom AI solutions.

During our AI consultancy (Finnish AI Region, n.d.), we encountered several use cases that entail the development of custom AI tools. Some of these use-cases include generation of sales quotations from multiple documents with multiple data formats, combining tacit and documented knowledge in AI assistants, dynamic generation of programming codes based on new use-cases, automatic resolution of customer complaints, matchmaking and networking, and the AI systems that improve their knowledge with user interactions, to name a few.

Generic end-user tools operate as standalone assistants and cannot directly integrate with an enterprise's IT systems or workflows. For instance, ChatGPT cannot automatically retrieve real-time internal data or trigger actions in business applications. In contrast, custom GenAI can be built into products and processes, connecting to CRM systems, knowledge bases, ERPs, or any relevant APIs (Van der Heijden, 2023). In particular, new advancements in GenAI that enable LLMs to connect to any data source, such as Anthropic's Model Context Protocol (MCP) (Anthropic, 2024), open new areas of custom AI solutions. Table I presents a comparison of generic and custom AI tools.

Table 1: Comparison of generic and custom AI tools

GenAI Tool Type	Use-Case Fit	Data Privacy	Scalability & Cost	Customization	Regulatory Compliance	Transparency & Control
Generic Tools	Limited	Conditional (e.g., MS Copilot)	Limited (costly at scale)	None	Poor	Low (black box)
Custom Tools	High	High (open-source models or secure cloud)	Flexible (tailored infra)	High (fine-tunable)	High	Full (pipeline control)

4. Software Frameworks for Developing GenAI Solutions

Developing GenAI solutions requires choosing software frameworks that align with the use case, organizational goals, and technical capacity. Code-based frameworks offer high flexibility and control, making them ideal for complex, custom applications, but they demand technical expertise and longer development time. Low/no-code platforms enable faster deployment with minimal effort, making them suitable for prototyping and simpler use cases, though they offer limited customization and may lead to vendor lock-in. Table II summarizes some low/no-code software frameworks for developing AI solutions.

Table 2: A comparison of popular low/no-code software frameworks suitable for GenAI solution development

Framework	Type & Features	Ease of Use	Common Use Cases	Ecosystem	Scalability	API/Integration
n8n (n8n, 2025)	Visual, open-source workflow builder	Moderate	Automation, custom bots	Large (400+ integrations)	Cluster-based	Webhooks, REST, custom nodes

Framework	Type & Features	Ease of Use	Common Use Cases	Ecosystem	Scalability	API/Integration
Motia (Motia, 2025)	Code-first, event-driven agents	Steep	Custom AI automation	Small, growing	Modular, cloud-ready	Extendable HTTP APIs
Flowise (Flowise, 2025)	No-code LLM builder (LangChainJS)	Easy	RAG apps, chatbots	Active open-source	Self-hosted/cloud	Custom nodes, APIs
Dify (Dify, 2025)	Low-code LLM with ops tools	Low	Internal tools, SaaS AI	Popular on GitHub	Kubernetes-ready	REST APIs, plugin support
Botpress (Botpress, 2025)	Conversational AI, modular NLU	Shallow	Multi-channel bots	Mature, large base	Horizontal	SDKs, API hooks
Langflow (Langflow, 2025)	Drag-and-drop LangChain canvas	Easy	Q&A bots, prototyping	Emerging open-source	Limited (SMB scale)	Python components, API access

LLMs can be customized in several ways. Fine-tuning is a primary method for customizing LLMs by further training them on task- or domain-specific datasets to improve performance on specialized tasks. This approach has been useful in adapting LLMs to various applications. For instance, fine-tuning has been applied to enhance domain-specific machine translation capabilities, addressing the limitations of general-purpose models in specialized fields like legal and medical translations (Hu et al., 2025).

The other way to customize LLM is Retrieval Augment Generation, which augments an LLM with an external information retrieval component to overcome the model's knowledge limitations (such as fixed training data or hallucinations). In this setup, the system fetches relevant documents or facts from a knowledge base in response to a query, and the LLM generates its output conditioned on that retrieved context (Li et al., 2024).

Integrating LLMs with knowledge graphs (KGs) is also an emerging technique to integrate structured, verified knowledge into generation processes. KGs store facts as interconnected entities and relations, offering a reliable and interpretable source of truth that can ground an LLM's responses. By incorporating KG data, the LLM's outputs can become more consistent and factual, helping to reduce hallucinations in complex reasoning tasks (Ji et al., 2024).

In more advanced systems, AI agents are designed to autonomously plan and execute tasks, enabling GenAI systems to achieve goals with minimal human input (Deloitte, 2025). Agentic frameworks allow these agents to dynamically interact with external data, APIs, and tools, supporting multi-step workflows, automation, and context-aware responses. Potential applications include report generation and information retrieval and validation (e.g., GPT Researcher (GPTR, 2025)). Table III compares some agentic frameworks.

RAG and agentic AI solutions can be developed using both code-based and low/no-code software frameworks for developing AI solutions. RAG improves response accuracy and mitigates hallucinations by retrieving relevant information from external sources before generating output. Frameworks like LangChain (LangChain, 2025) and LlamaIndex (LlamaIndex, 2025) enable RAG development by integrating LLMs with internal data or knowledge bases to power chatbots, recommendation engines, matchmaking tools, and document-based knowledge extraction.

Table3: A comparison of popular agentic frameworks for developing AI solutions

Software Framework	Key Features	Ease of Use	Use Cases	Ecosystem	Scalability	API Support	Limitations
LangGraph (LangGrah, 2025)	Visual, graph-based orchestration (LangChain-integrated)	Moderate	Enterprise AI apps (e.g., chatbots, CX)	Large, growing	High (prod-ready)	Agent workflow APIs	Limited docs, partial cloud support
BeeAI (BeeAI, 2025)	No/low-code, multi-agent	Easy	IT ops, internal AI tools	Small, enterprise-backed	High (parallel tasks)	Python/TS SDKs	Small ecosystem, maturing APIs

Software Framework	Key Features	Ease of Use	Use Cases	Ecosystem	Scalability	API Support	Limitations
	orchestration						
AutoGen (AutoGen, 2025)	Modular, Microsoft-backed, dynamic workflows	Moderate	Coding agents, supply chain, multi-agent ops	Strong research/enterprise	Very high (event-driven)	Human-in-loop APIs	Python-only, needs infra setup
CrewAI (CrewAI, 2025)	Lightweight, open-source, quick setup	Very easy	SMB workflows, content creation	Active grassroots	Cloud-ready (AWS/Azure)	Simple APIs	No streaming, limited model support

Anthropic's MCP is an open standard that connects LLMs to diverse data sources, enabling secure, flexible, and interoperable agent-based applications through a client-server architecture (Andreessen, 2025). It holds potential to enhance integration and data security across enterprise systems.

Selecting the right LLM is equally important for custom AI development. Proprietary LLMs (such as GPT-4o, O3, Claude-3.7-sonnet, and Gemini 2.5 Pro) offer strong capabilities but may lead to vendor dependency. Open-source alternatives (such as DeepSeek-V3, LLaMA 3, Qwen2.5, and Mistral Large Instruct) provide greater control for in-house use, though they require robust (hardware-software) infrastructure. A hybrid approach starts with proprietary models in secure environments (e.g., AWS, Azure) and transitions to open-source models. Key selection criteria include accuracy, context length, multimodality, latency, compute needs, token pricing, and API/tooling ecosystem.

A summary of the technologies for creating GenAI solutions is presented in Fig. 1.

5. Conclusion

This study highlights the limitations of generic GenAI tools in meeting the domain-specific and integration needs of businesses, justifying the growing necessity for custom-built solutions. While commercial platforms offer accessibility and a quick start, they often lack the transparency, control, and adaptability required for enterprise applications. Custom GenAI systems, integrated with organizational workflows and data environments, are better positioned to deliver lasting value and ensure regulatory compliance.

Effective AI adoption further demands strategic alignment with business goals, a thoughtful evaluation of frameworks, and a realistic assessment of integration complexity and internal expertise. A phased roadmap is essential: starting with commercial tool exploration, identifying organizational gaps, and progressing toward tailored solutions through co-development with technical experts. Building AI literacy across roles and collaborating with research and innovation networks further strengthens implementation.

With the identification of these gaps and needs, we are developing a GenAI toolkit for knowledge management in business that will allow businesses to create their custom, use-case-specific knowledge management applications.

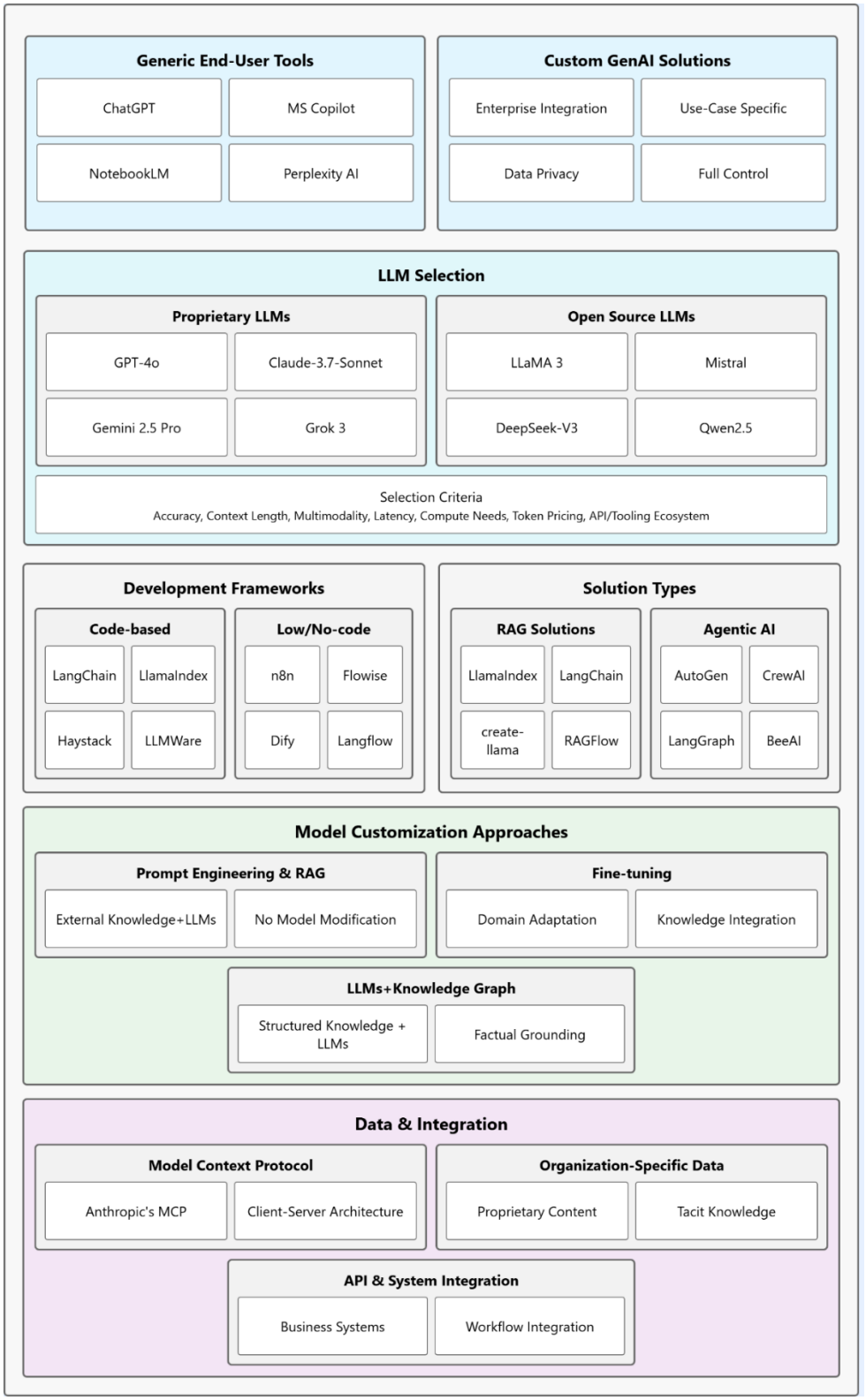


Figure 1: Overview of technologies for creating GenAI solutions

Acknowledgements

The present work is part of the Generative AI-Enhanced Knowledge Management in Business (GAIK) project, which is co-funded by the European Union, European Regional Development Fund (Euroopan Aluekehitys rahasto, EAKR).

Ethics Declaration: No ethical clearance was required for this research.

AI Declaration: An AI tool was used for rephrasing and summarizing some parts of the paper with careful validation.

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Improving the Recall of Factual Knowledge Based on Experiments Conducted by Herman Ebbinghaus

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Abstract: Learning factual information is an activity that most individuals have engaged in during their schooling, at university, or in specific courses. It is commonly stated that one "absorbs" facts, with the intention of retaining the learned material over time. According to memory psychologist Hermann Ebbinghaus, a specific pattern must be followed to prevent the forgetting of learned material. Ebbinghaus, H. (1885) Uber das Gedächtnis zur Experimentellen Psychologie Verlag von Duncker & Humblot, Leipzig. The article outlines the approach necessary to maximize retention. When a considerable number of individuals adhere to Ebbinghaus's pattern, it results in a group whose memory of the learned material improves from a lower level to a significantly higher one. If this group comprises employees within an organization, it leads to what is known as a "knowledge gain" for the organization, thereby enhancing the overall quality of its collective knowledge. This pertains to the concept of organizational memory—the total knowledge residing within an organization. In the article by Walsh J.P. and Ungson G.R. (1991), titled "Organizational Memory," published in the Academy of Management Review, the authors highlight the critical importance of effectively managing and leveraging an organization's accumulated knowledge, thereby elevating the practice of knowledge management.

Keywords: Ebbinghaus, Forgetting curve, Factual knowledge, Repetition, Memory certification

1. Introduction

In a previous article written by Palm, T and Fahlgren, J (2016) Academic knowledge control with E-exams and reflections on the Ebbinghaus forgetting curve, Department of Informatics and Media, Uppsala University, the theories put forward by the German memory researcher at the end of the 19th century were considered. The results of his experiments provide a reason to question how current knowledge checks are carried out in universities and colleges, especially with an emphasis on so-called factual knowledge. There is therefore reason to consider the current knowledge control of so-called factual knowledge in our higher education institutions and investigate whether better alternatives are available. This article aims to highlight that this is the case.

2. Fifty Years of Exam Tradition

For more than 50 years, written examinations at Swedish universities and colleges have been conducted in much the same way. A written exam is when the written test for students takes place at the end of a course with a duration of between five and ten weeks. The written exam at the end of the course often consists of a number of questions or problems to be answered. Examinees have a set amount of time to answer questions or solve given problems. It is now common for other types of examinations and compulsory ones to occur during the course.These may include seminars, laboratory work and assignments. Short written examinations are also used. In summary, there are a number of different forms of examination.

In connection with the university entrance examination or the theory test for driving licences, the tests are designed with so-called multiple choice questions. Such a question structure can, if desired, result in instananeous correction and reporting of results.

At present, so-called 'hall exams' are usually conducted by having students answer questions and problems on paper. The exam questions answered on paper are collected and handed over to the relevant teachers for marking. Students who fail the exam are given a second opportunity to take a re-exam. This takes place a few weeks after the first exam or at a later date, for example at the end of the semester. It is usually said that the chances of 'passing' the re-exam are greater than the chances of passing the first regular exam. One probably has in mind here that when the student is to take the re-exam, the student will repeat the course content once again. It is said that 'Repetition is the mother of all learning'.

3. Ebbinghaus Forgetting Curve And Views on its Consequences

3.1 Memory Research late 19th Century

At the end of the 19th century, the German psychologist Hermann Ebbinghaus reported, by conducting experiments on himself, how we remember and forget learnt material. He was able to show that if we check how much we remember over the course of a week, we forget the most in the first few days, and by the end of

the week we remember about 20% of what we have learnt. If the results are presented in a diagram, the memory curve falls steeply during the first few days of the week and flattens out at the end of the week. The falling curve is known as the 'forgetting curve' and is a well-known phenomenon.

In the discussion that follows, exact values are given in per cent, such as 20% and 80%. These values are provisional. Taking each individual's approach to memory means that no two individuals are alike. It is likely that the values will be more accurate when comparing larger groups, where average values can be discussed. In this case, there is no extensive experimental material to draw on. Rather, this report should be seen as a suggestion on how to proceed with investigating the results for a larger group of students.

Although much theory has been developed in the field of memory research since Ebbinghaus' findings were reported, he presented for the first time an understanding of how people remember and forget learnt material. He showed that unless the learnt material was repeated a certain number of times according to a set time pattern, only a small part of the original material was remembered, as mentioned earlier. In the 20th century, similar experiments were carried out and found that Ebbinghaus's discovery was correct and that it was primarily a matter of factual knowledge.

Even today, at the beginning of the 21st century, the forgetting curve is still referred to in the context of memory research experiments.

In Figure 1 below, the graph represents the so-called forgetting curve. The vertical axis indicates how much you remember. The higher up the vertical axis, the more you remember. The horizontal axis shows the number of days elapsed from the first knowledge check and when the other knowledge checks take place.

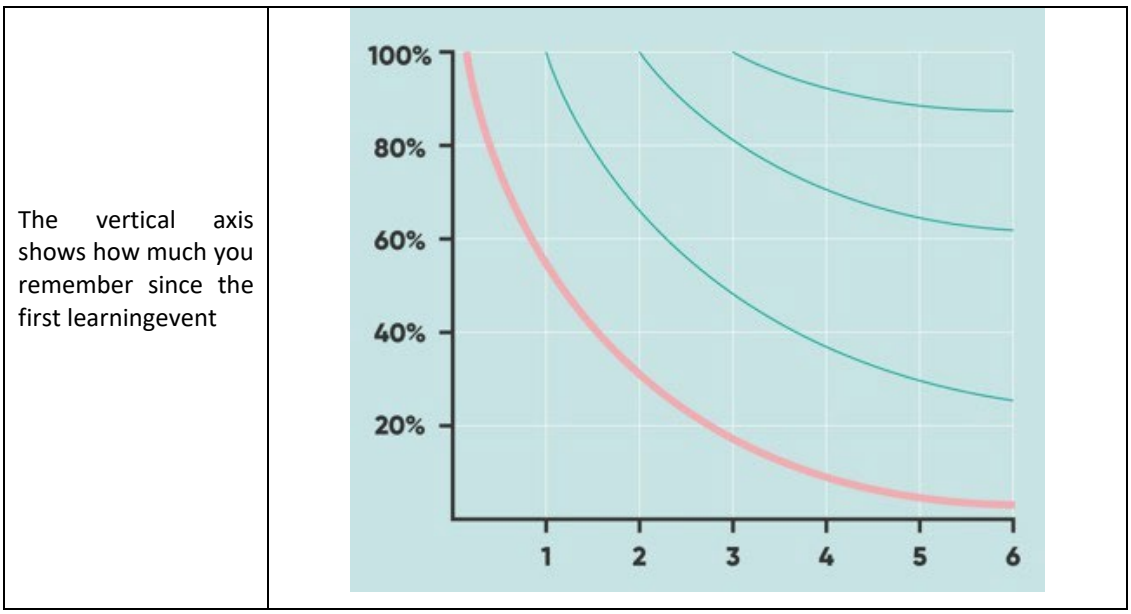


Figure 1: Ebbinghaus forgetting curve. (Herman Ebbinghaus 1885)

If you start from day 0 on the horizontal axis, i.e. the day you take your regular written exam, you remember 'everything'. After just one day, day 1 on the horizontal axis, you have forgotten almost half. The curve star-ting from day 0 passes day 1 and has dropped to almost 50%. After six days, the curve from the first know-ledge check has dropped considerably. You have forgotten most of it and remember about 20%. If you re-peat the test after one day, day 1, i.e. you rehearse first so that you know 'everything' before the second knowledge check and complete it, you remember more after 6 days compared to the first time. If you do the second, third and fourth knowledge checks, see Figure 1, you remember most of the facts, about 80%. The graph in Figure 1 represents an approximate picture of the forgetting curve. In addition to the first written ordinary exam, three knowledge checks follow. Some people mention both four and five knowledge checks in addition to the ordinary exam. Some of us remember more, while others do not remember as much. There are different views on how close in time the retests should take place.

But we still get an idea from the example, by looking at the diagram, of the shortcoming of writing only once and the advantage of writing several times in a row on the same subject. This means that if we take Ebbinghaus'

130-year-old results into our time while keeping in mind the way academic written exams are conducted in the present. This means that the knowledge material the student has 'learnt' and 'tested' during 3 years of study, the student remembers after a short time only the knowledge content corresponding to half a year of study.

We assume that the student in question has not benefited from having taken multiple exams on the same material. The remaining 2 1/2 years of 3 years of study have been forgotten. A very poor investment of time and money.

The 20% figure in paragraph 2.1 above and the 80% figure at the end of paragraph 5.2 below are taken from the data that can be interpreted from tables and graphs that report or refer to the forgetting experiment originally conducted by Ebbinghaus. In addition, the extent to which people remember and forget differs from one individual to another.

3.2 Repetition is Beneficial

As mentioned above, Ebbinghaus showed that if you repeat the learnt material about three times and do it after a certain time pattern, you remember knowledge equivalent to 2 1/2 years of study. A considerable improvement! According to Ebbinghaus, the time pattern for the first three repetitions should be relatively close in time, already during the first week, counting from the first knowledge check, the traditional written exam. Other accounts of the forgetting curve and how to reduce its steepness state that the four repetitions can take place over a couple of weeks. Wolf, Gary (2012) describes in the link, <http://quantifiedself.com/2012/06/spaced-repetition-and-learning/>, how to use different methods to reduce the forgetting curve and make learning more effective. Wolf's introduction refers to Ebbinghaus' discovery of 'the forgetting curve' and 'the spacing effect'. With 'the spacing effect' means that it is more beneficial to break up the learning of a material with breaks in between. Gipple, Jimi Gipple (2015), ICSlearningGROUP, refers to Ebbinghaus in his article 'eLearning: Overcoming the Forgetting Curve,

The findings of Gary Wolf and Jimi Gipple recognise that forgetfulness in education is a barrier to long-term learning. Mr Wolf has developed tools to help overcome forgetting that increases over time. It is therefore of great interest to know how memory research today views Ebbinghaus' discovery and what implications it may have for the knowledge control of theory theory at our universities.

In my opinion, the way in which knowledge verification is carried out in academic institutions will determine how much students remember after completing their studies. It is not difficult to see which of the students an employer would prefer to employ, the one who remembers 80% or the one who remembers 20% of the knowledge material covered during the programme. We assume that both students have been assessed as equivalent in other respects.

3.3 What can we do?

By drawing attention to the steep fall of the forgetting curve after learning and how to counteract a large part of forgetting, universities and colleges are faced with several choices. Therefore, to move the discussion forward, the concept of memory certification is introduced, which means that a student can report how much of the learnt material is retained over time. Should individual students be voluntarily memory certified up to the 80% memory level or should the whole institution be memory certified? If the institution chooses to let the individual student decide whether they want to be memory certified in addition to the existing procedures for knowledge control, it means an addition to the current procedures for written examination. Students who choose to recall certification in addition to the existing procedures are offered three knowledge checks distributed appropriately over time. The memory checks or exams, which follow the first written exam, must be changed to be more administratively manageable than the first one. If the management of the subsequent knowledge checks is not changed, at least three times more resources will be required to conduct a know-ledge check with certification up to the 80% level, taking into account the prevention of forgetting the learnt course content. Instead of marking the second and third know-ledge checks in the traditional way, it is advisable to move to so-called multiple choice exams in the form of e-exams. Feedback to the student is instantaneous and the cost of administration is significantly reduced com-pared to the traditional approach of 'marking by hand'. If the whole institution decides to move to memory certification, it re-quires preparatory work, mostly in the form of producing multiple choice questions with answer options.

3.4 Enhancing Long-Term Memory - a Competitive Advantage

We may thus prefer to allow individuals to choose to recertify themselves for 80% retention over time in addition to the current option of a written exam and 20% retention over time. We, as noted earlier, can also choose to

have the whole institution memory certified with the equivalent of 80% retention of knowledge over time. The choice depends very much on how much memory certification is perceived as a competitive tool in academic undergraduate education vis-à-vis other universities and employers.

4. Traditional or Memory-Certified Knowledge Check

4.1 Why Change?

As mentioned earlier, activities in higher education have traditionally been carried out in the same way de-cade after decade. Admittedly, several changes have been introduced with the aim of improving and stream-lining teaching. But to a large extent, many teaching activities are similar across the ages. In the past, it was common in Sweden for a whole 20-week course to be examined at the end of the semester. Now it is more common for the semester to be divided into shorter courses, which are examined at the end of the course, a way of dedramatising studies and in-creasing the possibility of more courses being completed. The prevailing perception of knowledge control at higher education institutions can be seen as relatively similar over time. Something along the lines of students 'emptying out' what they have 'learnt' during the course when they sit an exam. Instead, the organiser of the assessment should aim to ensure that a student retains as much of the learning material as possible for as long as possible.

4.2 Why TV Adverts?

On the vast majority of TV channels, the regular programme is frequently interrupted by commercials. The same adverts are repeated to remind viewers of the brand and product. Why is the same thing repeated over and over again? The intention, of course, is to make us remember and not forget the product in ques-tion, or for the Ebbinghaus forgetting curve not to drop steeply, but instead to stay in the upper 80%.

5. Discussion and Reflection on Written Exams in our Academic Institutions in the Light of the Results of the Ebbinghaus Experiment

5.1 Can the Current Written Exam be Streamlined?

The question is whether the results of Ebbinghaus' discovery have been overlooked out of tradition and habit, and whether we have therefore been content to check learnt knowledge on only one occasion. It does not seem entirely convincing that the current knowledge control in our academic institutions is based on science. The intention to investigate and clarify how to implement a more effective knowledge control and to strive to allow the student to retain most of the learned knowledge cannot be emphasised enough. If the approach to knowledge control is appropriately modified, the efficiency of retained knowledge over time would be greatly improved.

5.2 Questions Emphasising Increased Scientificly in Written Exams Should be discussed

- How can the academic knowledge management process, including preparation, implementation and follow-up, be improved and made more efficient by moving away from current analogue procedures to digital ones?
- What theories of learning psychology support the view that existing approaches to academic writing assessment are adequate and promote long-term learning?
- If the statement in point 2 cannot be fulfilled, what theories of learning psychology support the view that existing approaches to academic written knowledge assessment should be changed and improved with an emphasis on long-term retention of what has been learnt?

6. A Proposal for a First Comparative Experiment Between the old and the new

Of further interest is to have a larger group of students, 100 students. The group is randomly divided into two parts, where one group follows the traditional way of examining by doing a regular exam and those who 'do not pass' do a re-exam after 14 days. The other group takes a regular written exam on the course. The day after the regular exam is taken, the second group of students takes a first re-test one day after the regular exam, where the exam questions are presented in the form of multiple-choice questions in the same way as in the university entrance exam. Thereafter, two more re-exams with multiple choice questions are given a few days apart. The last and fourth re-tests are given in the traditional form, i.e. students answer in writing. The number of days needed for the latter option is proposed to be 5 days. The fourth re-examination is proposed to be the same as the re-examination of the regular written examination. To facilitate management, a digital e-examination system is used, where all manage-ment including planning, execution and follow-up is done digitally. One month later,

the entire student group, 100 students, undergoes a new written multiple-choice exam, where it is possible to compare the results.

7. Impact of the Introduction of the new Approach

With the proposed approach, each course is extended by one week, i.e. each 5-week course is extended to a 6-week course. For each new 6-week course, one week is lost. Compared to the number of 5-week courses in an academic year, which includes 8 5-week courses, moving to 6-week courses in an academic year, which in this case includes 40 weeks, results in the loss of one 5-week course. In the academic year of the new proposal, the knowledge content is reduced by the equivalent of 5 weeks, while in return, as shown above, students remember significantly more than they would have done under the old approach. More specifically, the student remembers 20% of the knowledge material from 8 x 5 week courses, i.e. 0.20 x 8 x 5 = 8 weeks of knowledge material. Knowledge material corresponding to 40 weeks of study has been reduced to 8 weeks of study. If, on the other hand, the student gets a memory certification, the corresponding memory material is 0.8 x 6.7 x 6 = 32.16 ≈ 32 weeks of knowledge material. The comparison between 8 and 32 weeks of study is significant.

However, there is every reason to consider the major difference in knowledge acquisition, namely 24 weeks of knowledge material. Even if we allow 20% and 80% to approach each other, say 30% and 70%, the difference becomes very large.

There is therefore a strong case for exploring the possibility of memory certification of knowledge tests in higher education institutions. Academic institutions that are the first to implement this approach will have a particularly strong competitive advantage.

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Introducing a Method for Reducing Time Loss in Knowledge Work

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Abstract: Time loss and its reduction have been widely studied and practiced in production work, with significant contributions from Taylor's "scientific management" in the USA, activity sampling in the UK, and the comprehensive approach seen with REFA in Germany. Today, the need to improve productivity and efficiency is also recognized in knowledge work (non-algorithmic office work). However, there is limited published research on time loss in this domain. Key factors contributing to time loss include interruptions and challenges related to information search. Consultant publications often highlight problematic emails and meetings as well. We have developed two methods for studying time loss in knowledge work: time studies using a tailored daily diary, and MyTimeLoss®, which involves the daily recording of loss events via loss cards. MyTimeLoss® is based on six (or seven) loss classes, encompassing 53 (or 61) specific loss reasons (or codes). Participants can record loss events using loss cards, available on both office and mobile devices. Both methods are bottom-up, relying on participant judgment, with participants encouraged to suggest actions for addressing identified time losses. Our practical studies, conducted over more than 10 years in several companies and hundreds of teams, demonstrate that time loss in knowledge work can be reduced through focused improvement actions that target the root causes of the biggest time losses. These changes can be implemented as a one-time project or as part of continuous improvement (CI) initiatives. The results are validated through repeated measurements—specifically, the reduction of previously identified time losses—and through feedback from individuals and teams. The benefits to organizations include increased net working time for knowledge workers, leading to various positive business outcomes. Participants also report less frustration, greater empowerment, and improved motivation. We believe it is time to implement large-scale time loss reduction in knowledge work across both the private and public sectors. We conclude the paper by discussing the implications of our approach for knowledge management research and practice.

Keywords: Time loss, Knowledge work, Time study, Loss card, Knowledge management in practice

1. Introduction

Time loss and its reduction have been widely studied and practiced in production work, with significant historical contributions from Taylor's "Scientific management" (Taylor 1911) and Gilbreth's Motion study (Gilbreth 1912) in the USA, Activity sampling in the UK (Tippett 1953), and the comprehensive "Rationalization" approach presented by REFA in Germany. Today, the production development concepts and tools are typically presented the umbrella of Industrial Engineering (IE), for example, the "30 standard methods of IE" (REFA, 2015). The original idea of all these methods was to deploy experts using principles and methods defined and defining the "one best way". However, in our approach, knowledge work is not studied and optimized by an outside expert. The knowledge workers themselves have always an active role in time loss identification as well as in improvements (Figure 1).

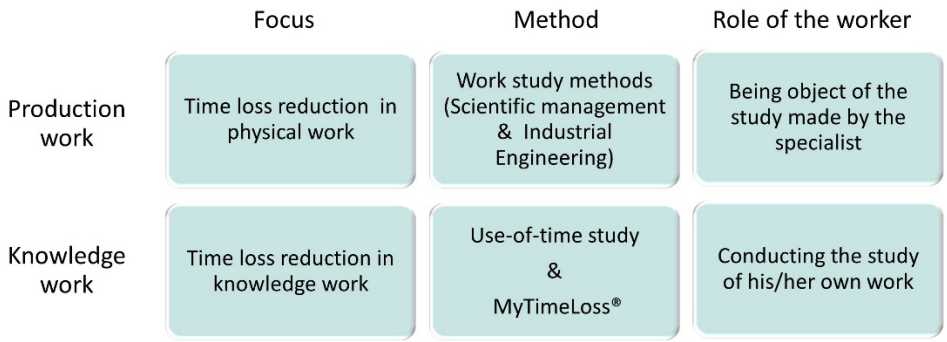


Figure 1: Time loss reduction in production vs. knowledge work

As Peter Drucker summarized, "the most important contribution of management in the 20th century was the fifty-fold increase in the productivity of the manual worker in manufacturing using these methods" (Drucker

1999, p.79). And then he continues setting the new challenge: “The most important contribution management needs to make in the 21st century is similarly to increase the productivity of knowledge work and knowledge workers" (Drucker 1999, p.79).

The term “knowledge worker” was introduced by Peter Drucker in 1959. In a later benchmark article, he refers to “technologists”—i.e., workers performing “both knowledge work *and* manual work”—as “the single biggest group of knowledge workers,” also noting that “they may also be the fastest-growing group” (Drucker 1999, p. 88). His examples include surgeons, nurses, lab technicians, and telecom installers. Other examples he mentions are teachers, salespersons, and computer operators (Drucker, 1999). We share his view on the scope of knowledge work and knowledge workers.

Today, the need to improve productivity and efficiency of white-collar work is becoming widely recognised. However, there is limited published research on time loss in this domain. Especially studies and publications sponsored by office and communication solutions suppliers particularly highlight the harmful role of interruptions (Spira and Goldes 2007). A positive impact of reduced disturbances has also been found in working from a home-office (Van der Meulen, Van Baalen and Van Heck 2012). The losses related to problems in information search appear in reports sponsored by software companies providing solutions for efficient information search (Starmind 2025). Consultant publications often emphasize problematic emails and meetings as well. All these four topics - and many more- are covered by our MyTimeLoss® method.

By *productivity,* we refer to the relationship between the output’s *quantity and quality*, and the knowledge worker’s working time. For an insightful elaboration on productivity in knowledge work see Erne 2011. This relation is typically depending on the level of the methods, processes and tools used. Thus, all *practical improvements* to methods, processes and tools are essential for true productivity development. For example, process improvements suggested by participants in our studies. Another frequent example are tools modifications done by specialists based on specific feedback of knowledge workers.

With *efficiency* we understand the degree to which the knowledge worker can reach the maximum productivity using the current methods and tools available. Typical efficiency loss is happening through various time losses.

Time loss happens whenever the knowledge worker cannot complete her/his professional task according to the planned process or if process/method contains extra or unproductive work that could be reduced with improvement actions. The knowledge worker typically recognises problems and inefficiencies, causing part of the effort being wasted. The work does not flow as it could.

We have encountered consequences of two frequent action lines (among others). Firstly, reducing personnel by merging tasks does not automatically lead to improved efficiency or productivity. In many cases, we have seen the opposite effect. For example, when support or preparation activities are shifted to the remaining knowledge workers, it can cause time loss and a deterioration in efficiency and productivity due to the adaptation of more “casual” ways of working and reducing the quality of output. Secondly, considerable IT investments aimed at significant cost reductions of operations (by increasing productivity) have sometimes failed to meet their targets – even resulting in the opposite outcome. These disappointments could have been avoided by implementing the time loss framework as part of the IT development process.

2. Our two Methods for Studying Time Loss in Knowledge Work

2.1 Use-of-time Study

2.1.1 Idea and background

Since the 1980s, we have used various forms and templates asking knowledge workers to record their use of time on rough level weekly and daily. The target has typically been to identify how much time (or what percentage of nominal capacity) is spent on certain critical activities. For example, how little do engineers in R&D department really make development work and how much technical support and administrative activities.

However, for more than 10 years we have used a more precise tool for daily recording of all kinds of activities during the workday. The need has come through industrial companies facing the challenge to manage their costs while the “fix costs” of white-collar work force have gained proportionally more importance.

2.1.2 Description of the method

First a dedicated *activity list* is compiled covering all work-related activities of the professional group to be studied. This is normally done involving a few experienced group representatives. The activity list differentiates

between *core job activities* and other activities. Core job is defined as the professional work, for which a person has been hired to the company (and the customer is paying for) i.e. the core of her/his creating value. Decision of what to include in core job is done together by management and the group representatives.

The activity list is then set up in a bespoke Excel template. For each working day in the time study every participant describes her/his activities indicating the time used and any time loss observed using one Excel sheet per day. Lunchbreaks, medical appointments, and similar personal time are excluded. Participants are asked to split their daily work to 10-20 different activities.

2.1.3 Conducting a use-of-time study

Proper initial training - including a trial day with personal feedback - has proven essential. It is also important that the participants get information about the purpose of the study and how their personal intimacy is protected. Management commitment and support is essential to communicate. Recognition and celebration of successful loss reduction actions supports the motivation to contribute. Motivated knowledge workers provide highly useful quality responses!

The study periods vary typically between 1-4 weeks and frequent personal feedback during the study has proven to greatly improve the quality of collected data. A period representative of the working year (or other time span) of the professional group is chosen. E.g. for controllers end and beginning of a month.

Results can be analysed using Pareto analysis, distribution diagrams and charts, waterfall diagrams, and other tools to identify the most important improvement opportunities for actions. As consultants we have often helped in the beginning to make these basic analyses. We have also helped to set up lists of action candidates. Team involvement in selecting the actions further improves their commitment to the method and its systematic use. For the management, the availability of quantitative data is important for justifying and allocating resources for improvement projects.

Often, a clever way for an organization has been to begin time studies and improvements with a *pilot group*. Based on the experiences and learning, the approach has then been extended to other groups of knowledge workers.

2.1.4 Results from use-of-time studies

We have been recording for hundreds of teams in various countries the following kinds of values:

- Core job 30-80% of total work time, typically about 60% (non-core activities 20-70 %).
- Time loss 10-40% of total work time typically about 20%.
- Practical improvement suggestions for 10-20% of the time loss registrations.

Thus, often the fully realistic potential to increase share of net working time available for the knowledge worker is concluded 1-1,5 days per week. In many cases this has been reached with either separate projects or continuous (incremental) improvements.

2.2 MyTimeLoss® Method

2.2.1 Idea, background and development

During our consultant work with various organisations, we received suggestions to develop a tool usable with mobile devices for recording time loss events - *Loss cards*. We have also a long history of implementing *War Room* type of *Continuous Improvement* method based on daily recording of loss events as physical loss cards in production environments and expanding to other functions. The loss registration has been working well over many years the longest lifetimes being now close to 15 years. Thus, the idea to develop a tool for “digital loss cards” was born.

2.2.2 Structure of MyTimeLoss®

We analysed all our previous studies (most of which were conducted as use-of-time studies). Classifying the time losses identified we concluded six general *Loss Classes* which can be seen in figure 2. The six loss classes encompass 53 specific *Loss Reasons*, all of which are based on results in our studies. All loss reasons have real life examples based on knowledge workers’ time study responses (Figure 3). The basic structure is always the same for all users. However, there are optional Key Words, which can be added for any group and/or organization.

Our ambition is to cover as 7th Loss class the Contact Work. This includes preliminarily in our tool 8 specific loss reasons. Contact Work refers to time losses occurring in contexts such as health care appointments, teaching engagements or issues arising during sales interactions.



Figure 2: Loss Classes

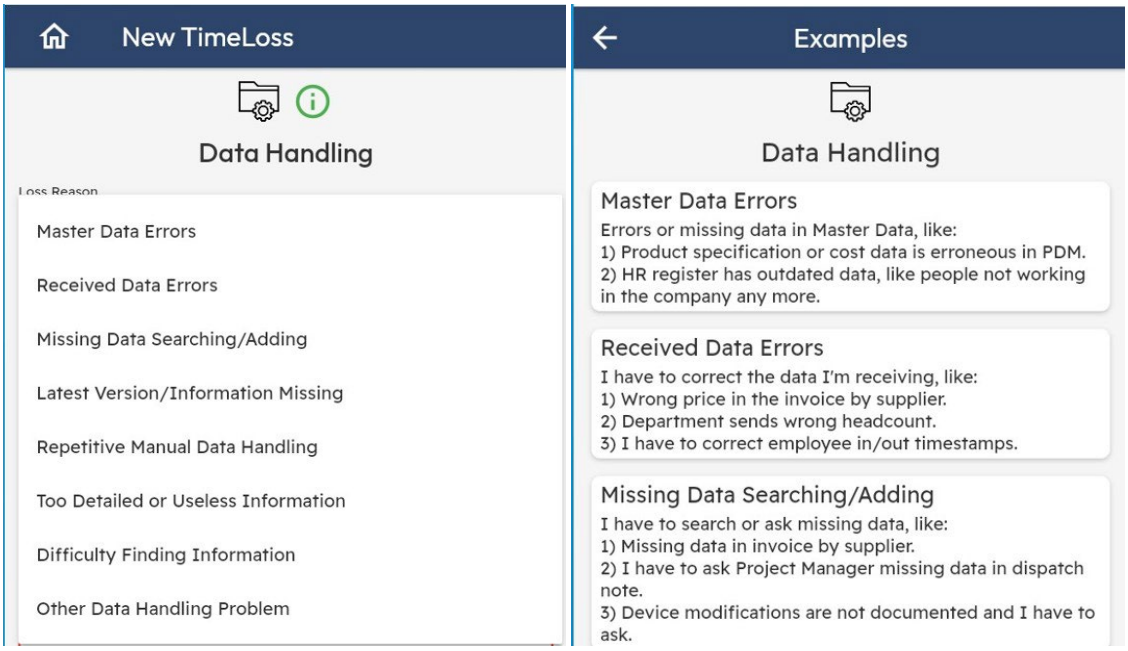


Figure 3: Example of Reason Codes and real-life Examples for Data Handling Loss Class

2.2.3 Using MyTimeLoss®

Like in time studies it is important that MyTimeLoss® users know why it is deployed in the organization. All loss cards are registered with participant names and are visible within the organization. Therefore, respect and trust are essential for superior results – both in loss and action idea registration and implementation of improvements.

Instruction videos are available for tutorials. Some organizations have preferred to use initial training like for use-of-time studies.

It is also possible to use MyTimeLoss® only by an individual for her/his personal job reflection and development.

Knowledge workers register loss events in their daily work either for a specific period(s) or continuously. The registration includes selecting the proper Loss Class and Loss Reason as well as showing the amount of lost time

(Figures 3 and 4). It is also requested to provide a brief description of the loss event and suggest an action for improvement (if on top of the mind). Knowledge workers can also highlight particularly frustrating loss events by marking them with a *Red Flag*. In case the team and/or organization has agreed key words the most appropriate is also selected.

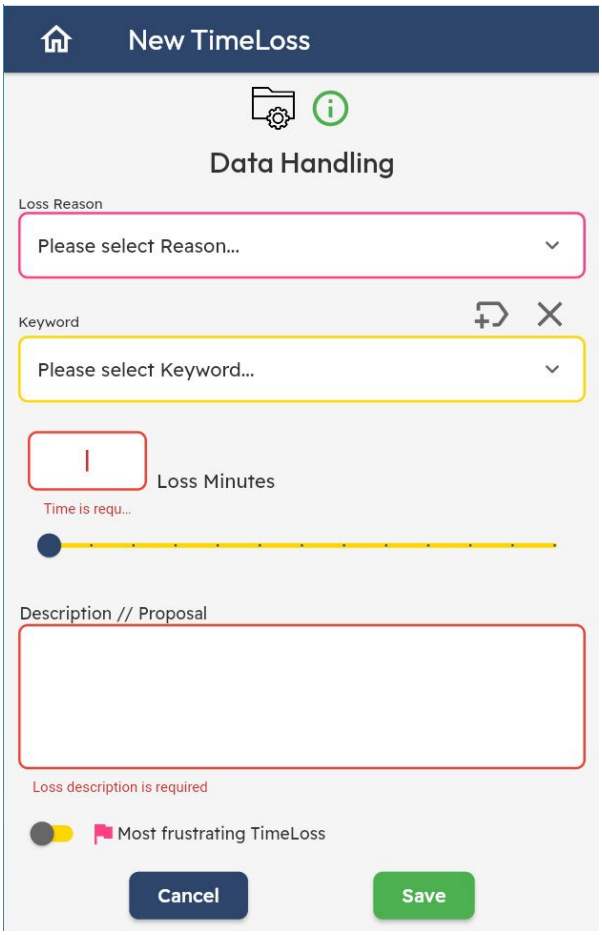


Figure 4: Time Loss Data input by participants

2.2.4 Optional AI suggestions

MyTimeLoss® has optional AI tool (MyTimeLoss Assistant) for providing comments and suggestions in case the participant wants to use it. The first option for a person is to ask feedback of her/his loss registration activity and coverage of different loss classes. The second option is to ask the assistant suggestions for actions concerning the losses accumulated in Paretos.

At the moment we have noticed that individuals who are familiar with use of AI and use it frequently for other purposes also tend to check at least sporadically AI comments. However also many users do not use the option.

2.2.5 Results from MyTimeLoss® studies

The teams and individuals using the method have provided the following kinds of results:

- Time loss accounted for 10-30% of total work time (somewhat lower than for use-of-time studies, which require more detailed recording of participants' daily activities).
- Practical improvement suggestions were made for 10-70% of registered losses (clearly more than in use-of-time studies).
- "Red flags", which mark particularly frustrating time losses, were attached to 5-25% of registered loss events (not part of the use-of-time study method).

The results show a realistic potential to reduce/eliminate time loss, increasing the net working time available to knowledge workers by 0.5 to over 1 day per week.

For action purposes MyTimeLoss® provides built-in Pareto distributions (Figure 5). The Paretos can be easily viewed based on loss classes or reasons on one hand and on key words on the other hand. Drilling down into the largest loss(es) provides easily sufficient detail for effective action planning (Figure 6). Action ideas recorded on the loss cards can be accessed directly or through separate Excel-based analysis.

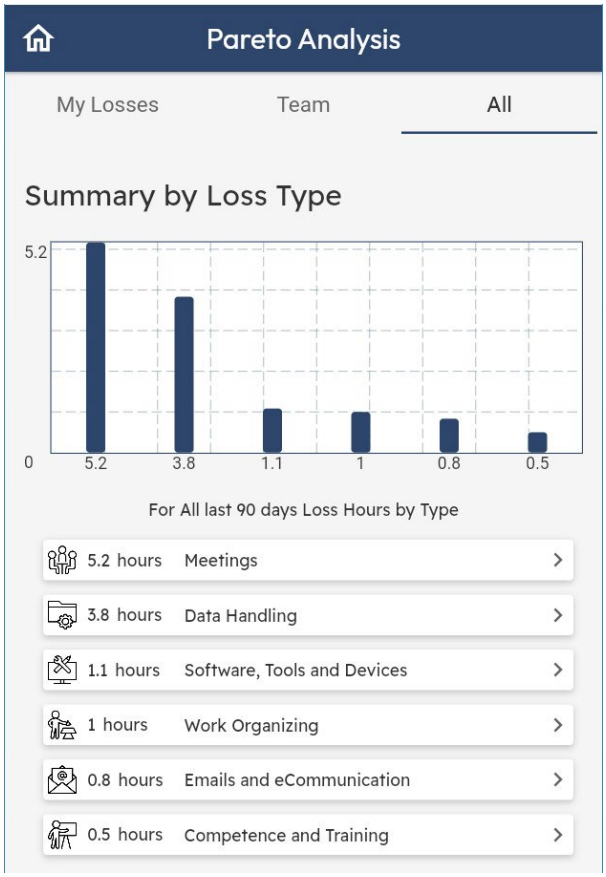


Figure 5: Example of a main Pareto by Loss Classes

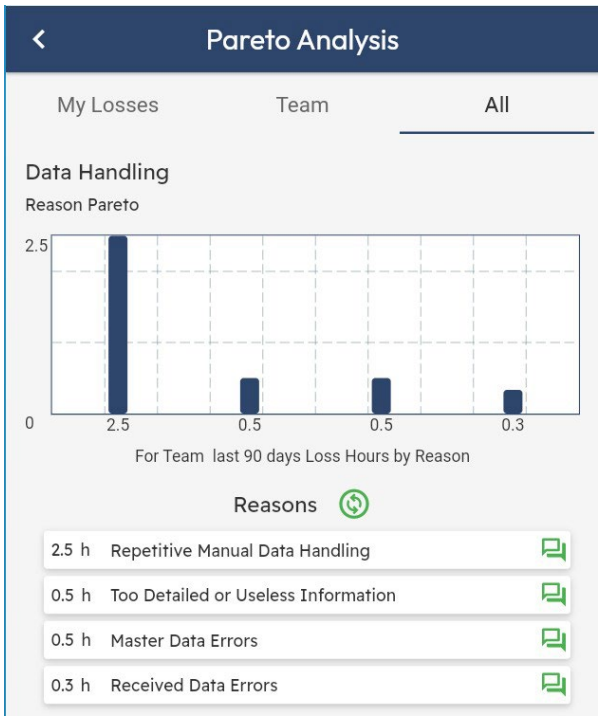


Figure 6: Example of a detail Pareto by Loss Reason

3. Results in Organizations

3.1 Organising Improvement Actions

3.1.1 One-time projects

We have experience in several companies of making first a study to map the initial potential (starting point). Then a number of projects is planned and executed addressing the top and medium size time losses as well as sometimes some "minor quick wins". Later, a second measurement is done validating the achievements and discovering the next time losses to be acted upon. Sometimes this has been repeated even a third time.

3.1.2 Continuous Improvement (CI)

Companies where loss cards are registered continuously (or repeatedly multiple times a year) have been utilising Continuous Improvement (CI) approach (Figure 7). The idea has been to use appropriate models for types of improvement projects – e.g. 2-Step or 4-Step. Sometimes this has been anchored to corporate annual target setting by having number of completed projects and annualised cumulative time loss reduction as quantified targets for Units. Even including real-time follow-up and internal benchmarking in company intranet.

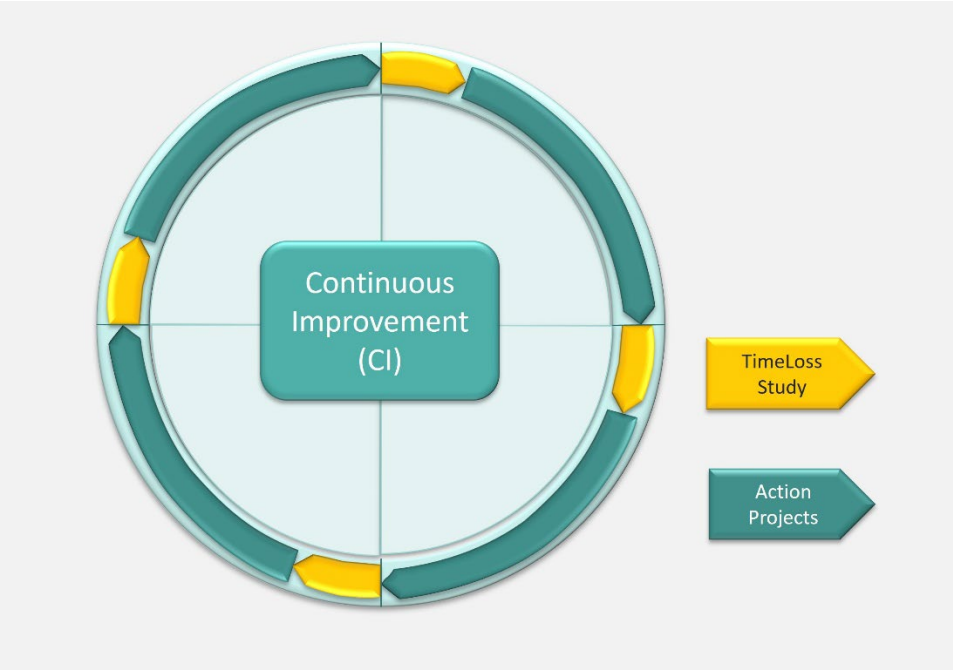


Figure 7: Continuous Improvement (CI) annual cycle with time loss measurement periods

3.2 Results Achieved

3.2.1 Reduction of time loss

Results using one-time-projects for teams (time span in teams and companies 1-2 years):

- Time loss reduction 5-75 % for teams and 5-20 % for companies (re-measurements 1-3 times).
- Typically, 20-80% of the identified improvement potential has been achieved.

Results using loss cards and Continuous Improvement (CI) approach:

- Time loss reduction annually over several years 2-25% for teams and around 3-5% annually for whole companies.
- Typically, 20-80% of the identified improvement potential has been achieved.

When using the CI approach, the impact of the improvement actions is verified through diminishing of specific loss cards, due to the root cause actions.

Interestingly, Peter Drucker is calculating the 50-fold productivity improvement of manual worker based on "rate of 3% per annum compound—which means it has been risen fifty-fold since Taylor" (Drucker 1999).

3.2.2 Focus on core job

Results using one-time-projects (conducted over 1-2 years within teams and companies):

- The share of core job activities improved by 5-40%, reaching up to 80-90% in some cases, with 1-3 re-measurements).
- Typically, 25-80% of the identified improvement potential has been achieved.

The ratio of core to non-core job activities is not directly measured in MyTimeLoss® or other loss card-based methods.

3.2.3 Well-being and motivation of participants

As consultants we always organise feedback meetings (communication) of study findings and action priorities and possibilities. Participants often express appreciation for "being listened to" and for the opportunity to initiate practical improvements in their daily work. Turning useless complaints into systematic data collection followed by actions to remove sources of frustration, is typically received positively. People report experiencing less frustration and greater motivation.

3.2.4 Observations by managers

Time studies have provided many managers with a feasible way to know better the daily activities and problems of their teams. Both activity focuses and time losses for different team members and different professional roles/subgroups are fundamental in improving the division of labour, balancing capacities, removing bottlenecks, improving tools and their usage as well as setting personal development goals (together with individuals). Managers taking part themselves in our studies often note that they learn to recognise time loss in their own work and observe similar learning processes among their teams and colleagues.

3.2.5 Experiences from start-up companies and more mature organisations

Start-up companies tend to work in a more situational and "inspirational" manner than more mature, organisations, with less fixed roles, responsibilities, processes and tools. Start-ups can however also benefit mapping and acting upon their time losses with MyTimeLoss®. Obviously the Paretos, Red flags and action ideas show points for improvement to provide more of the valuable knowledge workers' net time for growth. Improvements to tools, processes and personnel competencies can often be simpler, more straightforward and faster to implement.

3.2.6 Learning to see

Perhaps the most valuable outcome is that individuals become more aware of how they use their time, learn to recognise time loss in their own work and also in and between their teams. Time loss becomes a topic to discuss during lunch or coffee break among colleagues and with managers. A proactive, preventative mindset also begins to grow. These organizations can thus achieve a big competitive advantage.

3.2.7 DIKW reflection

In the process of using MyTimeLoss® method, time loss *data* registered is transformed into *information* by loss classification, reason coding, key word tagging and systematic description. The information is then analysed using Pareto analyses across multiple levels and timespans, uncovering patterns, trends, and relationships. The resulting insights provide *knowledge* for all stakeholders of why and how the time loss phenomena occur. This, in turn, enables and encourages an organizational culture of continuous improvement, supporting both corrective and preventive actions related to time loss among knowledge workers. This *wisdom* cannot simply be copied across companies and organizations; it can only be achieved by progressing through the Data–Information–Knowledge–Wisdom (DIKW) steps.

4. Conclusion

Identifying time loss in knowledge work - by managers, engineers, controllers, researchers, nurses, teachers, and other knowledge workers themselves - enables its reduction and, in some cases, its complete elimination. The frustrations experienced - when work is not flowing as it should – disappear, allowing motivation and the working atmosphere to improve. There is time loss in every organisation in knowledge workers' daily activities. Conducting time loss studies before, during, and after major IT investments—such as in Document Management (DM) systems, R&D software, or ERP systems—can significantly accelerate and, in many cases, ensure the

realisation of the intended productivity gains. Obviously, we consider this to be a win-win between customers, suppliers, organisations and knowledge workers.

The results we have presented stem from a structured series of steps. Firstly - like for the industrial pioneers developing the physical work study in last centuries – it is important to take a realistic "photograph" of the work. Today this is done with the motivated knowledge worker. The principle of "garbage in, garbage out" has never been worthwhile—and never will be. Secondly the data must be analysed. Pareto distributions of loss time and frequency on different levels show the top losses. Thirdly the root causes of top losses must be analysed, actions planned and executed, results measured and validated. This is common way for both one-time projects and CI. In both cases there must be adequate resources deployed to solve the root-causes of the losses in a limited time. From our experience, we recommend that organisations limit the number of concurrent improvement projects. The individual projects should typically not last more than 3-4 months.

To cover properly the work of medical doctors and other health care experts, teachers, salespersons, and others using essential part of their time in contact with one or several persons, we are developing the contents of *Contact Work* as 7th Loss Class. We are looking forward to co-operation with all interested academic or public/private sector actors.

Our contribution is a non-academic one. We are aware of the pioneering character of our pursuit. There is certainly need for fundamental academic research in Knowledge Management field on this topic. We welcome research on time loss in different professions and on "toolboxes" for effective improvement actions in certain typical time loss situations. We believe, that now is the time to implement large-scale time loss reduction in knowledge work across both the public and private sectors.

Time loss is a happy thing!

Ethics declaration: We hereby declare that this conference paper is our own work and that all sources used have been acknowledged. We have not copied or used unauthorized assistance. In all data collection ethical standards were followed, including consent and confidentiality.

AI declaration: We acknowledge the use of MS Word and ChatGPT for intermediate grammar and spell-checking. All final content of this conference paper was reviewed and edited in all details by us.

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Figures of Speech: Boosting Tacit Knowledge Externalization in Projects

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Abstract: "Using the process of Externalization, subjective tacit knowledge based on experience is converted into objective explicit knowledge" (Tiwana, 2002). Externalization is the most difficult process to put into practice. "It is a quintessential knowledge-creation process in that tacit knowledge becomes explicit, taking the shapes of metaphors, analogies, concepts, hypotheses or models" (Nonaka Takeuchi, 1995). "Tacit knowledge, by its nature, it's hard to articulate through analytical methods of deduction and induction" (Villa, 2023). Literal language uses words in their most basic sense for conveying information clearly and directly. Although literal language is straightforward and factual, it nevertheless proves limited in uncovering tacit knowledge. Literal language can describe the tip of the iceberg, ignoring the iceberg. While literal language conveys the exact meaning of words, figurative language conveys a deeper more imaginative meaning. Thus, figurative language should be used for uncovering the iceberg. Figures of speech are linguistic tools used to convey meaning and enhance the impact of language by deviating from the literal interpretation of words. They add richness and depth to writing, depicting something in a non-literal way, evoking emotions, painting vivid pictures, highlighting the essence of a personal experience, conveying a concept in a tasty fragrant way, avoiding time-consuming details. An appropriate metaphor is worth much more than a thousand words! This paper is aimed at discussing in a very practical way the application of a set of figures of speech for boosting the externalization of tacit knowledge in projectized environments. First of all, each figure of speech is briefly explained in terms of meaning, purpose, and application. Then benefits deriving from figures of speech are discussed. Similarly, the obstacles to use the figures of speech in a shared and effective manner. Finally, some advices are provided to project key roles, such as project manager, subject matter experts, agile coach, in order to become more familiar with figures of speech in projects. This way, figures of speech can effectively bridge knowledge management and project management, enhancing project success and personal development.

Keywords: Tacit knowledge, Knowledge externalization, Literal language, Figurative language, Figures of speech, Learning history

1. Sketching the Scene

We can open the paper with a learning history. "Learning history is a written narrative of a company's recent set of critical episodes" (Kleiner Roth, 1998). "A good story is often the best way to convey meaningful knowledge" (Davenport Prusak, 1998). "Successful knowledge-sharing examples are gathered and documented in the form of lessons learned and best practices and these then form the kernel of organizational stories" (Dalkir, 2011). Imagine we are in a large agile project to be executed with a fractal organization based on five distributed development teams (seven people each). We decide to manage the project using the scaled approach "SoS - Scrum of Scrums" also known as "Meta Scrum". SoS necessarily requires to run some mandatory ceremonies including sprint retrospective. A sprint retrospective is a meeting held at the end of a sprint (aka "iteration"), typically every two weeks. "The purpose of Sprint Retrospective is to plan ways to increase quality and effectiveness. The Scrum Team inspects how the last Sprint went with regards to individuals, interactions, processes, tools, and their Definition of Done. Assumptions that led them astray are identified and their origins explored. The Scrum Team discusses what went well during the Sprint, what problems it encountered, and how those problems were (or were not) solved. The Scrum Team identifies the most helpful changes to improve its effectiveness" (Schwaber Sutherland, 2020). Sprint retrospective is based on the twelfth principle of Agile Manifesto: "At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behavior accordingly" (Authors of agile manifesto, 2001). Sprint retrospective can be performed physically in presence or remotely. In both cases, sprint retrospective requires a live synchronous interaction. Sprint retrospective is a powerful opportunity for sharing knowledge, according to a continuous improvement perspective. However, sprint retrospective might be unproductive with participants discussing but not going into things and simply exchanging obvious considerations. In short: "much ado about nothing!". Scrum retrospective is focused on process and people. During this meeting, the agile team (product owner and development team members) reflects on the past sprint to identify what went well, what didn't, what can be done differently, and how processes and behaviors can be improved. The goal is to create an action plan for implementing improvements as needed. Effective sprint retrospectives require agile team members to communicate openly, provide constructive feedback, listen actively, collaborate, reflect, commit to improvement, be accountable, show empathy, maintain transparency, and keep a positive attitude. These behaviors foster a productive and supportive environment where continuous improvement can thrive. Coming back to the case history, each of

the five teams must hold its own local retrospective and then a summary retrospective must be held among the representatives of the five teams. Individuals (35 in total) have different levels of experience and mastery about the sprint retrospective ceremony, within the same team and among teams. Thus, tacit knowledge gained by each individual participating in sprint retrospectives, should be shared as much as possible in the most effective way, in order to better perform the next retrospectives. How to share my tacit knowledge distilling which way a retrospective should be experienced? A hyperbole could be the winning card. Hyperbole is a figure of speech that entails deliberate and obvious exaggeration used for emphasizing the magnitude of the topic in question. It doesn't must be taken literally but it should be used for creating a strong impression or adding dramatic effect to a key point. Speaking about projects, hyperbole should be used in the collective moments of the project life cycle during which people are called to share a common mindset and meaning of things. On the one hand, the application of hyperbole in managing projects can foster these benefits: emphasize key points, motivate and inspire the team, introduce humour, enhance clarity and impact, and encourage creativity. These benefits contribute to a more dynamic and effective project management environment. On the other hand, the application of hyperbole in managing projects might cope with some obstacles and try to limit these negative effects: misinterpretation, loss of credibility, desensitization, cultural misunderstandings, and undermining the seriousness of critical situations. For example, Misinterpretation: "We need to work 24/7 to meet this mandatory deadline!". This hyperbole might be taken as a literal requirement rather than an emphasis on urgency, creating confusion, demotivation, sense of inadequacy, fear within the project team. Coming back to the case history, this may be a powerful hyperbole for depicting the deep essence of the sprint retrospective: "Some drops of blood must flow during the sprint retrospective". It's an amplified way of emphasizing the intensity and honesty required during a sprint retrospective. This hyperbole emphasizes the need for intense, honest, and sometimes uncomfortable discussions to drive meaningful improvements. It highlights the importance of facing conflicts directly and being committed to the process of continuous improvement, even if it involves difficult conversations, moving away the comfort zone before the point of no return. In summary, "Better to shed a few drops of blood today, than to bleed ourselves dry tomorrow".

2. The Figures of Speech for the Externalization of Tacit Knowledge in Projects

There are a lot of figures of speech. It's generally accepted that there are approximately 200 to 300 distinct figures of speech. This range includes both commonly used figures and least known ones. For the purpose of this paper a set of eight figures of speech will be discussed. They are: 1) hyperbole (already described in chapter 1 of this paper), 2) metaphor, 3) simile, 4) oxymoron, 5) imagery, 6) paradox, 7) personification, 8) euphemism. These figures are relevant to projectized environments, particularly during early stages of new product development. *"New knowledge was created based on discussions in a collaborative design workshop and stories and metaphors were important mechanisms for this"* (Sakellariou Karantinou Goffin, 2017).

3. Figure of Speech n.2 – Metaphor

Metaphor is a figure of speech that entails the comparison of two unlike things by stating that one thing is another, thereby highlighting an assonance between them, directly equating the two elements. Therefore, in a metaphor a word or phrase is applied to a subject, object or action to which it is not literally applicable. The purpose of a metaphor is to create a vivid image or to convey a concept in a more or impactful way. Speaking about projects, we can discuss this metaphor: *"Product Owner is Janus Bifrons".* Who is Janus Bifrons? Janus Bifrons is a figure from Roman mythology. Janus is the god of beginnings, gates, transitions, time, duality, doorways, passages, and endings. He is usually depicted as having two faces, one looking to one direction (the future) and the other one to the opposite direction (the past), symbolizing his ability to see both forward and backward in time, making him a central figure in rituals and ceremonies related to beginnings and endings. Who is the Product Owner? The Product Owner in an agile environment is a crucial role responsible for maximizing the value of the product resulting from the work of the development team(s). This role represents the voice of the customer and ensures that the team(s) delivers value to the business. The Product Owner conveys the product vision and goals to the team(s) and is accountable for creating and prioritizing the product backlog. Why Product Owner is Janus Bifrons? Janus Bifrons, with his two faces looking both forward and backward, symbolizes the duality and transitions that are central to the Product Owner's responsibilities. More in depth: a) like Janus, the Product Owner looks forward to the future, defining the product vision and strategy to guide the development team. At the same time, Product Owner looks backward, considering past feedback and performance to refine and improve the product; b) Product Owner, on the one hand, must discover needs and expectations of various stakeholders, business owners first of all, on the other hand he/she must clarify requirements to development team(s) and discuss and regularly validate product increments. Similarly to how

Janus oversees transitions and dualities, Product Owner ensures that the product backlog reflects both immediate priorities and long-term goals; c) Janus is the god of transitions, and the Product Owner facilitates the transition of ideas from concept to implementation based on timeboxed iterations. The metaphor should foster the following benefits: Clarity in that it helps team members and stakeholders to understand the dual nature of the Product Owner's responsibilities; Engagement in that it depicts a vivid and memorable image that can make this role more recognized and played; Focus in that it underlines the importance of looking both forward and backward to ensure continuous improvement and alignment with the product vision. However, the metaphor might cope with these potential obstacles and negative effects: Ignorance in that some agile team members might not be familiar with Janus Bifrons, leading to confusion; Cultural relevance in that this metaphor may not fit with all cultural contexts, potentially limiting its effectiveness if not even offend cultural values; Over-Simplification in that while this metaphor can clarify the essence of the role, it might oversimplify complex responsibilities and nuances. Summing-up, metaphors are strongly suggested in projectized situations for explaining complex concepts or roles, aligning team vision, highlighting challenges, and facilitating change management.

4. Figure of Speech n.3 – Simile

Simile is a figure of speech that compares two different things using the words "like" or "as" to highlight a similarity between them. Similes are used to make descriptions more pregnant by drawing parallels between the unfamiliar and the familiar. The purpose of a simile is to clarify a concept by underlining similarities between two different things that are very distant in reality but have a red thread that links them. *"Like a fish out of water"* (someone who is uncomfortable or out of place in a particular situation) and *"As clear as crystal"* (clarity of something, comparing it to the transparency of crystal) are common examples of similes. Speaking about projects, we can discuss this simile: *"Working in high-performing agile team it's like being in a beehive with many other hardworking bees filling the cells with honey".* It draws a bright comparison between the collaborative and industrious nature of a high-performing agile team and the organized, efficient work of bees in a beehive. This simile points out some key peculiarities. Collaboration: just as bees work together harmoniously to fill the cells with honey, team members in an agile team collaborate closely to create product increments in timeboxed sprints (iterations). At the end of each sprint a product increment is carried out, such as some cells are filled with honey; Efficiency: Bees are known for their efficiency and productivity, mirroring how agile teams strive to deliver high-quality product increments frequently and effectively; Role Specialization: in a beehive, each bee has a specific role, similar to how agile teams have defined roles, responsibilities, way of working that contribute to the overall performance of the sprint; Continuous Improvement: Bees continuously work to maintain and improve the hive, just as agile teams focus on iterative development and continuous improvement. The simile should foster the following benefits: Enhanced Understanding in that simile helps team members and stakeholders to visualize the collaborative and productive nature of a high-performing agile team; Increased Engagement in that the bright imagery of a beehive can make the concept more engaging and memorable; Improved Motivation in that comparing the agile team to hardworking bees can inspire and motivate team members to work diligently and collaboratively for carrying out the precious honey. However, the simile might cope with these potential obstacles and negative effects: Misinterpretation in that some team members might not fully understand the comparison if they are not familiar with the behavior of bees; Cultural Sensitivity in that simile often rely on culturally specific references that may not translate well across cross-culture teams. What is a common and easily understood comparison in one culture might be confusing or meaningless in another. If the audience is not familiar with the topic, the simile can fail to convey the intended meaning or create confusion. Summing-up, similes are strongly suggested in projectized situations to make people identify with a positive, rewarding, motivating, appreciated situation or to warn them of a negative, penalizing, demotivating, unseemly situation. Also, when a change of mindset is required to cope with project challenges, forcing people out their comfort zone and consolidated habits.

5. Figure of Speech n.4 – Oxymoron

Oxymoron is a figure of speech in which contradictory terms appear in conjunction. Oxymorons are used to reveal a deeper truth, to create a dramatic effect, to discuss innovative approaches. Thus, highlighting the complexity or duality of a subject. For example, *"Organized chaos"* underlines the balance between creativity and organization. Oxymorons can be effectively used in project management to convey complex ideas, and emphasize the multifaceted nature of a situation. For example*, "Agree to disagree"* can help to recognize differing viewpoints while promoting conflicts resolution in a project team; *"Calculated risk*" can inspire project team to take bold yet thoughtful actions. Speaking about projects, we assume to be in a large project crowded

by a very large number of stakeholders different from each other in terms of specialization, organizations to which they belong, physical location, interests at stake. Indeed, stakeholders are a relevant factor of complexity. A junior project manager asks a senior project manager for advice on how to manage communications with stakeholders. The senior project manager suggests to classify the stakeholders using the Interest/Power Matrix and to pay a great attention to stakeholders with High Interest and Low Power. The senior project manager emphatically declaims this oxymoron: *"Deafening silence".* It highlights the significant interest that these stakeholders have in the project, despite their limited influence. It underlines the importance of listening to their ideas/concerns and ensuring their voices are heard, even if they do not hold substantial power, fostering a more inclusive and attentive project environment. In summary *"no news, bad news".* Oxymorons should foster the following benefits: Enhanced Communication in that it can briefly convey complex ideas and making communication more effective; Humor and Engagement in that it can add a touch of humor, making discussions more engaging and less tense; Creative Thinking in that it asks people to embrace the duality to cope with. However, oxymorons might cope with these potential obstacles and negative effects: Overuse in that excessive use of oxymorons can make communication less serious or professional; Ambiguity in that oxymorons can create ambiguity, making it difficult for team members to understand the exact message; Dilution of Seriousness in that in critical situations, the use of oxymorons might undermine the seriousness of the message, leading to a lack of urgency or importance.

6. Figure of Speech n.5 – Imagery

Imagery is a figure of speech that involves the use of bright mental images for the listener. It helps to paint a picture in mind, visualize scenes, and make the experience more immersive and engaging. Imagery enhances the experience by appealing to the senses and creating vivid mental pictures. There are different types of images depending on the sense you want to activate. These are some types of imagery: Visual Imagery highlights what we see, such as colors, shapes, and appearances: *"The fog was falling thickly over the project requirements"*; Tactile Imagery involves the sense of touch, describing textures and sensations: *"The rough bark of the project sponsor scraped against the skin of project manager"*; Olfactory Imagery relates to smells, evoking the sense of scent: *"The heavy atmosphere that can be felt in project status meetings".* Speaking about projects, "*Beyond the Pillars of Hercules*" is an imagery that can be used effectively for representing risk identification in complex projects. This phrase historically refers to the limits of the known world, symbolized by the Strait of Gibraltar, beyond which lay uncharted territories. In project management, using such imagery can help the project team to uncover risks that may not be immediately visible but could significantly influence project performance and results. It encourages a comprehensive and imaginative approach, helping the project team to explore a broader spectrum of potential risks. This way, the project team may ignore what Hercules wrote on the pillars: *"Nec plus ultra"* (a Latin phrase that translates to "nothing more beyond"). Imagery should be used in project situations such as: risk identification for exploring hidden risks; stakeholder engagement for describing project benefits in appealing terms to gain stakeholder buy-in; team motivation using powerful images to inspire the project team; communication of vision painting a clear picture of the project's end goal to align team efforts. Imagery should foster the following benefits: Enhanced Understanding in that it helps stakeholders and team members visualize complex concepts; Increased Engagement in that it makes communication more engaging and memorable; Improved Creativity in that it stimulates creative thinking and innovative solutions. However, imagery might cope with these potential obstacles and negative effects: Ambiguity in that vague or unclear imagery can lead to confusion and misalignment; Distraction: in that overly elaborated imagery can distract from the main message; Resistance in that some stakeholders may prefer straightforward, data-driven communication over imaginative descriptions.

7. Figure of Speech n.6 – Paradox

Paradox is a figure of speech based on a statement or concept that contradicts itself or clashes intuition and common sense, but it may still hold a fundamental truth. It often challenges our understanding and forces us to think more deeply about the underlying principles. A paradox seems to be self-contradictory statement but, upon closer examination, reveals an underlying truth. Paradoxes can be used to illustrate complex ideas and provoke critical thinking. These are some typical projectized situations where paradoxes should be applied: Matrix Organization inside which the functional dimension provides stability and vertical expertise, while the project dimension drives innovation and change. Recognizing the paradoxical need for both can enhance organizational performance; Leadership Styles when the combination of commanding and participative leadership styles best responds to different project needs and team dynamics. Speaking about projects, a senior project manager wishes to share the tacit knowledge he/she gained managing risks in large, complex, innovative

projects. The paradox that sums up his/her undeniable and precious experience is *"The more risks, the better!"* This paradox can indeed hold valuable insights. At first glance, the paradox seems counterintuitive because risks are generally perceived as threats to project success. However, it suggests that a higher number of risks today can reduce the number of unforeseens and problems tomorrow. This paradox fosters a proactive behaviour against uncertainty, which allows for the early identification of a greater number of risks that feed into the risk register and related management activities (tracking, assessing, responding, monitoring). The paradox should foster the following benefits: Enhanced Critical Thinking in that it encourages team members to think deeply and consider multiple perspectives; Improved Problem-Solving in that it helps in identifying innovative solutions by challenging conventional wisdom; Balanced Decision-Making in that it promotes a holistic view that integrates seemingly opposing strategies for better outcomes. However, the paradox might cope with these potential obstacles and negative effects: Confusion in that paradoxes can be difficult to grasp, leading to confusion among team members; Resistance to Change in that some team members may resist paradoxical thinking, preferring clear-cut solutions; Implementation Challenges in that balancing paradoxical strategies can be complex and may require significant effort and coordination.

8. Figure of Speech n.7 – Personification

Personification is a figure of speech that gives human characteristics to non-human entities, objects or abstract concepts. Personification is used to create emotional connections by making inanimate things relatable to human experiences. Personification is a powerful way to share a more engaging representation of a topic. This way, listeners can better connect to and imagine what the deep meaning of what you are communicating. *"The project never sleeps"* attributes the human quality of needing sleep to a project, which is an inanimate concept. This personification underlines that the project is continuously active and ongoing, without any breaks or downtime, much like a person who never sleeps. The implied meaning is that the project is always in motion, with constant activities, tasks, and progress being made, regardless of the time of day. Speaking about projects, two subject matter experts are sharing their experiences about project estimates and agree that *"The estimates speak to you, listen to them!"* is an excellent personification to reveal their secret in project estimates. This personification underlines the importance of paying close attention to project estimates as they provide critical insights for successful project management. The implied meaning is that numbers are just numbers if we do not document the underlying rationales. Estimates, like cold numbers, can only be bargained while rationales can be negotiated as needed. These are some typical projectized situations where personification should be applied: Stakeholder Communication in that the use of personification in presentations or reports makes complex data more engaging; Team Motivation in that describing project goals or challenges in human terms inspires and motivates team members; Risk Management in that personifying risks makes them more tangible and easier to understand for the team; Change Management in that humanizing abstract concepts like organizational change can help recipients to move from as-is toward to-be. Personification should foster the following benefits: Enhanced Engagement in that it makes communication more engaging and memorable; Emotional Connection in that it helps to create an emotional bond with the audience, making the message more impactful; Simplified Understanding in that it simplifies complex concepts by relating them to human experiences. However, personification might cope with these potential obstacles and negative effects: Over-Simplification in that it may oversimplify complex issues, leading to a lack of depth in understanding; Inappropriate Use in that it may be seen as unprofessional or confusing, particularly around technical topics.

9. Figure of Speech n.8 – Euphemism

Euphemism is a figure of speech where a mild or indirect word or expression is used in place of one that is considered rude or unpleasant. Euphemisms soften the impact of the message and make it more agreeable. They avoid direct reference to sensitive subjects, helping to maintain politeness and social acceptance in a specific organizational and cultural environment. These are some typical projectized situations where euphemism should be applied: Performance Reviews to provide constructive feedback without reducing team members' morale: *"We need to work on some areas of improvement and not your weaknesses";* Conflict Resolution addressing conflicts or issues in a way that minimizes tension among a contract negotiation with a supplier: *"It is clear that we have different opinions rather than irreconcilable positions".* Speaking about projects, we are in a very complex project from a relational, diplomatic and political point of view, due to the large number of institutional stakeholders representing different organizations and countries. The interests at stake are significant and mostly undeclared. The project manager needs to raise the awareness of the team about how to move with caution in such a slippery context, bringing his/her own experience gained over the years on similar projects. One euphemism that project manager suggests is *"Open point and not problem".*

"Open point" is a softer, less negative term compared to "problem". It suggests an issue that needs attention and resolution without the negative connotations associated with "problem". "Open point" frames the issue in a more positive light, suggesting it is something to be addressed rather than a fault or failure. Moreover, it promotes a collaborative approach for finding solutions rather than assigning blame. Euphemism should foster the following benefits: Preserves Relationships in that it helps in maintaining positive relationships throughout the life of the project; Enhances Diplomacy in that it facilitates more diplomatic and tactful communication, particularly in projects where political and cultural awareness is vital; Maintains Team Motivation in that it helps to address harsh situations respecting people. However, euphemisms might cope with these potential obstacles and negative effects: Unresolved Problems in that it skirts around the issue, doesn't address it directly and doesn't get to the point; Lack of Clarity in that it can lead to a lack of transparency and create ambiguity and confusion about the topic under discussion; Misinterpretation in that the message you want to convey could be underestimated, taken lightly or even manipulated.

10. Figures of Speech in Action

Too often project roles are not so familiar with figurative language, particularly those with a technical background. Figures of speech are use occasionally without a common and intentional purpose. They are left to discretion and personal attitude of individuals instead of being a team communication pattern. They are *"The cherries on the cake, but not the cake".* They are not a relevant subset of project management language. This situation occurs regardless of the project management approach adopted (predictive, incremental, iterative, adaptive) and limits the sharing of tacit knowledge in projects. Therefore, the systematic use of figures of speech should be an important area of improvement to invest in. How? These are practical actions to improve awareness and mastery in figurative language: Simplify the concept selecting a set of figures of speech and preparing a glossary with a brief profile for each of them; Use meaningful examples providing examples of typical projectized situations; Show benefits highlighting how figures of speech can explicit tacit knowledge, share experiences, improve creativity and engagement. For example, analogies can clarify technical details to non-technical stakeholders; Success and failure stories sharing case histories where the good or bad use of figurative language led to successful or unsuccessful project results; Workshops running meetings where team members can practice figures of speech in specific projectized situations; Practical application creating opportunities for team members to apply figures of speech in project meetings, presentations, communications with stakeholders and other key steps of the project.

11. Conclusion

Speaking about tacit knowledge in projects, there is a significant gap. On the one hand, investing in figures of speech is worthwhile. Because figurative language is more effective than literal language to externalize the verbalizable part of tacit knowledge. On the other hand, figures of speech are poorly and badly used, due to the limited awareness and mastery owned by project roles. This way, tacit knowledge remains a private property of individuals and not a shared asset of teams and organizations. This gap may be filled through a widespread and systematic use of figurative language, as a distinctive skill of project key roles. It requires to define, agree and implement an improvement plan that includes a glossary of a set of figures of speech, meaningful examples, list of expected benefits, case histories, facilitated workshops, practical applications in real projects. This challenge assumes a strong commitment by top management and openness and willingness of the project key roles to experiment and adopt figurative language. Otherwise, figures of speech remain a "dead letter" and tacit knowledge a hidden treasure.

Ethics and AI Declarations: For this paper, an ethics declaration is not required, AI Infinity chatbot by PMI® was used for finding definitions and adapting them within the text of paper.

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Work in Progress Papers

Building a Generative AI Toolkit for Leveraging Knowledge Processes: The GAIK Project Report

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Abstract: While Generative AI (GenAI) has the potential to transform knowledge work, its proper application in business remains a challenge. To obtain benefits from GenAI, companies must navigate a complex landscape of technologies and best practices for their implementation. The selection, integration, and implementation of specific GenAI solutions are complex, particularly for small and medium-sized enterprises. To address this issue, we have launched a research and development project named GAIK (Generative AI-enhanced Knowledge Management) to develop a business-oriented GenAI toolkit to improve three processes: knowledge capture, synthesis, and access. The toolkit will include software components (modules and code libraries), guidelines, process models, templates, and reusable knowledge models, enabling companies and technology providers to develop easy-to-deploy knowledge management solutions using business data. This paper describes the envisioned toolkit, its potential use cases, and the required research activities to develop and apply it.

Keywords: Knowledge management, Generative AI, Toolkit, Software product lines, Design science research

1. Problem

GenAI is transforming how individuals and organizations create, capture, and access knowledge. It significantly boosts productivity across a wide range of knowledge-intensive tasks. For example, according to the US National Bureau of Economic Research, GenAI systems can increase productivity by 14% on average (as measured by issues resolved per hour), and by 34% for novice and low-skilled workers (Brynjolfsson et al, 2023). Industry and academia see a significant potential of GenAI for streamlining knowledge processes (Alavi et al., 2024; Murphy, 2023; Pimentel & Veliz, 2024).

While businesses recognize the potential of GenAI to empower employees and enhance the customer experience, the diverse range of GenAI solutions and the complexity of integrating AI into organizational products and processes present significant challenges. Companies struggle to leverage AI effectively due to concerns over data privacy and confidentiality, transparency in operations, and the accuracy of knowledge capture, synthesis, and access. While several existing GenAI solutions, such as Microsoft Co-pilot, attempt to address the challenge of precise knowledge access across scattered business documents, they often fall short in providing a tailored, customized, and holistic approach that meets the unique and rapidly evolving needs of modern businesses. These solutions typically offer broad functionalities but lack the specificity required to handle the nuanced and domain-specific KM needs of small and medium-sized enterprises (SMEs). In addition to these issues, businesses also face difficulties in developing and deploying complex GenAI solutions due to a lack of expertise and uncertainty about the appropriate level of AI integration. This challenge is particularly acute in SMEs, which often possess vast amounts of data but lack the specialized expertise to implement effective

knowledge management (KM) solutions. This gap results in underutilized data, inefficiencies, and missed opportunities to leverage information and drive business growth and innovation.

2. Expected Solution and Project Results

To address these challenges, we have launched a research and development (R&D) project named GAIK (Generative AI-enhanced Knowledge Management) to create a GenAI-based business-oriented toolkit for SMEs supporting knowledge capture, synthesis, and access processes. This toolkit will enable businesses to develop and implement company-specific GenAI solutions by customising reusable components, helping companies manage their information more efficiently and effectively.

The toolkit for GenAI-enhanced KM will comprise software components (customized products, code libraries), method components (guidelines, process models, templates), and content components (reusable knowledge models). This toolkit will help companies develop and implement GenAI-based solutions for creating, capturing, and accessing their knowledge within the selected use cases: 1. GenAI assistant (conversational agent) to talk to business data and systems for enhancing the knowledge access process, 2. GenAI assistant for creating reports and documents for enhancing the knowledge synthesis process, 3. GenAI assistant for converting speech into structured documents for enhancing the knowledge capture process.

These generic solutions address the needs of SMEs that were identified during the preparatory project and will be tested within company-specific use cases. Working demos/prototypes of GenAI tools for company-specific use cases will be deployed to test and evaluate our toolkit and generic solutions. Fig. 1 depicts a high-level view of the project results.

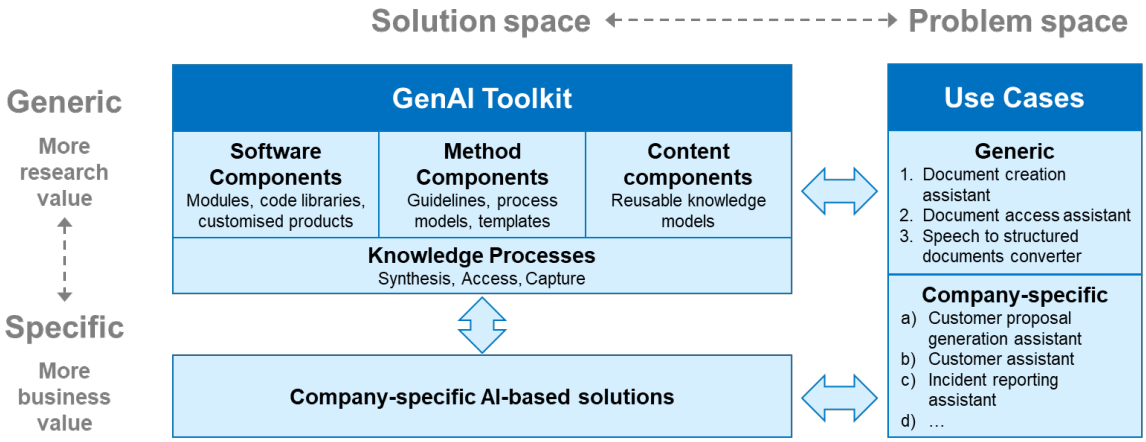


Figure 1: Overview of the project results: GenAI-enhanced KM toolkit and its applications

The project employs the action design research methodology (Sein et al., 2011) to develop and evaluate IT-based artifacts, specifically the toolkit. The project is a cooperation between industry and academia: the consortium includes 3 academic partners and six companies from Finland. The companies provide the use cases and testbeds for the R&D activities (Kudryavtsev et al, 2025).

From a theoretical perspective, the toolkit implements the idea of knowledge and software reuse, which entails leveraging existing knowledge and systems to create new solutions (Sandkuhl, 2015; Barros-Justo et al, 2019). More specifically, the concept of software product lines (Clements, Northrop, 2002; Pohl et al., 2005; International Organization for Standardization, 2015) and component-based software engineering (Tiwari, Kumar, 2021) will be used. A software product line is “a set of software-intensive systems that share a common, managed set of features satisfying the specific needs of a particular market segment or mission and that are developed from a common set of core assets (artifacts) in a prescribed way” (Clements, Northrop, 2002). Software product line engineering has proven to enable companies to develop a diversity of similar systems at a lower cost, in a shorter time, and with higher quality compared to the development of unique systems (Pohl et al., 2005; International Organization for Standardization, 2015). Component-Based Software Engineering (CBSE) is a software development paradigm that emphasizes the construction of systems through the assembly of pre-existing software units, or components (Tiwari, Kumar, 2021). While software product lines and Component-Based Software Engineering are primarily applied to software systems, we plan to use these approaches for a type of socio-technical system, more specifically, knowledge management systems (ISO 30401, 2018; Carlucci et al, 2022) by complementing them with knowledge reuse methods (Sandkuhl, 2015).

3. Use Cases and Expected Benefits for Companies

The identification of business needs and use cases for the toolkit is described in more detail by Kudryavtsev et al. (2024). The toolkit will address the needs of SMEs, which were clarified through interviews and co-creation workshops with over 20 companies. For knowledge access, companies need AI assistants to support the employees' interaction with the company's knowledge and systems, providing flexible chatbot-style access to company-specific manuals, documentation, learning content, and software services. For knowledge synthesis, tools are needed to generate customer proposals and various reports. For knowledge capture, speech-to-structured-document conversion tools are required for automated reporting of work-related incidents and similar tasks. Table 1 describes generic and company-specific use cases. We are currently updating and elaborating these use cases with companies.

Although Table 1 associates each company-specific case with one generic use case and knowledge process, it often happens that one company-specific case requires several knowledge processes. For example, customer experience reporting and incident reporting require not only knowledge synthesis but also knowledge capture from different sources and formats. In such cases we highlighted the leading generic use case and knowledge process for a company-specific use case.

Table 1: Generic and company-specific use cases

Generic use cases and k-process	Company-specific use cases
1. From speech, images and texts to structured documents Knowledge capture	Gen-AI assistant for extracting and translating transcripts from learning video and audio content GenAI-assistant for safety observations Gen-AI assistant for generating structured construction project diaries from speech, images and text Building inspections report creation assistant
2. Report and document creation assistant Knowledge synthesis	Customer proposal/quotation generation assistant Sales order processing assistant (will convert customer order into structured data for the ERP system) Gen-AI assistant for automatic incident reporting Customer experience reporting
3. AI assistant to talk to your company data and systems Knowledge access	Customer support assistant, Q&A based on the ticket history Customer guidance system based on the company's guides and instructions GenAI-based assistant on top of the existing scheduling/optimization software (platform)

Below are the expected project outcomes, along with approaches for their qualitative and quantitative verification. The results of verification experiments can be widely used to assess the impact and profitability of GenAI improvements in KM processes. The toolkit and GAIK project, in general, aim at improvements in the following knowledge process areas in business:

- Efficient Knowledge Capture: The project will enhance the accuracy and efficiency of capturing knowledge by automating the conversion of speech to structured documents. This includes tasks such as incident documentation and extracting transcripts from learning videos, which makes the documentation process faster and more reliable.
- Improved Knowledge Synthesis: By developing automatic report and document generation tools, the project will simplify the creation of various business documents such as quotations, sales orders, and project summaries. This will reduce the time and effort required to produce these documents, resulting in cost and time savings.
- Enhanced Knowledge Access: The project will improve the way employees access information by integrating AI assistants that provide GenAI-based conversational interactions with company knowledge and systems. This enhancement will streamline the process of finding relevant information, making it faster and more efficient.

4. Research Agenda in the GAIK Project

The aim of creating the GenAI toolkit raises many research questions that cover managerial and technological domains. These questions guide our research plans.

One main area of interest is understanding how GenAI enhances knowledge management and improves knowledge-related processes in organizations. We will identify the factors that contribute to the successful use of GenAI, along with the challenges related to these factors. Addressing ethical considerations in the implementation of GenAI is another important aspect of our research.

From a business perspective, we are examining how to ensure the adoption of GenAI solutions and how to integrate these solutions into existing organizational processes. We also aim to assess the business value that GenAI brings, ensuring that its impact can be measured and evaluated.

On the technological side, we are focused on determining which GenAI frameworks and models are most suitable for the toolkit and company-specific solutions. We will evaluate the accuracy and reliability of GenAI solutions in real business settings. The adaptation of solutions to data variability (structured/unstructured, various modalities) will be explored to ensure the toolkit's applicability to diverse cases. We will also consider how to ensure these solutions are understandable and transparent.

To understand how to assemble the reusable building blocks into the toolkit, we are analyzing best practices for reusing knowledge in software and solution development (including software product lines methods).

Overall, our research aims to bridge the gap between organizational needs and the capabilities of GenAI technologies, ensuring that these tools can be implemented in ways that are effective, ethical, and beneficial for knowledge management.

5. Conclusions

This paper has outlined the development and intended outcomes of a Generative AI-enhanced knowledge management toolkit to address current key KM challenges faced by businesses. The toolkit offers a flexible and modular solution, allowing both technical and non-technical users to create customized GenAI-based knowledge management (KM) solutions. Non-technical users can quickly implement their specific use cases, while technical users, such as AI programmers, benefit from the toolkit's flexibility to further customize or enhance the use cases according to their needs. While the identified use cases reflect the contemporary KM needs, they also serve as test cases to demonstrate the toolkit’s functionality. However, future steps will involve evolving the current company-specific use cases into a generalized architecture, ensuring broader applicability to current KM demands in various business contexts. The creation of the GenAI toolkit not only requires the development of software and methods but also raises several research questions spanning both managerial and technological domains. These questions form the foundation of our research agenda, which was also described in the paper.

Acknowledgements

The present work is part of the Generative AI-Enhanced Knowledge Management in Business (GAIK) project, which is co-funded by the European Union, European Regional Development Fund (Euroopan Aluekehitys rahasto, EAKR).

Ethics Declaration: No ethical clearance was required for this research.

AI Declaration: An AI tool was used for rephrasing and summarizing some parts of the paper with careful validation.

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Neighbour's Hens Looking Like Turkeys? Understanding the Effect of Envy on Knowledge-Hiding

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Abstract: The literature on knowledge hiding has been growing since the mid-2020s, with studies examining the antecedents, outcomes, and boundary conditions of knowledge hiding at workplaces. However, less empirical attention has been paid to the association between the emotions employees experience at work and knowledge hiding directed at co-workers. Accordingly, based on the Conservative Resources (COR) theory, this study aims to empirically test a novel model that examines the influence of perceived workplace envy on co-worker-directed knowledge hiding behaviour of individuals, with emotional exhaustion as the mediator. The study also examines whether supervisor undermining acts as a boundary condition in the relationships mentioned above. The authors plan to collect data by surveying 350-400 employees working in IT/ITES companies in India. The data will be collected at 2 time points – responses on workplace envy, supervisor undermining, and other demographic variables will be collected at time point 1. After a gap of 2-3 months, data on emotional exhaustion and knowledge hiding behaviour will be collected. To test the research hypotheses, Structural Equation Modeling (SEM) will be employed. The authors expect the findings to reveal the following: perceived workplace envy positively correlates with co-worker directed knowledge hiding behaviour; emotional exhaustion acts as a mediator between envy and knowledge hiding; and supervisor undermining moderates the positive correlation between perceived workplace envy and emotional exhaustion. This study extends the knowledge management literature by exploring the association between employee emotions and knowledge hiding behaviour. In addition, from a conservation of resources perspective, the study uncovers a critical underlying mechanism, emotional exhaustion, and explains how comparison-based emotions like envy experienced by the envious person lead to knowledge hiding from the envied person. Furthermore, from a practical perspective, understanding the nuances of knowledge hiding among employees enables practitioners to design effective strategies to curb such behaviours in the workplace.

Keywords: Emotional exhaustion, Knowledge hiding, Perceived workplace envy, Supervisor undermining

1. Introduction

In knowledge-driven organisations, employee collaboration and knowledge sharing are considered as the cornerstone of innovation and sustained productivity. Despite organisational efforts to facilitate open communication, knowledge hiding - the intentional act of withholding or concealing knowledge that other organisational members require or expect to know (Connelly et al., 2012) – persists as a common issue in most workplaces. While recent studies have identified a range of antecedents to knowledge hiding, the role of affective responses triggered by social comparisons in workplaces remains underexplored. In particular, the influence of emotions like envy - an unpleasant and painful feeling individuals experience when they desire what their coworkers possess, but they themselves lack (Smith and Kim, 2007) – demands further scholarly attention. Past empirical studies show that to reduce the pain caused by envy, individuals try to diminish the target's strengths, especially when the perceived social gap is insurmountable (Van de Ven, Zeelenberg and Pieters, 2009). Despite the indication that envious employees engage in counterproductive behaviours like knowledge hiding, few studies have provided empirical evidence on the association between envy and knowledge hiding directed at coworkers (Peng, Bell and Li, 2021; Shamsudin et al., 2023). Also, there is a dearth of studies in extant literature that discuss how a comparison-based emotion like envy manifests into knowledge hiding.

Accordingly, this study investigates the relationship between workplace envy and knowledge hiding, addressing the key research question: *How does perceived workplace envy (PWE) influence knowledge-hiding behaviour (KHB) of employees?.* Drawing from the Conservation of Resources (COR) Theory, we identify emotional exhaustion (EE) as a mediator that explains the association between PWE and KHB. Furthermore, we examine how supervisor undermining (SU) as a boundary condition influences the relationship between PWE and EE, eventually leading to KHB.

2. Hypothesis Development

2.1 Perceived Workplace Envy and Knowledge Hiding

Envy, characterized by feelings of inferiority, resentment, and hostility (Vecchio, 2005), mainly emerges when the envier compares oneself with others who have something he/she desires. From a social comparison theory perspective, it can be claimed that when individuals experience envy, they feel motivated to minimize the comparison gap by engaging in dysfunctional behaviours such as undermining others or boosting their own status (Van de Ven, Zeelenberg and Pieters, 2009). Since knowledge is perceived as power, hiding it from the envied person can be gratifying for the envious person. It hinders the envied person's job performance, while preserving the envious individual's personal power and relative standing in the organisation (Peng, Bell and Li, 2021). Especially in competitive work environments that stimulate employee envy, knowledge hiding can be used as a tactic by employees to gain self-control and self-worth (Shamsudin et al., 2023). Hence, the following hypothesis:

H1: PWE is positively related to KHB

2.2 Mediating Role of Emotional Exhaustion

Drawing on the rationale of COR Theory, we will now examine the psychological underpinning that connects PWE with KHB of individuals. As per the theory, when individuals face a threat or actual loss of resources, they become more sensitive to resource depletion. This leads to high levels of stress, which drive them to safeguard the remaining resources (Hobfoll, 2018). Envious employees tend to perceive that they are treated unfairly, feel exploited and are more likely to feel depressed and angry. This drains their emotional energy, leading to emotional exhaustion (EE), which refers to "a state of feeling overextended and depleted of one's emotional and physical resources" (Maslach and Leiter, 2008, p. 498). Thus, employees perceive a continued loss of resources (Hobfoll, 2018), which motivates them to engage in knowledge hiding as a resource protection or resource loss prevention strategy. Based on this logic, we propose that the influence of PWE on KHB can be elucidated through EE, as emotionally exhausted employees reduce the loss of their resources by engaging in KHB. Hence, the following hypothesis:

H2: EE mediate the relationship between PWE and KHB

2.3 Moderating Role of Supervisor Undermining

Supervisor undermining can be defined as "supervisory behaviour that is intended to hinder, over time, the ability of subordinates to establish and maintain positive interpersonal relationships, work-related success, and favorable reputations" (Duffy, Gangster and Pagon, 2002, p 332). It is a form of destructive leadership behaviour that includes both active and passive behaviours like supervisors making subordinates feel incompetent, insulting them, and dismissing their work-related queries and concerns (Duffy, Gangster and Pagon, 2002). Extant research demonstrates that victims of supervisor undermining experience depression, have lower levels of self-efficacy and job satisfaction, which eventually affects their overall job performance (Duffy et al., 2006; Eissa, Chinchanachokchai and Wyland, 2017).

In the context of workplace envy, when envious employees experience undermining, it threatens their sense of self-worth and perceived competence, and amplifies the emotional resource depletion resulting from perceived envy. The hostile environment created by SU characterized by workplace mistreatment and a lack of avenues for professional validation, make envious employees more frustrated and disengaged, thereby worsening EE. Hence, we propose that SU acts as a boundary condition that exacerbates the emotional strain experienced by envious employees who already perceive themselves as disadvantaged due to social comparison. Thus, the following hypothesis:

H3: SU moderates the direct relationship between PWE and EE such that the relationship will be stronger when the employee experiences a high level of SU.

3. Methodology

3.1 Procedure

The authors plan to test the hypothesized model by administering a two-wave survey among 350-400 employees working in Information Technology (IT) sector in India. The highly competitive and performance-driven culture of IT organizations places strong emphasis on individual accomplishments and professional growth, making it more prone to social comparison among employees, thereby forming a relevant context to

explore the relationship between envy and knowledge hiding. Employees with minimum one year of experience in the current organization will be chosen as survey participants to ensure that they have adequate exposure to team processes and peer interactions. The data will be collected using a self-administered questionnaire that will be distributed to the employees via email and other professional networks like LinkedIn. In the first wave of the survey, responses on workplace envy, supervisor undermining, and other demographic variables will be collected. The second wave of the survey will be administered 2-3 months later to assess emotional exhaustion and knowledge hiding behaviour of employees. In addition, demographic information of participants like age, gender, organisational tenure, education, and job level will be gathered, as these variables influence employees' knowledge behaviours.

3.2 Measures

Perceived workplace envy: To measure PWE, the 5-item scale developed by Vecchio (2005) will be used. A sample item is "It is somewhat annoying to see others have all the luck in getting the best assignments".

Emotional exhaustion: Maslach and Jackson's (1981) 9-item scale will be used to measure EE. Sample item includes "I feel used up at the end of the workday".

Knowledge hiding behaviour: We consider KHB as a holistic construct and plan to measure the construct using the 12-item scale developed by Connelly et al. (2012). The participants will be asked to respond to the following question: "In the past 3-4 months, when a co-worker requested knowledge from you, did you display the following behaviours?" A sample behaviour includes "Told him/her that I would help him/her out later but stalled as much as possible".

All the above constructs will be measured on a five-point scale ranging from 1 (strongly disagree) to 5 (strongly agree).

Supervisor undermining: To measure SU, we will use 13-item scale developed by Duffy, Gangster and Pagon (2002) and the items will be measured on a five-point scale with responses ranging from 1 (never) to 5 (almost every day). A sample item includes "How often has your supervisor intentionally made you feel incompetent?"

Control variables: Following past studies (Liu, Zhu and Lam, 2020, Zhao et al., 2016), we consider the participant's age, gender, education, job level and organisational tenure as the potential control variables.

4. Conclusion and Implications

From a theoretical perspective, we advance the literature on knowledge hiding by examining employee emotions as an antecedent of KHB. In addition, drawing from COR theory, the study uncovers a critical underlying mechanism, EE, to explain how comparison-based emotions like envy experienced by employees lead to knowledge hiding from the envied person. Further, we introduce SU as a boundary condition to propose a moderation-mediated model.

From a practical perspective, understanding the complexities of knowledge hiding among employees allows practitioners to develop effective strategies to curb such behaviours in the workplace.

Ethics declaration: This study is still in its conceptual stage and does not involve human participants at this phase. Once the study progresses to data collection phase, necessary approval will be sought from the relevant institutional ethics committee.

AI declaration: The authors have used AI tools (ChatGPT, Quillbot) for language refinement and grammatical corrections. The research idea and arguments remain the sole contribution of the authors.

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AI and Cyber Threat Intelligence Management in the Energy Sector

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Abstract: Integrating artificial intelligence (AI) and cyber threat intelligence (CTI) into the energy sector has revolutionised the management of electrical systems and cybersecurity. This work-in-progress paper explores the current state and prospects of AI and CTI in the European energy sector, presenting a management model to ensure the ethical, transparent, and responsible use of AI within the DYNAMO project. The model leverages the ALTAI framework and the Z-Inspection® method, adhering to the requirements of the GDPR and the EU AI Act. AI is emerging as a key technology in managing electrical systems, optimising energy flow, and enhancing grid stability and operational efficiency. Examples include Siemens Spectrum Power and Schneider Electric's EcoStruxure. AI also aids in predicting electricity demand and renewable energy production, improving resource management and reducing waste. The EU AI Act classifies AI systems in the energy sector as high-risk, requiring stringent data protection, transparency, and human oversight. The ALTAI framework emphasises seven core principles: human agency, technical robustness, privacy, transparency, diversity, societal well-being, and accountability. The DYNAMO project aims to create a technical solution for small and medium-sized critical infrastructure companies to share CTI and support business continuity management. It uses the ECHO Early Warning System (E-EWS) for cyber threat information exchange. The AI governance model includes policies, processes, and technical frameworks to ensure AI systems remain ethical, secure, and responsible. Key components include encryption for secure data transfer, role-based access controls, integration of GDPR and EU AI Act requirements, and an adaptive framework with training modules and real-time feedback loops. Results indicate compliance with GDPR and EU AI Act requirements, effective response to new cyber threats, and high user satisfaction. This research underscores the importance of adaptability and regulatory compliance in AI governance frameworks. Future work includes real-world testing, iterative refinement, and broader stakeholder collaboration to further develop and validate the proposed model.

Keywords: AI governance, ALTAI, DYNAMO project, EU AI Act, Z-Inspection®

1. Introduction

Integrating AI into the energy sector and cybersecurity has revolutionised the management of electrical systems and cyber threat intelligence. The use of AI in cybersecurity, particularly in CTI, has introduced complex regulatory and operational challenges. Some of the more impactful challenges are balancing data privacy, security, and adaptability while ensuring compliance with frameworks such as the GDPR and the EU AI Act. On the other hand, the EU regulation aims to ensure the efficiency, competitiveness, and sustainability of the energy markets (European Parliament, 2024a). According to the AI Act (EU 2024/1689), the use of AI in energy sector systems is defined as high-risk (European Parliament, 2024b). These systems are subject to strict requirements for data protection, transparency, and human oversight. The Act requires surveillance for the use of AI and influences also influences organisations outside the Union borders (Heymann et al., 2023). However, the practical requirements for ensuring the safe use of AI are still lacking (Niet, 2022).

2. Research Methodology

This work-in-progress paper applies the Design Science Research Methodology (DSRM) (Hevner & Chatterjee, 2010). The first activity, *problem identification and motivation*, involves clearly defining the research problem and its significance, such as the challenges in managing AI and cybersecurity in the energy sector, identified in Work Package 2 "End-user & System Requirements" of the DYNAMO (2025) project. The second activity, *defining the objectives for a solution,* sets goals for the research, which in this paper is ensuring the reliability, security, and ethicality of AI systems.

This paper focuses on the third activity, *design and development*, where the artifact “the integration of the ALTAI framework and the Z-Inspection® method into AI system management” is created. The activities 4-7, *demonstration*, *evaluation*, and *communication* (Hevner & Chatterjee, 2010), are beyond the scope of this WIP paper.

3. AI in the Energy Sector

AI is emerging as a crucial technology for managing electrical systems, optimising energy flow, and enhancing grid stability and operational efficiency. Examples include Siemens Spectrum Power and Schneider Electric's EcoStruxure, which leverages AI for energy management and automation. AI also aids in forecasting electricity demand and renewable energy production, improving resource management and reducing waste (Rozite et al., 2023). AI’s ability to perform real-time analysis and decision-making makes it well-equipped to manage data-

driven environments such as power grids. AI systems can optimise the flow of energy, improving grid stability and operational efficiency. Examples of the use of AI in electrical systems include Siemens Spectrum Power and Schneider Electric's EcoStruxure. Siemens Spectrum Power leverages AI to monitor grid stability and optimise energy flows across electrical systems (Siemens AG, 2025). Similarly, (Schneider Electric, 2025) describes its EcoStruxure platform using AI for energy management and automation, driving efficiency across electrical networks.

One of the key contributions of AI to the energy sector is forecasting, particularly for electricity demand and renewable energy production (Khan et al., 2023). AI helps utilities manage resources, improving grid resilience and reducing energy waste. IBM's Environmental Intelligence Solution platform uses AI to provide climate insights, enabling businesses to anticipate disruptions, mitigate risks, and build sustainable operations (IBM, 2025). AI also plays a central role in business: by analysing large data sets, energy companies can better understand customer needs, enhance service offerings, and make data-driven decisions that increase operational efficiency and customer satisfaction (Heymann et al., 2023).

3.1 Cybersecurity and CTI

Integrating AI and CTI is vital for securing critical infrastructure such as power grids. AI enhances threat detection and defence mechanisms by identifying anomalies and automating routine cybersecurity tasks. In the long term, AI could provide proactive security anticipating and preventing attacks, although attackers may also use AI to develop more sophisticated threats.

The energy sector faces attacks from Advanced Persistent Threat (APT) actors, including spear phishing and ransomware campaigns. Effective CTI sharing requires reliable data, social trust, and overcoming fears of competition and reputation loss. Many EU energy operators lack a Security Operations Centre (SOC) for monitoring information technology (IT) and operational technology (OT) operations, indicating a need for improved capabilities.

Due to its criticality, the energy sector is a target of APT actors and faces attacks against Industrial Control Systems (ICS), as well as spear phishing and ransomware campaigns (Govea et al., 2024). In CTI, sharing reliable data and the management environment are emphasised, but sharing requires social trust between the parties (MITRE Corporation, 2012; Rajamäki, 2024). In addition to trust requirements, the fear of competition and losing reputation, as well as limited resources, hinder the CTI exchange within the sector (Paice and McKeown, 2023). Another issue is the current state of maturity within the available security products (Kalodanis et al., 2023) and their users. Approximately half of the EU energy operators do not use SOC for monitoring their IT/OT operations (ENISA, 2024). Therefore, it can be inferred that there remains work to do before the capabilities of SMEs enable effective CTI sharing.

3.2 Regulatory Considerations and Ethics

The AI Act (EU 2024/1689) classifies AI systems in the energy sector as high-risk, requiring rigorous data protection, transparency, and human oversight. To ensure the safe use of AI, it is essential to comply with these regulatory requirements and address the practical challenges associated with their implementation.

The Z-Inspection® methodology uses an interdisciplinary approach to identify ethical tensions and risks (Zicari et al., 2021). Z-Inspection® process evaluates the reliability of AI systems in practice. It is based on applied ethics and aims to ensure that AI systems are ethical, technically reliable, and suitable for the organisation. This process can help identify and manage ethical and technical risks associated with the use of AI in cybersecurity. For example, in the energy sector and the DYNAMO project, Z-Inspection® can help assess how well AI systems detect and respond to cyber threats, ensuring that the systems operate transparently and responsibly. Additionally, Z-Inspection® can help ensure that systems comply with the EU AI regulation and GDPR and provide feedback and recommendations for system improvements.

ALTAI (Assessment List for Trustworthy Artificial Intelligence) is a tool developed by the European Commission's High-Level Expert Group to help organisations assess the reliability of their AI systems. ALTAI focuses on seven principles: human agency, technical reliability, privacy, transparency, diversity, societal well-being, and accountability. The ALTAI framework can help ensure that AI systems comply with regulatory requirements, such as GDPR and the EU AI regulation, and that they are safe and ethical to use in cybersecurity. In the DYNAMO project, the ALTAI framework can guide the development and use of AI systems and provide recommendations and guidelines for adapting and improving the systems.

4. Proposed Ethical AI Governance Process for the Energy Sector

By integrating the Z-Inspection® (Zicari, et al., 2021) process and the ALTAI framework into energy sector management, a comprehensive governance model can be created that ensures the ethicality, safety, and accountability of AI systems. This can include the assessment of ethical and technical risks, ensuring regulatory compliance, and continuous improvement and adaptation through training modules and real-time feedback loops.

Table 1 presents the proposed framework for ethical AI governance in the energy sector. It has been developed by benchmarking the SHAPES project's ethical evaluation with the ALTAI tool (Rajamäki et al., 2023) and the pilot project "Responsible use of AI '' in cooperation with the Province of Friesland, Rijks ICT Gilde- part of the Ministry of the Interior and Kingdom Relations (BZK), applying Z-Inspection® Initiative (Boonstra et al., 2024).

Table 1: Ethical AI governance framework

Step	Description
Define the scope and objectives of the assessment.	*Clear scope:* Clearly define what aspects of the energy sector will be assessed, such as the management of electrical systems and cybersecurity measures. This helps focus on essential questions and avoid the assessment expanding too much. *Objectives:* Define the objectives of the assessment, such as ensuring the reliability, security, and ethicality of AI systems used in managing energy flow and grid stability.
Assemble a multidisciplinary assessment team.	*Experts*: Assemble a team that includes technical experts in AI and energy systems, ethical experts, cybersecurity experts, and possibly legal experts to ensure compliance with regulations like GDPR and the EU AI Act. *Common language:* Ensure that the team has a common language and understanding of the assessment's objectives and methods to facilitate effective communication and collaboration.
Use a structured assessment method (z-inspection or the ALTAI tool).	*Z-Inspection® process:* Utilize the Z-Inspection® process, which includes three phases: preparation, assessment, and resolution. This process helps identify and address ethical issues and tensions specific to the energy sector. *ALTAI process*: Utilize the checklists and concrete steps provided by the ALTAI tool to conduct the assessment, ensuring that all relevant aspects are covered systematically.
Evaluate technical aspects.	*Technical reliability:* Assess the technical reliability of the AI system, including data handling, labelling, system architecture, and robustness. This ensures that the AI system can effectively manage electrical systems and optimise energy flow. *Cybersecurity*: Ensure that the AI system meets cybersecurity requirements and has appropriate protection mechanisms to safeguard against cyber threats.
Evaluate ethical aspects.	*Human rights:* Assess how the AI system impacts fundamental rights, such as privacy, data protection, and good governance. This includes ensuring that the AI system does not infringe on the rights of individuals and communities. *Ethical principles:* Apply the ALTAI tool for trustworthy AI, focusing on principles such as respect for human autonomy, prevention of harm, fairness, and explicability.
Engage stakeholders.	*Users and decision-makers:* Engage the system's users and decision-makers in the assessment process. This helps ensure that their views and concerns are taken into account, leading to more effective and accepted AI solutions. *Transparency*: Ensure that the assessment results and recommendations are open and accessible to all stakeholders, fostering trust and collaboration.
Continuous monitoring and improvement.	*Monitoring*: Continuously monitor the use and impact of the AI system in the energy sector. Make necessary corrections and improvements to the system's operation and ethical aspects to maintain high standards. *Feedback*: Continuously collect feedback from users and stakeholders about the system's operation and ethicality. This helps identify areas for improvement and ensures the AI system remains effective and trustworthy.

By following these steps, the integration of AI and cyber threat intelligence into the energy sector can be managed effectively, ensuring that AI systems are reliable, secure, ethical, and respectful of fundamental rights.

5. Discussion and Conclusions

This work-in-progress paper's result is the concept of an ethical AI governance model, which provides a comprehensive approach to managing AI and cyber threat intelligence in the energy sector. The model

emphasizes ethicality, security, and regulatory compliance. Developing the model and achieving its full potential requires continuous testing, refinement, and collaboration with stakeholders.

The proposed governance model addresses the dual objectives of regulatory compliance and operational adaptability within the DYNAMO project, and it is easily extendable from the energy sector to other critical areas. By aligning AI governance with GDPR and the EU AI Act, this model provides a blueprint for secure and resilient CTI systems in cybersecurity. The integration of the ALTAI framework and Z-Inspection® method ensures that AI systems are ethical, transparent, and responsible, meeting stringent data protection and human oversight requirements.

The ethical AI governance model successfully enhances secure information sharing, compliance with regulatory standards, and user satisfaction. The adaptive framework, which includes encryption for secure data transfer, role-based access controls, and real-time feedback loops, demonstrates the importance of continuous monitoring and improvement in maintaining high standards of AI governance.

Future work involves DSRM's activities 4-7, such as real-world testing, iterative refinement, and broader stakeholder collaboration to further develop and validate the proposed model. Expanding the scope to include additional feedback mechanisms and scaling the model for broader applications will be crucial steps in ensuring its effectiveness and reliability.

Acknowledgements

Acknowledgment is paid to the DYNAMO Project, funded by the European Union under grant agreement no. 101069601. Views and opinions expressed are however those of the authors only and do not necessarily reflect those of the European Union or European Commission. Neither the European Union nor the granting authority can be held responsible for them.

Ethics declaration: Ethical clearance was not required for the research.

AI declaration: In section 3, the analysis of the articles by Rajamäki et al. (2023) and Boonstra et al. (2024) utilized artificial intelligence. The paper's spelling was verified using the artificial intelligence tool.

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People Search and the Structural Dimension in Knowledge Management Systems

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Abstract: This paper's starting point is the challenges that users experience when trying to locate colleagues with the aim of sharing knowledge. Beginning with the requirements to include cognitive, relational, and structural dimensions in knowledge management systems, we outline AI-based approaches and solutions that can contribute, in particular, to the structural dimension by means of people metadata. The aim is to strengthen searching in knowledge management systems and ultimately to be able to improve knowledge sharing.

Keywords: Knowledge management systems, Knowledge sharing, Knowledge search, People search

1. Introduction

Knowledge sharing refers to when knowledge is made available and presented to others in an organization in a way that is absorbable and useful for others (Ipe, 2003). Basically, knowledge sharing is made possible through two overall strategies: 1) a codification strategy whereby knowledge is codified, stored, and disseminated through the use of information technology, and 2) a personalization strategy, whereby sharing takes place through person-to-person interaction (Hansen, Nohria and Tierney, 1999).

The term "knowledge management" was coined in the 1990s (Jennex, 2008). Since then, the field has undergone different phases. Initially, the focus was on repositories for managing knowledge, which was followed by a generation of research focusing on knowledge sharing (Ackerman et al, 2013). Recently, de Carvalho et al (2018) have argued that a third generation of knowledge and expertise sharing is approaching, whereby advanced technologies offer new ways of capturing and sharing knowledge. Despite the change of focus in later generations of research, repositories and platforms still play an important role in supporting knowledge sharing and locating people and expertise in organizations.

However, it has been acknowledged that knowledge management systems need to mirror the knowledge-sharing activities surrounding them. Inspired by the concept of social capital, Ackerman and Halverson (2003) identified three dimensions for improving knowledge management systems to better support knowledge sharing. They include a cognitive dimension in which it is emphasized that a common understanding and a shared language are important prerequisites for knowledge sharing. The relational dimension highlights the importance of understanding and sharing norms, identity, mutual obligations, and trust. The structural dimension addresses employees' need to find and collaborate with others to obtain resources they do not possess themselves (Ackerman and Halverson, 2003). The structural dimension implies that employees can easily locate and identify colleagues, which is otherwise known to be a challenge.

2. Challenges in People Search

Searchers in the workplace generally search for people for three reasons: 1) to contact the person; 2) to find documents or data that the person has produced; or 3) because a person possesses specific expert knowledge (Balog, 2007; Freund, 2015; Hertzum, 2014; Hertzum and Pejtersen, 2000; Schoegje et al, 2023). A recent study identified a specific role of people search as part of the retrieval process, i.e., when a person is searched for as a shortcut to identify another person who knows about a certain topic or as a stepping stone to help in remembering related projects, people, and lab data and to determine how this information may be used in an exploratory search (Svarre, Lykke and Bygholm, 2024). People are critical information sources because they provide contextual and historical insights and contribute explanations and ideas for searching.

Although enterprise search is critical for business performance, research on the topic remains limited (White, 2020; 2023). Only few studies refer to challenges in connection with people search. Lykke et al (2022) describe how people search is challenged by spelling errors, inconsistent person metadata, and missing mentions of persons related to, e.g., a certain project, lab test, or product development. Furthermore, it is highlighted as problematic that persons disappear from the people directory when leaving a company. In search situations, the information seeker may remember a retired project manager, whom they would like to consult to get the names

of specific persons who carried out a particular project. Another problem is when a searcher may remember the person's initials but not their full name, which is what is mostly used as person metadata.

Overall, these examples show the importance of being able to connect and show relationships between people and the projects they have been involved in, the products, organisms, and technology they have worked with, the lab tests they have completed, and the colleagues with whom they have worked.

3. Possible Solutions

Based on the problems identified above, we present recent AI-based solutions aimed at improving people search as a means to strengthen the structural dimension and, in turn, enhance knowledge sharing.

Several papers are based on machine learning, a combination of algorithms and method often used in artificial intelligence (Mukhamediev et al., 2022). Gammack et al (2022) draw on machine learning and semantic search in their suggestion to improve access to design documentation in the form of heterogeneous technical materials. In assessing the outcome of the solution without testing it with end users, they conclude that the solution has much potential while also being challenged by the diverse nature of the materials included in the system. Another study, by Lykke (2022), uses the same combination of semantic search and machine learning for improving people search by their initials in a biotech company, which has been shown to be challenging. However, initials are commonly associated with alternative meanings of the same combination of letters, which disturbs the precision of the solution. This solution was an early attempt, so further refinement with semantic tools could potentially be an improvement.

An ontology is a structured tool used for deducing relations in machine learning and AI (Ghidalia et al, 2024). Ontologies are efficient tools for assisting knowledge sharing in organizations by managing organizational knowledge, e.g., during search. Osman, Mohd Noah and Saad (2022) reviewed 13 papers presenting ontology-based knowledge management tools for knowledge sharing across a range of knowledge domains. Ontologies were used for various purposes across the reviewed studies, e.g., knowledge extraction, knowledge inputs and annotation, and matching processes to support retrieval. Their review concludes that despite using ontologies, it is still a challenge to find and extract fragmented and incomplete knowledge. The authors also point towards the potential of automating the process of building ontologies, as there are many manually created ontologies in the reviewed papers (Osman, Mohd Noah and Saad, 2022).

Lastly, generative AI and large language models (LLMs), such as ChatGPT and CoPilot, can also strengthen people search and the structural dimension. Based on deep learning and trained on vast amounts of text, LLMs are capable of solving a wide range of tasks, including question answering and summarizing text (Birhane et al, 2023; Meyer et al, 2023). Applied to internal systems and data, generative AI can improve and democratize access to organizational knowledge through search, connect employees, and perhaps even strengthen knowledge-sharing cultures (Alavi, Leidner and Mousavi, 2024; Sumbal and Amber, 2025). However, attention should be paid to overreliance in the responses given, as well as ethics and legal issues (Alavi, Leidner and Mousavi, 2024).

4. Concluding Remarks

This paper has investigated recent developments and initiatives that can assist in, or perhaps even handle, the assignment of people metadata in knowledge management systems. Supporting people search and the structural dimension of knowledge management systems can be a challenge in many ways, for example, due to heterogeneous meanings of words, employees whose details are deleted from corporate systems when they change jobs or retire, and inconsistent or missing assignment of person metadata. However, new technologies and approaches may hold the potential to reduce such challenges by offering novel approaches to handling person metadata and access to the knowledge of colleagues. Future research should closely evaluate the effect of these approaches in strengthening the structural dimension of knowledge management systems.

Ethics declaration: No ethical clearance was needed for the work presented in the current paper.

AI declaration: No AI tools were applied in the development of the current paper.

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Late Submissions

Evaluation of Port Managers' Perception of Organizational Unlearning and its Influence on Organizational Performance

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Abstract: Organizational unlearning is widely considered an essential condition for successful adaptation to environmental changes, as it promotes organizational learning and improves company performance, Tsang and Zahra (2008). With transformations in the external environment, experiences and often-valued beliefs become an obstacle to organizational adaptation, Becker (2018). According to Hedberg (1981), an organization's inability to unlearn becomes a weakness in the long run, since over time, much of the strategic knowledge acquired becomes obsolete. In this sense, organizational success depends on its ability to abandon knowledge, values, behaviours or routines which, although they were sources of competitive advantage in the past, are no longer so today. This process of giving up knowledge must start with people, because they are the ones who make organizational unlearning possible, since organizations unlearn through them, since they don't have mental activities. (Cegarra-Navarro; Wensley; Batistic; Evans *et al.*, 2021)). In this article we analyze port managers' perceptions of the unlearning practices implemented in their organizations and their influence on their organizational performance, since the sector faces challenges in terms of process modernization, competitiveness, safety and expansion. Based on a quantitative approach, we conducted surveys of Angolan port managers and used statistical methods to test two hypotheses related to unlearning practices and organizational culture. To test the research hypotheses, we used Cronbach's alpha to assess the internal reliability of the items in the three constructs, simple linear regression to analyze the relationship between the variables organizational unlearning, unlearning practices and organizational culture and Pearson's correlation to examine the relationships between the variables. The results show that both unlearning practices and organizational culture are positively related to organizational performance. We point to future studies that analyze the barriers to unlearning and the role of AI in this context.

Keywords: Organizational unlearning, Unlearning practices, Organizational culture, Organizational performance

1. Introduction

Today's organizations are characterized by continuous change. These changes require the development of the capacity to learn along cognitive, behavioral and normative dimensions (Srithika and Brattacharyya, 2009). (2013) add that changes caused by the increasing variability and turbulence of the external environment have brought more uncertainty to the survival and development of companies. To increase their ability to adapt to the external environment, organizations need to constantly improve their organizational flexibility.

The field of organizational knowledge management has fostered research into organizational learning and *unlearning*, especially since the publication of Hedberg's (1981) article entitled "*How organizations learn and unlearn*". However, while studies on learning have progressed significantly, research on unlearning has been very limited (Tsang and Zahra, 2008).

Despite the consensus in the literature regarding the importance and necessity of unlearning, especially in organizational contexts, many researchers have expressed concerns regarding conceptual coherence, applicability, the unlearning cycle and the need to update obsolete knowledge (klammer, 2024; Chen *et al*., 2024, Tsang and Zahra, 2008).

Xu *et al*. (2024) point out that although organizational unlearning plays a vital role in facilitating new product development, its unlearning micro-processes (i.e. how to effectively unlearn) remain poorly understood.

This article analyses port managers' perceptions of the unlearning practices established by organizations and their effects on organizational performance.

Based on the literature, we defined two research hypotheses:

H1: *Organizational unlearning practices have a positive influence on organizational performance.*

To support this research hypothesis, we used the study by Cegarra-Navarro and Wensley (2019), in which the authors state that knowledge can quickly become obsolete, requiring constant renewal and adaptation. Organizations that cling excessively to established knowledge run the risk of losing their competitive advantage by failing to adapt to market changes.

Day (2024) states that when an organization actively participates in unlearning, it eliminates obsolete knowledge, facilitating the assimilation of new ideas, methodologies and practices. This dynamic is essential for cultivating a culture of continuous learning and innovation, especially in rapidly evolving environments where adaptability is decisive for maintaining competitive advantage.

According to the authors, it is essential for organizations to develop the capacity to unlearn in order to update their knowledge base, adapt to new conditions, remain competitive and improve organizational performance.

H2: *Organizational culture positively influences organizational performance.*

In order to maintain a clearer understanding of the influence of a company's culture on organizational unlearning, we sought to identify the cultural practices developed by port managers to promote and encourage the identification of obsolete routines.

According to Pardim et al. (2024), an organization is structured to coordinate activities and control the performance of its members, and can be classified as mechanistic or organic, depending on its objectives, strategies and environment. An organization's ability to respond to market pressures is crucial to its performance. In this context, the behaviour of managers and organizational culture are fundamental sources of competitive advantage. Investments aimed at generating ideas are necessary to ensure rapid adaptation to environmental changes.

2. Literature Review

2.1 Organizational Unlearning

The concept of organizational unlearning has often been mentioned in the literature without a clear definition of its process boundaries (Tsang and Zahra, 2008).

Studies of organizational unlearning began with Hedberg (1981), whose research analyzed Swedish companies that were struggling to avoid bankruptcy due to changes in the external environment and the failure to pay sufficient attention to the evolution of this environment (Sharma *et al*.,2022).

The limitations in literature prevent a more comprehensive understanding of organizational unlearning. However, the topic has received increasing attention in recent years, with an emphasis on the conceptual construction of the process, as well as the identification of its stages and levels (Klammer (2024; Tsang and Zahra, 2008).

For Becker (2018), one of the reasons for the increased interest in organizational unlearning in recent years is related to the rapid changes in the business environment and the resulting organizational transformations.

In the last decade, unlearning has gained prominence due to its relevant role in overcoming outdated knowledge and promoting reflective learning, especially in more turbulent contexts (Xu *et al*., 2024).

2.2 Unlearning Concept

In analyzing the existing literature on unlearning, it is possible to find various concepts. In this article we highlight those that present elements such as "conscious" and "intentional" elimination of "beliefs", "routines", "values", "change of action", "unloading", "renunciation", "discarding" as elements that connect the various concepts.

Table 1: Concepts of organizational unlearning

Authors; year	Concepts	Titles	Magazines
Johannessen and Hauan (1994)	Unlearning requires changing methods of action;	Communication-A systems theoretical point of view (third-order cybernetics).	*Systems Practice* (Springer)
Holan and Phillips (2004)	Unlearning as the intentional removal of established knowledge in an organization;	*Remembrance of things past? The dynamics of organizational forgetting.*	Management Science
Akgun *et al.*, (2007)	They consider unlearning as the elimination of organizational memory and it is operationalized as changes in the "beliefs" and "routines" of organizations;	Organizational unlearning as changes in beliefs and routines in organizations.	Journal Of Organizational Change Management
Tsang and Zahra (2008)	Organizational unlearning is the shedding of old routines to make way for new ones;	Organizational unlearning.	Human Relations

Authors; year	Concepts	Titles	Magazines
Yildiz (2010)	It introduces the concept of unlearning as a key factor in the success of knowledge transfer;	Compatibility and unlearning in knowledge transfer in mergers and acquisitions.	Scandinavian Journal Of Management
Wang *et al.*, (2019)	Unlearning is a process that takes place at the individual level and then spreads to the organization as a whole;	Individual unlearning, organizational unlearning and strategic flexibility the down-up change perspective.	Baltic Journal Of Management
Kmieciak, (2020).	It is a conscious and intentional process of renunciation, which does not necessarily imply the permanent destruction of what has been learned, but rather the choice not to use what is stored in memory;	*Critical reflection and innovative work behavior: The mediating role of individual unlearning*.	Personnel Review
Hamza *et al.*, (2024)	Organizational unlearning occurs when organizations discard knowledge, beliefs or routines;	Unlearning diversity management.	Journal Of World Business
Pardim *et al.*, (2024)	It is a conscious and intentional process of renunciation, which does not necessarily imply the permanent destruction of what has been learned, but rather the choice not to use what is stored in memory;	Determining factors of individual and organizational unlearning in the generation and realization of ideas: a multigroup analysis from organizational structure.	Innovation & Management Review
Xu (2024)	Organizational unlearning is the process by which companies intentionally change their "beliefs" and "routines";	Organizational unlearning: A process of tension imposition, integration, and splitting.	European Management Review
For Klammer *et al.*, (2024)	Organizational unlearning involves the intentional elimination of obsolete knowledge in order to facilitate innovation.	Organizational unlearning as a process: What we know, what we don't know, what we should know.	Management Review Quarterly

2.3 Criticism of Unlearning

Although terms such as knowledge, logic, routines and beliefs are widely used to describe what constitutes organizational unlearning, existing studies do not always clearly define the types of knowledge structures that are being investigated and unlearned (Klamman *et al.,* 2024; Xu*, et al.,* 2024).

Despite the growing acceptance of organizational unlearning in scientific literature, the concept has generated controversy, mainly due to its conceptual ambiguities (Klammer *et al*., 2022). In this sense, Klammer *et al*. (2023) argued that the term "organizational unlearning" can convey the mistaken idea that knowledge can simply be eliminated, as if knowledge structures could be objectified and selectively erased from organizational memory.

In a more recent publication, the authors (Klammer et al. in 2024) reinforce that although the concept has gained ground in scientific research, it continues to raise debate due to the lack of clarity and consensus on its definition and practical application.

In addition, many researchers present unlearning with an exclusively positive connotation. However, this process has some weaknesses. One of the criticisms is the fact that, in the reality of organizations, the knowledge discarded is not always inferior to the new knowledge adopted (Tsang and Zahra, 2008). Furthermore, old knowledge is not completely eliminated, but tends to coexist with new knowledge, at least in the short and medium term (Hamza-Orlinska et al., 2024).

A particularly strong criticism of the concept of unlearning is raised by Howells and Scholderer (2016) who consider unlearning to be a superfluous term, arguing that there is no record of a definition even in the main psychology dictionaries, thus questioning its conceptual and scientific legitimacy.

2.4 Organizational Performance

In digital and constantly evolving economies, digital transformation has emerged as a key strategy for organizations to face market crises and improve their functional efficiency (Zhan et al., 2024).

These digital transformations involve not only technological updates, but also environmental, cultural and strategic changes. Organizational culture and market-oriented strategies are also impacted, helping to

strengthen the company's strategic flexibility. Together, these elements help the process of replacing obsolete routines (Wang et al., 2013; 2019).

In this scenario, organizations must not only use their existing capabilities, but also develop new competencies in order to achieve long-term success and maintain a sustainable competitive advantage.

The act of unlearning certain beliefs is believed to facilitate the development of new, more relevant and valuable knowledge. Scholars have described unlearning contexts as renewal environments, which create better opportunities for decision-making and promote higher quality performance (Cegarra-Navarro and Wensley, 2019).

According to Hamza-orlinska et al. (2024), organizational unlearning occurs when organizations reject or abandon knowledge, beliefs or routines that have become outdated. An important assumption is that certain information, when retained, can inhibit organizational performance

In this way, this study promotes the analysis of the perception of port managers in Angola regarding the unlearning practices adopted by their organizations and their influence on organizational performance.

3. Methods

This study used the quantitative research method through the application of a questionnaire survey, with the aim of collecting empirical data to test the study's hypotheses. To ensure the content validity and appropriateness of the constructs, especially the measures related to the elimination of routines in the Angolan context, a pilot test was carried out with senior professionals from Angolan ports. The participating managers were invited to answer the questionnaire and provide feedback on the wording and structure of the questions. Based on these contributions, some questions were revised to improve the clarity and comprehension of the instrument.

It was explained to the managers that the survey was for academic purposes only. They were also assured that the answers would be kept confidential and promised that a summary of the results would be sent to them.

The questionnaire was administered in person, in physical format, at the respondents' workplace. This approach was adopted due to the high probability of low adherence to the survey if carried out remotely. In all, 77 port managers took part in the study, covering positions ranging from section heads to executive directors. In order to maximize the response rate, specific days for administering the questionnaires were defined in advance in conjunction with the human resources department. A technician from the organization accompanied us and introduced us to the managers of the different functional areas. During the survey, participants received two documents: A letter of introduction presenting the purpose of the study and the structured questionnaire, with closed questions on a linket scale from 1 (totally disagree) to 7 (totally agree).

The questionnaire consisted of one dependent variable (Organizational Performance) and two independent variables (Organizational Unlearning Practices and Organizational Culture). In addition, measures were taken to ensure the reliability of the data.

3.1 Socio-Demographic Profile of the Sample

The sample consisted of 47% female and 53% male participants. With regard to education, 88% of the respondents had a bachelor's degree and 12% a master's degree. As for age, 34% of the managers were aged between 38-47, 29% between 48-57, 20% between 28-37 and 18% were over 57. In terms of seniority in the organization, 52% had been with the company for more than 10 years, 26% between 6 and 10 years and 22% between 1 and 5 years. In terms of positions held, the most important were executive directors (5%), directors (24.7%), department heads (18%) and section heads (17%) and professionals from other areas (35%). The managers of two large ports took part in the survey, namely the port of Luanda (42%) and Lobito (58%).

3.2 Construction of Constructs and Reliability Analysis

Based on our hypotheses, three constructs were defined, namely unlearning practices, organizational performance and organizational culture.

Given the exploratory nature of the study, a reliability analysis was carried out using Cronbach's alpha, with the aim of verifying that the items in the constructs were internally consistent and properly interrelated.

4. Results

4.1 Reliability Test

Three constructs of the research model were tested and their reliability assessed using the Cronbach's alpha coefficient:

The first construct, referring to organizational unlearning practices, is made up of five *items* and showed α = 0.755, indicating good data reliability.

The second construct, related to organizational performance, obtained α = 0.735, also considered satisfactory.

The third construct, organizational culture, is made up of four items and showed α = 0.631, which, although less than ideal, is acceptable within the parameters of exploratory research and is classified as moderately reliable.

5. Hypothesis Testing

5.1 Correlation Analysis

Table 2: Pearson correlations

	PDO	DO	MCO
PDO	1	.916**	.980**
Sig. (2-tailed)		<.001	<.001
N	77	77	77
DO	.916**	1	.978**
Sig. (2-tailed)	<.001		<.001
N	77	77	77
COM	.980**	.978**	1
Sig. (2-tailed)	<.001	<.001	
N	77	77	77

To assess the linear relationship between the variables Organizational Unlearning Practices, Organizational Performance and Organizational Culture, a Pearson correlation analysis was carried out based on the 77 observations. The results shown in the table above indicate positive and statistically significant correlations between the variables analyzed. There is a strong correlation between ODP and OD (r=0.916; p< 0.001) indicating that an increase in one of these variables has an impact on the other. Similarly, we can observe the correlation between Organizational Performance and Organizational Culture (r=0.978; p< 0.001) indicating that organizational culture has a strong influence on organizational performance.

Table 3 - Linear regression with one variable

Regression

Entered/Removed Variables

Model	Entered Variables	Variables Removed	Method
1	PDO	.	Enter

a. Dependent Variable: DO

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,916	,839	,837	,27488

a. Predictors: (Constant), PDO

ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	29,458	1	29,458	389,867	<,001
Residual	5,667	75	,076		
Total	35,125	76			

a. Dependent Variable: DO

b. Predictors: (Constant), PDO

The results of the simple linear regression show that the Organizational Unlearning Practices variable is a strong predictor of the Organizational Performance variable, explaining 83.9% of the variance observed (R2=0.839). The model showed high statistical significance (p< 0.001) which reinforces the reliability of the data obtained.

These data allow us to accept hypothesis H1 that organizational performance practices influence organizational performance.

Entered/Removed Variables

Model	Entered Variables	Variables Removed	Method
1	COM	.	Enter

a. Dependent Variable: DO

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,978	,956	,956	,14307

a. Predictors: (Constant), MCO

ANOVA

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	33,590	1	33,590	1641,084	<,001
Residual	1,535	75	.020		
Total	35,125	76			

a. Dependent Variable: DO

b. Predictors: (Constant), MCO

We then analyzed the relationship between the organizational performance variable and organizational culture and checked it using a simple linear regression and the results indicate that the model is explanatory with high statistical significance (F (1.75) = 1641.084; p < 0.001), which shows that organizational culture has a strong explanatory capacity in relation to the dependent variable. The results show that organizational culture is positively related to organizational performance.

6. Discussions

The empirical results show that the hypotheses formulated and based on the literature, especially Tsang and Zahra (2008) were confirmed. A strong relationship was observed between unlearning practices and organizational performance, indicating that the more ports promote the conscious elimination of obsolete routines, procedures and beliefs, the higher the organization's performance tends to be.

In addition, organizational culture has also been shown to play an essential role in performance, which reinforces the importance of an organizational environment geared towards continuous learning, continuous innovation and the systematic discarding of obsolete practices.

Based on the data obtained from the 77 port managers of the ports of Lobito and Luanda, it was found that both organizational unlearning practices and organizational culture are positively associated with organizational performance; and, moreover, they are positively related to each other. Taken together, the results provide strong support for the proposed research model, demonstrating the robustness of the relationships between the variables studied and allowing hypotheses 1 and 2 to be confirmed.

7. Conclusions

Research indicates that unlearning is a phenomenon that can be studied in isolation from learning. It is therefore already possible to consider unlearning separately from organizational learning, since the organization can discontinue existing practices and routines without necessarily following through with the addition of a new routine (Holan and Philips, 2004; Tsang and Zhara, 2008).

This study has allowed us to conclude that both organizational unlearning practices and organizational culture have a significant and positive influence on the organizational performance of Angolan ports. These variables act as catalysts in the identification and elimination of obsolete routines, while at the same time providing the incorporation of more innovative practices and routines adapted to the current context.

The research hypotheses were empirically confirmed with statistically significant correlations between the constructs analyzed, which reinforces the interdependence between unlearning, organizational culture and performance.

In view of these findings, it is recommended that port managers invest in structured policies aimed at the systematic identification and elimination of obsolete routines, through clear procedures and objectives defined by management. When well understood and institutionally supported, these processes contribute significantly to strengthening innovation, competitiveness and sustainable performance.

7.1 Research Limitations

This study has limitations of various kinds, which must be taken into account when interpreting the results:

Firstly, it should be noted that only managers from the ports of Lobito and Luanda were interviewed, which is a geographical limitation of the sample. There is still no clear information on the possibility of alignment or divergence in the perceptions of the Ports of Cabinda and Namibe, which restricts the generalization of the findings for the Angolan port sector.

In addition, the sample size can be considered modest, considering the significant number of managers and employees working in different functional areas of the ports. This may limit the statistical representativeness and breadth of the analysis.

In addition, we believe that other relevant variables for understanding the perception of managers were not considered in this analysis, such as environmental changes, legislative changes or regulatory aspects that could have contributed to a more comprehensive and robust understanding of the phenomenon investigated.

7.2 Clues for Future Research

Future research could focus on more in-depth empirical studies, exploring, for example, managers' perceptions of organizational unlearning by analyzing the barriers to unlearning.

Another promising line of research involves analyzing the size and seniority of organizations in order to investigate how these variables influence resistance to change. Organizations with more entrenched practices and routines, due to their length of existence, may be more resistant to unlearning than newer, more flexible organizations.

We also suggest that studies be carried out to assess whether exposure to the external environment (international competition, regulation or technology) acts as an inducing factor for the creation of departments or internal mechanisms aimed at identifying and eliminating obsolete routines.

Finally, it is important to develop empirical research aimed at understanding how organizations are effectively unlearning management and operations practices. In this sense, it would be pertinent to apply the model of unlearning dimensions proposed by Yildiz (2020), which includes cognitive unlearning, behavioral unlearning and normative unlearning.

Acknowledgements

We would like to express our thanks to NECE for the institutional support and the conditions created for the development of this work, highlighting the academic and scientific environment provided which contributes to consolidating academic reflections.

We would also like to thank the anonymous reviewers for their constructive and useful comments.

AI declaration: This work has been reviewed using ChatGPT 2025 software to improve textual clarity and language (as the author of the article is not a native English speaker), as well as to correct grammatical and spelling errors. I declare that this software was not used at any time to create content for the research process. Its use was supervised and carefully reviewed by the author to ensure the accuracy and integrity of the information in this research. In addition, it should be noted that the article was reviewed after its completion using the international anti-plagiarism software Turnitin. We declare its use in a transparent, ethical and responsible manner, assuming full responsibility for the final content. We emphasize that there is no conflict of interest on the part of other parties involved.

Ethics declaration: We confirm that this article complies with the ethical principles of scientific research and is my own work. Whenever we have consulted works published by third parties, these have been clearly cited. We declare that this work and any part of it have not been previously submitted for any other purpose, evaluation or otherwise. We also confirm that we have obtained the informed consent of all persons involved in the work of this article, following the ethical guidelines of the school. We confirm that we have followed the Code of Conduct for Integrity while working on this manuscript.

Conflict of Interest Statement: We declare no conflict of interest.

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Appendix

Variables	Items	Contents
Organizational Unlearning Practices	PDO1	The organization continuously promotes the elimination of outdated routines.
	PDO2	The elimination of obsolete routines takes place in a structured and planned manner.
	PDO3	The organization recognizes the elimination of inefficient routines as positive and necessary.
	PDO4	Before eliminating processes, the organization carefully analyzes the impact on the bottom line.
	PDO5	Employees are trained to adopt new technological processes.
Organizational Performance	DO1	The new implementations contribute to greater operational efficiency.
	DO2	Customer satisfaction has increased with the adoption of new procedures.
	DO3	There was a significant reduction in accidents at work after the changes were implemented.
	DO4	The adoption of new routines has helped to reduce operating costs.
	DO5	The implementation of new procedures has made workers feel more valued.
Organizational Culture	CO1	The organization encourages employees to question established practices.
	CO2	Debates are held to assess the relevance of current processes.
	CO3	The organization offers training courses that encourage the abandonment of obsolete practices.
	CO4	Employee suggestions to replace obsolete practices are well received by the organization.

Parliamentary Organisation, History and Knowledge

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Abstract: This study elucidates how the historical and organisational evolution of parliamentary staff is related to the establishment and development of organisational knowledge resources within parliamentary institutions. The use of parliamentary staff reflects an effort to acquire institutional expertise, knowledge and professionalism in the legislative branch to counterbalance a perceived advantage within executive agencies. Parliamentary staff contribute to constructing organisational memory and knowledge, by shaping and sharing knowledge resources that support legislative processes. Parliamentary staff preserve continuity, institutional memory, and expertise. The rise of expertise and knowledge within parliamentary staff is related to the increasing organisational complexity over time of parliamentary administrations that enables parliamentary staff to develop knowledge capabilities assets that contribute to fostering the effectiveness and decision-making capacity of parliamentary bodies. The organisational and professional development of parliamentary staff helps improve knowledge capabilities and expertise, supporting parliaments in exerting influence on policy making.

Keywords: Organisation and knowledge, History and organisation, Parliamentary staff

1. Introduction

Parliament could not effectively perform institutional functions, concerning law making and policy making without the support of administrative and legislative parliamentary staff that exert influence on policy processes by expertise, professional advice and consulting (DeGregorio, 1975; Fox and Hammond, 1977), leading to autonomous and independent, effective and efficient working parliamentary institutions (Hammond, 1984; Romzek and Utter, 1977; Ryle, 1981). Parliamentary staff relies on expertise and knowledge acquisition, and professionalism in the legislative branch to counterbalance a perceived expertise advantage within executive branch agencies (Campbell and Laporte, 1981; Bontadini, 1983). Organisations need to acquire and generate knowledge, and invest on knowledge (Davenport and Prusak, 1998), and rely on knowledge and organisational infrastructures and capabilities (Gold, Malhotra and Segars, 2001). Parliamentary staff rely on knowledge assets and capabilities. The organisational design supports the rise and the improvement of knowledge within organisations. The research question refers to how the basics of organisational knowledge arise, and how knowledge management infrastructures are related to the organisational design and complexity. There are few studies that investigate the relationship between organisational knowledge management sources and the historical evolution of the organisational structure. The aim of this paper is to elucidate how organisational as well as historical development of parliamentary staff helps support the rise of knowledge sources and capabilities within the parliamentary organisation. This study relies on archival and qualitative data related to a review of literature in the field of law and history on the organisational development of parliamentary administrations. The study is descriptive and exploratory. The attentiveness to historical research and perspective in organisational analysis is rising. Historical narrative helps to understand the organisational phenomena and advance in organisation studies (Clark and Rowlinson, 2004). The organisational knowledge relates to historical development and evolution of parliaments as complex organisations that contribute to enabling knowledge-intensive resources and practices. It is important to explore how organisational knowledge sources are built and sustained historically in order to let people and structures may contribute to learning and knowledge organisational practices. The study is organised as follows. After introduction and theoretical background that refers to the relationships between knowledge, memory and organisations, the methodological section follows in the third paragraph. The fourth paragraph elucidates the relationship between knowledge development and the organisational complexity of parliamentary staff. The historical and organisational evolution and development of Italian parliamentary staff is presented in the fifth paragraph (1861-1907). Finally, discussion and conclusions are set out.

2. Knowledge, Memory and Organisations

Knowledge is an essential source that enables the organisations to develop successfully in long term horizon. According to Davenport and Prusak (1998) knowledge refers to a fluid mix of framed experiences, values, and contextual information, and expert insight to incorporate new experiences and information. Organisations need to create and improve knowledge assets and infrastructures to drive organisational success and learning. As stated by Gold, Malhotra and Segars (2001) organisations need of knowledge infrastructures, and rely on the organisational structure as a means to develop knowledge capabilities and processes. Organisations need to

enhance, preserve and maintain the knowledge assets (Freeze and Kulkarni, 2007). Singh Sandhawalia and Dalcher (2011) have stated that a knowledge management capability framework enables common understanding, and provides a track to implement knowledge-led initiatives. The organisational structures enable the rise of knowledge infrastructures and facilitates the development of a culture of knowledge within the organisation (Pandey and Dutta, 2013). Organisations need to develop continuously new knowledge sources in order to improve innovation processes (Vesperi, Reina, Ventura, Cristofaro and Melina, 2024), and contribute to value co-creation in order to identify new solutions for knowledge generation (Vesperi, Melina and Ventura, 2023). Organisations recognize knowledge sources in order to develop collective intelligence and support the skills of employees to create and enhance organisational knowledge infrastructures and resources (Bollinger and Smith, 2001). Organisations need to develop the organisational memory which helps store communicable and integrated knowledge (Walsh and Ungson, 1991), proceeding coherently with historical perspectives of organisational development (Booth and Rowlinson, 2006). Knowledge is embedded in routines, practices, systems, and people (Argote and Ingram, 2000). Organisational memory, routines, norms and professional expertise help support knowledge creation and knowledge retention (Argote and Miron-Spektor 2011). These knowledge sources evolve over time being influenced by organisational design and historical development (Levitt and March, 1988).

3. Methodological Section

The study refers to a qualitative, descriptive and exploratory methodology to analyse how organisational and historical evolution of parliamentary administration is related to the rise and development of knowledge sources and infrastructures that parliamentary staff develop to provide aide and assistance to parliamentary organisation and institution. The study focuses on one exploratory and illustrative case study concerning the historical and organisational development of parliamentary administration and staff within the Kingdom of Italy since 1861 to 1907. The case study helps to explore and provide a comprehensive understanding of a phenomenon in relation to the context whereas the boundaries are not clearly evident. The case study methodology follows an empirical inquiry without the rigidity of a predefined structure for observations and analysis (Yin, 2009). Historical analyses help understand organisational development and evolution in long term horizon (Kieser, 1994). History helps variable selection and hypotheses generation within a theoretical context (Üsdiken and Kieser, 2004; Üsdiken, Kipping and Engwall, 2011). The study relies on the analysis of literature in the field of law and history of parliamentary staff and administration. Reinterpreting the issues emerging in the literature coherently with the organisational setting helps us to appreciate how organisational knowledge is rising in relation to historical and organisational development in long term horizon.

4. Knowledge Development and Organisational Complexity Within Parliamentary Organisations

Parliaments depend on expert sources of information, knowledge and advice provided by parliamentary staff (Fox and Hammond, 1977). Parliaments have developed staff structures coherently with their own historical traditions and roles (Blishcke, 1981 Campbell and Laporte, 1981), relying on parliamentary staff which provide increased knowledge and expert advice (Cheli, 1983), and no partisan and independent assistance of the executive branch agencies (Finzi, 1934). The professional development of parliamentary staff relies on advanced stages of parliamentary system (Soddu, 1999) in relation to both the strategic role of Parliaments and the organisational evolution of parliamentary administrations (Chimenti, 1981). Staff structure is typically incremental, slow and fragmented (Chimenti, 1981; Ciaurro, 1983). The structure of parliamentary administration develops in several work units (Bontadini, 1983): the *substantial units* provide cognitive and consulting support and aide the operating work flow; the *vicarious* and *consultant units* enforce the legislative technique; the *technical* and *instrumental units* perform only executive tasks; the *formal units* translate law making in formal acts. Parliamentary staff rely on specialized knowledge, and influence the policy making process (DeGregorio, 1975). They contribute to expanding the pool of resources and information upon which Parliament draws (Malbin, 1977), developing knowledge and information sources and capabilities, providing technical and specialized assistance, consulting and advice on law making (Ciaurro, 1983). Parliamentary staff contribute to forging the expertise within the parliamentary institution, acting as custodians of historical and procedural memory, and interpreters of procedure and processes (Ferrari Zumbini, 1987; Negri, 1984), managing data and information, and making a knowledge-led and information-driven parliamentary organisation (Bontadini, 1983).

5. Historical and Organisational Evolution of Italian Parliamentary Staff (1861-1907)

According to the article 61 of the *Statuto Albertino* about the organisational autonomy of Parliament, the Senate and the Chamber of Deputies may exercise their prerogatives by internal regulations. Since 1851 the Chambers of Subalpine Parliament could draw up the budget without the assistance and support of Ministry of Interior, and without any discussion and proposal by government (since 1852). Parliamentary staff was grouped into four offices: the Office of Account and Minutes process; the Secretariat to aide parliamentary sittings, the Library and the Questura were responsible for administrative management. The Senate could use also three reviewers attending at the translation of stenographic. The Librarian-Archivist was in charge to keep the protocol and make and inventory of documents and papers (Pinto, 1983). Thereby, parliamentary staff was able to perform merely administrative tasks (Pacelli, 2001).

Principles of organisational flexibility were introduced with regards to internal regulations of Chamber of Deputies' administration (1863) (Traversa, 1997). Professionalism and knowledge capabilities of stenographs and reviewers increased and improved. Employees were hired by public examination (In Senate since 1869; in the Chamber after 1874 – for stenographs since 1866) (Pacelli, 2001).

The role of General Director which was directly accountable to the Bureau, at the apex of the parliamentary bureaucracy, was instituted with Francesco Crispi assuming the role of Speaker of the Chamber of Deputies (on 1876 November 21). The staff structure was transitioning from a decentralized design of autonomous and independent work units to hierarchical and centralized structure. In 1877 the Office of Speaker could appoint the Reviewer of minutes report instead of the whole assembly (Pinto, 1983). Support staff work units were grouped in one department which was articulated into six functional units under the administrative and political authority of Bureau (strategic apex): the Secretariat; the Questura; the Revision; the Stenography; the Library and the Archive.

Since 1892-1893, as a proactive legislature, the Chamber of Deputies played an effective and political role in order to support the Giolitti's policies that contributed to modernising administrative government and public services (Pacelli, 2000). Parliament could play a proactive role on discussion and examination of laws instead of overseeing public policies implemented by the executive authority and government (Montaldo, 2001). At the beginning of the 20th century the organisational structure of parliamentary administration at Chamber of Deputies developed as centralized and vertical design. The Bureau was the key part of organisation. The Services were: the Secretariat and Archive, the Questura and Post, the Library, the Compiler of minutes process, the Review, the Stenography (Pinto, 1983). The design of the structure helped maintaining the physical facilities, accounting management for its expenditures, and providing transcripts of its debates (Chimenti, 1994; Ciaurro, 1983).

The parliamentary institution needed to reinforce the information and knowledge sources, and the quality of legislative documentation, study and research, and to improve the quality of human resources and professionalism of staff in order to improve, enabling the parliamentary staff to provide aide to the legislators with regards to the policy process. With regards to the increasing workload of legislature, the Speaker of the Chamber needed to be assisted by a top administrative manager who was able to provide expertise and develop knowledge and professional consulting in relation to the parliamentary procedure. With Giuseppe Marcora assuming the role of Speaker of the Chamber of Deputies (1904 November 20) the organisational design of governance mechanisms and structure could lead to parliamentary staff able to provide a legal, procedural and technical support and aide to deputies without being dependent of political parties. Bureau approved the distinction between legislative and administrative departments (1905 April 12) consistently with the organisational model of French National Assembly's bureaucracy (Pacelli, 2000).

The office of Secretary-General was instituted on 1907 June 2 (Pacelli, 1984). The lawyer Camillo Montalcini was appointed as the first Secretary-General on 1907 July 1 (Pacelli, 2000). Legislative and administrative services and work units were grouped in a structure articulated in four services: the Secretariat; the Office of minutes report; the Questure and the Library. The Director of the Questure was responsible on administrative matters and financial management. The Secretary-General should ensure the effective functioning of legislative and study support services in order to satisfy the deputies' demands about law making and procedure consulting, and let knowledge capabilities and assets develop. The Secretariat was structured into several work units: the Archive; the Review; the Stenography and the Legislative Statistics (Pacelli, 2000). As a professional advisor and expert on law and parliamentary procedures, the Secretary-General might support the Speaker in parliamentary sessions, and keep the archives and minutes report of Bureau, acting as *primus inter pares* among the senior officials. Professionalism and specialization of staff on parliamentary procedure and law improved in relation to

the operational complexity of work units. As a custodian of praxis and procedural regulations, parliamentary staff could play an autonomous and institutional role by developing knowledge capabilities to support the parliamentary institution and organisation (Pinto, 1983; Traversa, 1997; Pacelli, 1984).

6. Discussion, Implications and Conclusions

The rise of knowledge infrastructures and sources is related to the organisational complexity and design of parliamentary administration. Parliamentary staff may contribute to increased knowledge sources and professional capabilities, leading to knowledge management and sharing practices. The organisational development of parliamentary administrations supports the rise of knowledge sources and infrastructures that improve the parliamentary workload, and contribute to the organisational learning of parliamentary systems and structures. More competent and knowledge-led the staff, the more alternatives it will cover. The support of parliamentary staff to the legislative body will be depending on knowledge sources, coherently with the organisational development of Parliament and the complexity of its administrative support staff or apparatus. The increasing professionalization of staff in the fields of law and interpretation of procedure influenced the strategic behaviours of the legislature, leading to an increased organisational knowledge, and enabling knowledge sharing and management within the structure of parliamentary staff. The organisation design and the rise of knowledge sources are strictly dependent on historical, managerial and organisational development of parliamentary institutions. Professional, knowledge-led empowerment and organisational autonomy of parliamentary staff enable the parliamentary staff to provide both no partisan and technical support and aide to Members of Parliament, providing knowledge and information sources. Professionalism and knowledge-led competences of parliamentary staff may improve in relation to increasing strategic and organisational evolution of parliamentary administration. There are managerial and organisational implications. Advanced stages of parliamentary system and organisation support the rise of knowledge and information sources and infrastructures, leading to professional development of parliamentary staff. The organisational design enables the rise of knowledge assets and capabilities. The rise and the implementation of knowledge sources and infrastructures relies on managerial competences and development. Professional development of parliamentary staff helps improve knowledge capabilities and sources. Parliaments should invest in organisational design and knowledge sources in order to improve the performances and of parliamentary staff. This study is mainly descriptive and exploratory. There are several limitations. Historical research and analysis on the organisation design and practices of Italian parliamentary administrations should be completed. Future research implies to investigate the relationship between knowledge management practices, human resource management and professional development of parliamentary staff.

Ethical statement: I declare that any ethical clearance was required for the research.

AI statement: I declare that AI tool were not used to create this paper.

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Types of Knowledge Transfer to Students Through Experiential Learning

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Abstract: The purpose of the article is to analyse students' perceptions of how tacit or explicit knowledge is transferred after participating in courses and seminars that use an experiential learning method (such as learning a new software product, involvement in business games, or participating in a business plan presentation event during a local competition of this kind). Edgar Dale states that: we remember 10% of what we read, 20% of what we hear, 30% of what we see, 50% of what we see and hear, 70% of what we discuss with others, and 90% of what we personally experience (simulate a model or experience a phenomenon, design/perform a presentation/experiment) (Dale, 1969). The research on the type and volume of knowledge transferred included a qualitative component based on interviews with teachers who applied the mentioned teaching methods, as well as a quantitative component using a questionnaire developed from a bibliographic analysis of articles focused on methodologies in educational sciences, knowledge management, and business games. The qualitative instrument was applied to a sample of management students from various universities who had previously participated in the types of activities described. The quantitative data collected was analysed using statistical applications, while the qualitative responses were processed with Atlas.ti.

Keywords: Knowledge, Transfer, Experiential learning, Business games, Students

1. Introduction

The transfer of explicit or implicit knowledge from teachers to students is the reason for the education system. In today's world, where students are heavily influenced by technology and quickly lose the ability to focus on educational tasks, teachers need to find and use other methods or strategies, and one of them could be experiential learning. This form of education focuses on the idea that the best way to learn things is through experience because it stays in the mind and helps students retain information and remember facts (Gorghiu, et al, 2016). Experiential learning provides students with the opportunity to actively engage in the acquisition of skills and knowledge (Gross et al, 2017). Students participate in a concrete experience (Do), repeat that experience and other evidence (Reflect), develop theories in accordance with the experience and information (Think), and formulate an assumption or discuss a problem (Apply) (Kong, 2021). According to Kolb (1984), learning is the process by which knowledge is created through the transformation of experience, where the reason for this process must be continuous and is not an independent entity that is acquired or passed on. A good implementation of such a form of learning offers the teacher the opportunity to follow how the students absorb the knowledge imparted and how it is subsequently applied in the case of a practical experience based on simulation games. Information conveyed through traditional methods seems boring and very often attention is drawn to the surrounding technological devices (when a message on a social network is much more important than an explanation by the teacher). We observe, at least hypothetically, a change in the role of the teacher in the relationship with the student, which is why different teaching methods must be analysed and implemented on a large scale so that the transmission of knowledge corresponds to the way in which they accumulate and learn (there are many examples in which courses in PDF format are converted into podcasts with the help of artificial intelligence applications and listened to at times when the young person uses different means of transport, attends other meetings, etc.). Knowledge is understood as a spectrum of rational, emotional and spiritual areas of knowledge, which is why learning is not understood as a simple transfer of knowledge, but as a complex process of perception, reflection and structuring of meanings from direct experience to abstract thinking (Brătianu and Vătămănescu, 2017). Simulations are a form of active learning, but few studies have looked at the most effective way to teach students how to use simulation for better learning transfer (Mayer et

al., 2011). The study is the first part of a large-scale research project to find out how different types of knowledge are taught through business games or other experiential learning methods - using a software application for product design, role-playing, practical projects, social experiments, etc.

2. Literature Review

Education is the most important form that leads to the development of society, which, influenced by technology, is in a constant state of change, through properly orientated investment. Under the current conditions, the role of researchers is to investigate, identify and apply various methods of knowledge transfer to current and future generations of students, as higher education is considered the centre where knowledge is created and transferred to society, and also a centre of learning for society (Dhamdhere, 2015). In our opinion, one of these methods could be experiential learning, as role plays, real projects, business games, product design offer students the opportunity to observe an immediate outcome by putting them in an almost real situation: managing a simulated organisation through business games, creating promotional material or designing a product in different software applications: Corel Draw, AutoCAD, SketchUp, discovering personal or group skills through role-playing (simulated interviews, observations, focus groups, etc.), participating in a session to support an investment project carried out in a specific field of expertise together with colleagues or friends, or organising an event from concept to the last guest, or digital learning using VR or other technologies. These forms of education based on practical experience enable both the teacher and the learner to understand and solve complex decision-making problems and thus acquire tacit knowledge. According to Vidya, explicit knowledge is easy to learn and disseminate because it is teachable, encodable, articulable, observable and simple, while tacit knowledge is difficult to express or document through formal language because it is felt, observed and experienced (Vidya et al., 2019). Su and Li believe that the knowledge transfer process is influenced by the following factors: the dimension of the transfer subject, the dimension of the transfer behaviour and the dimension of the transfer context (Su and Li, 2020). Tacit knowledge refers to skills, abilities and individual achievements acquired through experience, which is why alternative terms are used to describe this knowledge: Experiential knowledge, social knowledge, “know-how” knowledge (Bibolli et al., 2021) and contains two components: a technical component reflecting the know-how of professional activities and a cognitive component reflecting mental models, beliefs and perceptions (Lefter et al., 2011), experiential learning provides students with the opportunity to develop both of these components because the games make learning conscious, require them to think about the outcomes of the simulation enterprise, and make decisions in the context of the competition. Characterised by stickiness (memory is attention in the past tense), the knowledge transfer process requires two sequences of steps for good performance: firstly 'learning before doing' or secondly experimenting in a constructed environment before the knowledge is actually applied by the recipient — and then 'learning by doing' (Szulanski, 2000). Tacit knowledge, depends the capacity of person to act and experiment because they are not verbalized or articulated, became difficult to describe or explicated (Chang et al. 2014). According to Reber, a psychologist, who suggest that connect this type of knowledge with experiential learning: 1) Tacit learning is the foundation of obtaining tacit knowledge and it is also the representative and summary of environment structure; 2) the best way of acquiring tacit knowledge is unconscious learning; and 3) Tacit knowledge can be used in problem solving and to make a reasonable judgment.

For this situation, the common methods to transferring are: *knowledge capture* is a process that involves extraction of knowledge or experiential matter from teacher and colleagues (Dzekashu and McCollum, 2014) and includes identifying, collecting, sharing and applying (Wang et al, 2022, Sagiter, 2014). The concept is relevant in experiential learning because after the knowledge is captured, it must then be located by a potential reuse (Delugach et al., 2016). The captured knowledge are necessary in these didactic activities, while they are being executed, (Kamara et al, 2003) can be easily applied in the next stages of the exercises proposed for solving; *knowledge elicitation*, part of knowledge acquisition, is typically followed by distillation to extract key lessons and insights in concise form suitable for transferring (Cook, 1994, Sagiter, 2014) or according to Gavrilova and Andreeva methods and tools to capturing and validating expert’s knowledge as efficient and effective as possible (Gavrilova and Andreeva, 2012). Knowledge elicitation difficulties occur because expert knowledge can manifest itself in diverse formats, and it is challenging to effectively utilize all of these different formats (Bockting, Radev and Burkner, 2024); *knowledge distillation* a comprehensive method, to transfer efficiently complex knowledge from one model – the teacher – to another model – the students (Dou, Ye and Wang, 2023; Sabah et al. 2024). This form of transfer requires, in our opinion, a series of motivational factors from both sides: the teacher to apply teaching methods adapted to the characteristics as the students and the young people to be cognitively connected for a period of time (students report attention declines of 1 min or less more often than longer attention lapses (Bunce et al. 2010) to the information transmitted through the teacher's message.

3. Methodology

3.1 Nature of the Study

This study is the first part of a comprehensive investigation aimed at tracing the ways in which knowledge is transmitted from teacher to student through forms of experiential learning: Role-play, real-life projects, simulation games, product design. The current study aims to find out what management skills students believe they can develop through experiential knowledge transfer before actually participating in business games, after the rules of the game have been presented and they have made the first decision, but without knowing the results obtained. Analysing the way in which a complex simulation exercise is perceived, explaining to students how the knowledge taught by teachers taking specific courses in management is used and the practical implications of applying the acquired skills, can show how knowledge transfer has been achieved and how students apply the acquired knowledge.

The second part of the research will be carried out after the completion of participation in business games, but also in other didactic activities based on the use of product design, role-playing and project development applications, in order to capture and evaluate the way in which young people acquire knowledge.

3.2 The Research Instrument

The research instrument we propose and test is a questionnaire containing the following:

- The informed consent to participate in this study and the way in which students were told how they could use the information provided if there were any questions that were clarified by the research team's responses.
- A question about the extent to which they feel they will apply the knowledge gained in the disciplines previously studied that has implications for participation in simulation games;
- A question about how the information learnt and accumulated in previously studied disciplines will enable them to solve decision-making problems in simulation games.
- A question about whether the information provided by the animator during the presentation of the game was clear and precise;
- Question about how the animator encouraged the students to make mistakes, because "mistakes are the most important ingredient for success" (Thomas Edison);
- Five questions on the extent to which participation in the game enables the development of management skills, such as Re-evaluation of beliefs about the way they learn (Learning_change_mode), discovery of entrepreneurial skills (Entrep_skills), discovery of managerial skills (Manager_skills), ability to experiment (Experimental_skills);
- The scale was a Likert scale from one to five: very little, a little, neutral, a lot and a lot, which enabled us to determine the way in which the students collect and use the knowledge imparted for the development of skills and abilities in the sense of Kolb's Experiential Learning Cycle (Kolb, 1984). The survey was conducted online. Google Forms were used and the data was collected between 17 and 21 March 2025. We received 86 responses from the students who were willing to participate in the simulation exercise.

3.3 The Sample

The respondents are third-year students, the final semester of the management specialisation, who have business games as part of their curriculum, and the 86 represent approximately 78% of all 110 students enrolled.

3.4 Methods and Techniques Used for Data Analysis

Microsoft Excel and R Stata were used to analyse the data. Since the purpose of the analysis was to find out how students perceive the way in which an organisation's management knowledge was transferred and captured in the above study programme to be used in the case of a practical simulation exercise, and how participating in a form of experiential learning activity develops their management skills and decision-making ability, we consider a descriptive analysis useful to achieve the proposed objectives.

4. Results

The way in which students considered the previously studied curriculum subjects to be valuable in solving the requirements and determining the specific simulation game decisions after being presented with the rules of the game and making their first decisions in simulation games is shown graphically in Figure 1. It can be seen

that there are some subjects that are considered relevant, perhaps also due to the fact that the scenario proposed by the simulation games is a specific scenario for an electronic equipment manufacturing company, where the decisions regarding the production processes were important in the first decision sequence, compared to the individual marketing elements (price, product, promotion, demand), which were evaluated at an average level, as their influence increases as we progress with the decisions in the sequences. The answers given to the discipline of financial management are interesting because they were told that they do not have the ability to manage financial flows, that the use of money and the financial balance sheet of the simulated company are viewed with interest, which means that the knowledge captured has been transferred and is being used. Many neutral answers refer to disciplines such as human resources management, accounting and quality management, because as I said before, these were only applied to a very limited extent in the first phase, and in the following phases, as their influence increases, they will be interested in asking the animator or thinking strategies in these directions as well.

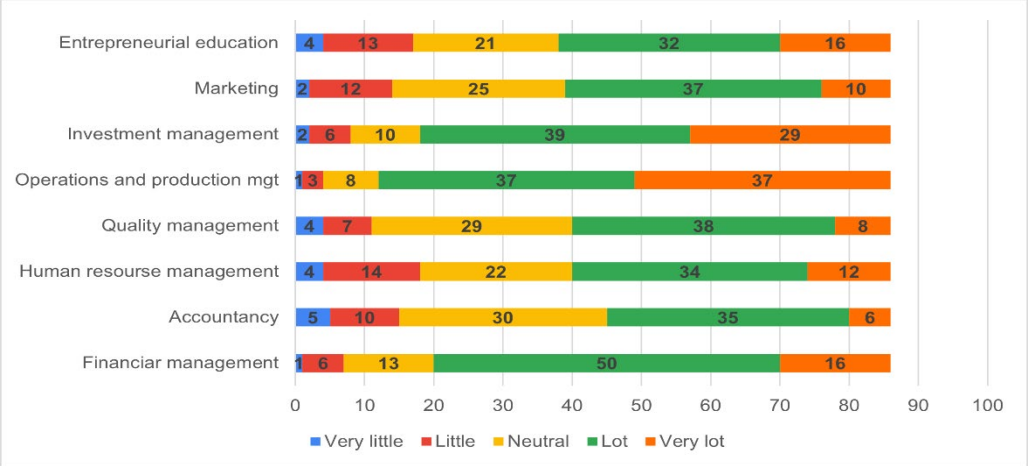


Figure 1: Distribution of answers regarding the importance of business games of the knowledge gained in other disciplines of the program curriculum

The numerical distribution of responses to each component of the Likert scale and the descriptive statistics for the variables considered are shown in Table 1. The median, which measures the central tendency of the responses, shows that the knowledge acquired in most subjects will help them "very much" in solving the requirements of business games. An exception is the financial accounting course, where the median is 3, which means a "neutral" situation. The average of the answers varies depending on the discipline, but as we have already mentioned, it is influenced by the time of decision making. It can be observed that the influence of information gathered in disciplines such as production and operations management, investment management, financial management is higher than in courses where the average is between [3.43 – 3.47], and financial accounting with 3.30.

Table 1: Descriptive statistics regarding the respondents' opinions on how the studied disciplines will help them in solving business game situations

Variables/curriculum courses	Min	Median	Mean	Max
Financial management	1	4.00	3.86	5
Accountancy	1	3.00	3.30	5
Human resource management	1	4.00	3.43	5
Quality management	1	4.00	3.46	5
Operations and production mgt	1	4.00	4.23	5
Investment management	1	4.00	4.00	5
Marketing	1	4.00	3.47	5
Entrepreneurial education	1	4.00	3.46	5

One aspect to consider in the transfer of knowledge in the case of experiential learning is the way in which the animator (teacher) presents the way of working in business games to the participants (students). The presentation is based on a manual for the participants that is available 24/7, where each decision component is

interpreted and discussed. The evaluation of this aspect is important because, depending on the quantity and quality of knowledge acquired, students are able to solve the decision problems of each sequence in the game (out of a total of six decision periods). 78% of respondents rated the way the rules of the game were presented with 5 stars, Figure 2.

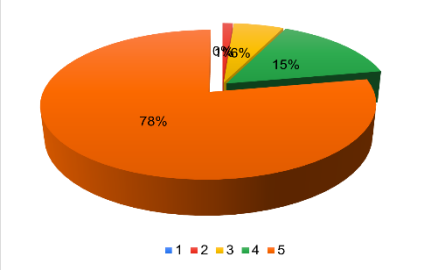


Figure 2: Percentage of grades awarded for the way business game rules were presented

Thomas Edison said that "mistakes are the most important ingredient for success". We believe that this statement is essential for experiential learning through business games, because the simulated environment allows students to interpret and observe the impact of the decisions made based on the results presented, using many performance indicators of an organisation. Even if the simulation is different from reality, it has a great pedagogical advantage, since the reduction of reality to a limited number of parameters makes it possible to illustrate the essential mechanisms and their interaction in a short time, but also a practical difficulty, since the modelling, however realistic it may be, is subject to simplistic (and therefore reductionist) rules. The mistakes made are immediately visible and analysed, understood and correctly interpreted so that they can be quickly corrected, but also so that the effects of the new decisions can be observed. The answers to this question had a scale from "1 - very small extent" to "5 - very large extent". The results of the survey are shown in Figure 3, from which we can see that 55% of respondents gave a score of "5", which means that the teacher encourages them to a very large extent to make mistakes in order to learn.

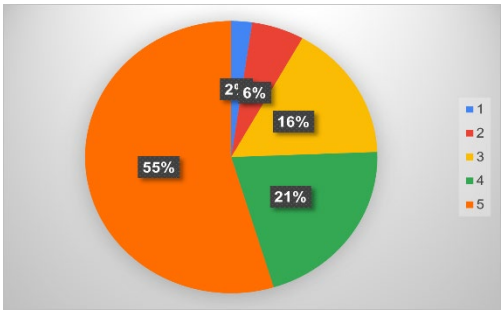


Figure 3: Percentage of grades awarded for the way the teacher encourages me to make mistakes

Using descriptive statistics, we wanted to measure the impact of knowledge transfer and the extent of knowledge acquisition on the results obtained by students when participating in simulation games (Table 2). On average, respondents felt that the knowledge used in the game from previous disciplines (3.68) and the quality of the presentation of the simulation games (4.69) were important for the decisions to be made in the simulation game sequences (3.70). They were encouraged to make mistakes (4.19), but they are not emotionally affected by the loss of the game (3.22), a characteristic that has been intensively observed in generations of young people in recent years, and are in no way influenced by the results achieved in the learning process.

Table 2: Descriptive statistics regarding the respondents' opinions impacts of knowledge acquisition

Variables/curriculum courses	Min	Median	Mean	Max
Useful knowledge transfer for other courses	1	4.00	3.68	5
Quality of business games presentation	2	5.00	4.69	5
Knowledge acquisition impact on quality of business game decision	1	4.00	3.70	5
Wrong impact of decisions in business games	1	4.00	4.19	5
Emotional effect of losing in business games	1	3.00	3.22	5

The correlation analysis (Table 3) between the variable quality of the presentation of simulation games (game_trans) and the re-evaluation of beliefs about the way they learn (Learning_change_mode) is r=0.33, p-value=0.0016, positive moderate, showing that respondents with a high level of knowledge acquisition through the presentation of games tend to adapt more easily to this experiential learning method. The statistical correlation between game_trans and entrepreneurial skills discovery (Entrep_skills) is positive, not very strong, but statistically significant with r=0.27, p-value=0.011, suggesting that knowledge accumulation through simulations might increase entrepreneurial skills, but similar is the correlation with entrepreneurial skills discovery (Manager_skills) with r=0.25 and p-value=0.016. A moderate to strong positive correlation exists between the quality of simulation game presentation (game_trans) and the ability to experiment (Experimental_skills), with a value of r=0.39 and p-value = 0.0001, which means that the more respondents participate in simulation exercises and the stronger their engagement, the greater the likelihood of developing exploration skills, testing and analysing the knowledge conveyed. This result means that the method of comprehensive knowledge distillation, efficient knowledge transfer from teacher to student works for the study participants.

Table 3: Correlation analysis between the quality of the information transmitted and skills acquired through business games

Variables	Game_trans	Learning_change_ mode	Entrep_skills	Manager_skills	Experimental_skills
quality of business games presentation (Game_trans)	1.00	r = 0.33 p-Value = 0.0016	r = 0.27 p-Value = 0.011	r = 0.25 p-Value = 0.016	r = 0.39 p-Value = 0.0001

5. Discussion

The effect of experiential learning on the study participants is somewhat cautious because, as it is a new form that differs from the classical form, the students do not trust that knowledge can be easily accumulated through simulation exercises. One aspect that was also explored was how they find the information accumulated in other disciplines from the university curricula specific to an educational management programme useful to understand and identify a number of aspects that could be improved within these courses so that the knowledge acquisition is relevant and meets the requirements of the local or national socio-economic environment. In addition, the knowledge discussed in these courses is absorbed by the students and becomes useful in the successive decisions that have to be made in business games. The way in which they accumulate their knowledge through knowledge elicitation, a part of knowledge acquisition, from the animator, who is an expert in this type of simulation, depends on how much attention they pay to the classic form of learning activity, which includes elements of analysis but also visualisation through writing down each aspect on the board. The results obtained show that the respondents were attentive and absorbed the information conveyed, but the next phase of the investigation at the end of participation will show whether the knowledge acquired was useful.

The emotional impact of participating in a simulation exercise is lower and students are not affected by the results obtained, which is why we can say that engagement is lower in the first phases and at the end, when the activity becomes exciting, competition between the teams involved is strong. The quality of the knowledge transfer is evaluated by the impact of its application by the students and how they consider that it affects their training as future professionals in management or entrepreneurship, which means that the process of knowledge distillation is applied in the form of experiential education facilitated by simulations of decision-making. In addition, it was also assessed whether this form of experiential learning changes the way knowledge is acquired, but since the respondents are still at the beginning, they could not measure whether this method hinders their ability to accumulate knowledge. The strong link with the ability to experiment is normal, as learning happens through experience, so the animator's requirement to make mistakes is likely to be successfully realised.

Not many scientific publication analyses how knowledge is transferred from teacher to learner in this form of learning, as the teacher will seek to transfer explicit knowledge that is easy to understand and apply, as opposed to the tacit knowledge that needs to pass through the learner's mental filter and be adapted to the specific organisational context. There are a variety of ways to encourage students to study the manual and rely on their own mental effort (Mayer et al., 2011). Very often the teacher encourages the student to read the material and with technological development the idea of critical thinking and contextual analysis is easily abandoned. The novelty of the study is that we seek to identify and explore the tacit knowledge that can be transferred through

the form of experiential learning and to look for ways in which the introduction of business games into students' education would increase awareness of the information conveyed by the teacher that can later be applied in specific organisational contexts (general management decisions, production, marketing, sales, human resources, etc.). This form of transfer based on business games could encourage students and employees to apply the knowledge acquired in business school or training programmes in working conditions (Lovin et al., 2021).

6. Conclusion

The need to identify and apply new forms of learning in the educational processes of university education is high in this period when students are influenced by the speed with which the economic, social and technological environment is changing. The research aimed to measure the way in which management knowledge is transferred, in a period somewhat on the border between classical learning, because the animator is obliged to present and explain the rules, a high volume of information offered in a short period of time, often considered boring by students (the frequent question is also us when we playing business games) and the first decision-making sequence in business. The results obtained confirm the fact that the students still do not trust that they will participate in a different course, in which they are convinced that have to use much of the knowledge accumulated in the previous disciplines, but without the experience of a job, they do not yet clearly understand the impact that could have in the case of a decision-making process. The simulation offers that virtual space for testing existing skills but also the development of new ones, considered perhaps not very relevant, provides understanding of the economic environment of business games and is supported to test the effects of certain theoretical or practical concepts that have been obtained during their university education.

Ethics declaration: Ethical clearance was not required for the research.

AI declaration: AI tools have not been used for the creation of the paper.

Acknowledgement

The European Commission's (EACEA) support to produce this publication, through Jean Monnet Module. Proiect 101127556 — EU Resilience Digital Skills - EU-ReDiSkills — ERASMUS-JMO-2023-HEI-TCH-RSCH, does not constitute an endorsement of the contents, which reflect the views only of the authors. Neither the European Union nor the granting authority can be held responsible for them.

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Exploring University Student Perceptions on Family Business: Career Choices and Knowledge Management

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Abstract: Family businesses are entrepreneurial organizations that are based on a mix between orientation towards corporate values and orientation towards family values (Lumpkin, et al., 2008; Davila, et al., 2024). At the same time, family businesses are a more widespread form of entrepreneurship around the world (Melina, et al., 2024; Vesperi, et al., 2024). For this reason, family businesses have attracted the attention of scholars and practitioners for decades. The aim of this article is to analyze the perceptions of students, enrolled in the last year of university and about to enter the labor market, regarding their propensity to work in a family business compared to a non-family business. Furthermore, the study seeks to clarify which factors push new graduates to choose to work in a family business. To achieve the objective, this study is based on a mixed qualitative-quantitative methodology. A semi-structured questionnaire was administered to students belonging to 5 Italian universities with the same study background. A semi-structured questionnaire was created as the main source for data collection. The questionnaire, divided into different sections, allowed to collect both qualitative and quantitative data and information. Furthermore, alternatives were identified that allowed the use of the AHP method with the Saaty matrix (Saaty, 1990; 2008; Fattoruso, et al., 2023). The results of this study highlight two fundamental aspects. The first aspect is related to the preferences that university students have in the propensity of their career choice. The second aspect is related to university-work policies. This study is not without limitations. The originality of this study is based on the use of the methodology for the assessment of university students' perception. In addition, this study highlights the preferences and alternative criteria that university students use for their career choice.

Keywords: Family business, Career choice, University student, Knowledge management, Mixed-Methods research

1. Introduction

Family businesses represent a significant percentage of the total number of companies globally and the backbone of many economies around the world.

Family businesses are a more widespread form of entrepreneurship around the world (Melina, et al., 2024; Vesperi, et al., 2024).

There are many reasons why they are created, but the common factor is the natural presence of a value system, the willingness to demonstrate dedication and sacrifice, and a sense of responsibility towards those who founded the business and those who take over its management.

In addition to this main objective, family businesses are characterized by specific distinctive elements such as their entrepreneurial style, choice of strategic objectives, internationalization and, last but not least, their approach to innovation.

Family businesses are entrepreneurial organizations that are based on a mix between orientation towards corporate values and orientation towards family values (Lumpkin, et al., 2008; Davila, et al., 2024).

They are a source of economic growth and employment.

On this basis, the aim of this article is to analyze the perceptions of students, enrolled in the last year of university and about to enter the labor market, regarding their propensity to work in a family business compared to a non-family business.

Furthermore, the study seeks to clarify which factors push new graduates to choose to work in a family business.

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This study is not without limitations. The originality of this study is based on the use of the methodology for the assessment of university students' perception. In addition, this study highlights the preferences and alternative criteria that university students use for their career choice.

2. Theoretical Framework

2.1 Family Business: Role and Organizational Elements

Family businesses are now a widespread phenomenon throughout the world. Family Firms play a significant role in the current economic system. FFs are organizations in which two or more family members influence the making strategic choices (Tagiuri and Davis, 1996) through the exercise of family ties, management roles or property rights. In FF there is a unique interaction between “family system” and the “business system”.

Kellermanns et al. (2008) argue that FF must satisfy at least one of three criteria: (i) being family ruled/managed, (ii) having a vision for the company consistent with the strategic direction held by the family and (iii) be potentially sustainable across multiple generation in the organization. The influence of the family, in business system, can vary over time e it can be manifested in many different ways (Astrachan et al., 2002).

According Poutziouris et al (2008) family business can be seen as a "metasystem" composed of three subsystems such as (1) the family control unit that represents the history, the tradition of the family; (2) the business complex, i.e. the structure and, with it, the strategies necessary to create value; finally we have (3) the family members, bearers of knowledge, skills and interests.

Numerous definitions are present in the literature, even today, a single and generally accepted notion has not been identified (Littunen et al, 2000).

The problem is that each company is its own and unique reality. Starting from this consideration, it is possible to develop different definitions, each linked to a specific aspect of this phenomenon. It is therefore necessary to identify some guiding variables of the company-family relationship and their degree of intensity necessary for a company to be judged as, precisely, of "family".

In literature there are three possible ways to consider to arrive at a notion, such as (1) the content, (2) the purpose and (3) the form of the company.

Donkels et al (1991) state that the most considered concept is the first and, more precisely, that of "control". However, it becomes appropriate to also consider other variables to be able to classify the company. Here the powers of governance and management of the family members come into play who, despite the participation of third parties in the capital, must maintain the prevalent influence.

According Astrachan et al (1996) it is therefore possible to define three concepts of family business, depending on the intensity of the family's involvement: a) restrictive approach according to which a family business is one in which the risk capital providers and the workers belong to a single family or to a few families united by kinship or affinity. According to this notion, family businesses will be mainly SMEs operating in the commercial, artisanal and service sectors, in which the economic subjects are members of the family. Here there is often confusion between the assets of the two institutions, business and family, the two systems almost coincide. This definition therefore requires the direct involvement of family members in business operations and their managerial responsibility b) medium approach is the one based on the reciprocal conditioning of one or a few families, linked by ties of kinship or affinity, holders of the risk capital provided. In this case, the company is defined as a type of “mixed” company. This notion is often adopted in North American countries where exponents such as P. Davis (1983) require that the policy and the general management be strongly influenced by members of the family.

Therefore, small, medium and large-sized companies can be included here in which the reciprocal influence has a strong intensity because the family members assume the general management or the role of exclusive governance in the Board of Directors or, simply, are the bearers of the entire risk capital or a significant share of it. However, the conditioning can also be presented in a less intensive form, admitting the participation of third parties in the capital, control and management of the company.

In any case, the presence of the founder or descendants and the constant involvement of these in the life of the company is necessary. The definitions within this category can therefore be classified based on the intensity of the emphasis placed on one of the following aspects, namely the ownership of the risk capital, control understood as the exercise of powers and, finally, the management of the company c) broad approach according to which the family must maintain a certain degree of control over the strategic direction of the company. Therefore, a family business is also considered to be an institution in which a family member influences business decisions indirectly, through directives to the CEO or the possession of a significant share of capital.

In light of what has been said so far, family businesses are complex systems characterized by the intense and continuous interaction between two distinct subsystems intertwined by mutual relationships, the business and the family. In family businesses, the conditions of existence and life events are different from those of traditional non-family businesses.

In many cases, the family nature presents an indisputable strength, as a source of competitive advantage, allowing the company to develop unique resources, because there is a conscious and responsible ownership and management that can bring tangible benefits in terms of continuity and development. Therefore, the link between the family system and the business system can be read, in a positive sense, in an empowerment perspective: the business gives power and unity to the family and the family, in turn, gives solidity and continuous vigor to the business. This interaction triggers a virtuous circle that benefits the family-business system as a whole, facilitating its evolutionary path towards success.

Whether small, medium or large, family businesses represent the direct manifestation of freedom of economic initiative and provide a fundamental contribution to employment and the economic and social development of the system.

2.2 Family Business and Employment: The Importance of Knowledge

Family businesses represent a significant part of the global economic landscape, contributing substantially to employment. Some authors consider the "family" component as a positive aspect within the family business and have emphasized the advantages that these companies have compared to other types of organizations and therefore can be more attractive from an employment point of view. Among the main ones we highlight:

- The working climate: characterized by the "sense of belonging" and the "spirit of sacrifice" present in all or almost all family members (Gersick et al., 1997; Sharma et al., 1997; Habbershon & Williams, 1999). The deep sense of belonging that the entrepreneur usually manifests for the family business translates into dedication and commitment, not only his own, but that of all the people who work in the company. People feel part of a big project and see it as their job contributes to achieving the company's objectives. For these reasons, they devote much of their time and energy to the family business and do so by choice, rather than out of obligation.
- Lower costs: HR costs are usually lower (recruitment, selection, etc.). In addition, family businesses offer more flexible work. In addition, they require lower monitoring and control costs and use leaner and more efficient organizational structures. In addition, agency and decision-making costs are also lower due to the simplified structure and the direct relationship between owners, managers, and family members (Chrisman et al., 2004).
- Less bureaucracy: which manifests itself in greater flexibility and speed in the decision-making process. Family businesses have a greater ability to adapt to environmental changes. This is due, fundamentally, to their less rigid structures and the informal systems that characterize them. In addition, they have a colloquial language that allows them to communicate more directly and exchange information more easily (Lu et al., 2013).
- Greater commitment to the corporate mission: an aspect directly related to the sense of belonging to the family business.
- The family business has a stronger reputation and relationship system with different stakeholders and is much more valued than the rest of the organizations. (Sharma et al., 1997).
- The family business has greater capacity for long-term planning and investments (Ward, 1997; Steir, 2001). These companies are characterized by having a "patient capital", with the ability to invest in the n projects that offer long-term opportunities. Because of this ability to look long-term, family businesses are less responsive to business cycles and have a lower cost of capital. These general advantages highlighted say little about the origin of the family firm's competitive advantage (Habbershon & Williams, 1999). At the same time, it is not known how these advantages impact the

strategic direction processes of the family business, its economic performance, or the achievement of its main goals (Sharma et al., 1997). The family's participation in the company can be a source of competitive advantage or can cause its decline (Eddleston & Kellermanns, 2007). Among the negative aspects of these types of companies are: nepotism, altruism, the mix of economic movements between the family and the company, delays in succession, problems related to insufficient self-financing and limited possibility of raising risk capital, excessive dependence and attachment to the figure of the founder, the difficulty of attracting talented people, etc. On the one hand, we are aware that family businesses have characteristics that motivate their success, on the other hand, we must also be aware that these strengths can be represent lasting sources of competitive advantage only if the risk factors attributable to the link between family, business and entrepreneur are adequately managed. The central point is therefore found in the management of intangible resources, basically knowledge. The importance that these resources acquire is essentially due to the creation and development of certain skills, abilities, relationships, and knowledge that allow the family business to make a difference on the market compared to the competition. among the resources that the family business possesses, knowledge is certainly the most important (Wang & Noe, 2010; Duh, 2014). This is mainly due to the fact that knowledge has a differential characteristic, knowledge grows and multiplies, even exponentially, knowledge can be used, distributed and shared. Knowledge is seen as the sum of competences, skills and experiences applied by individuals in the form of theoretical knowledge and actions taken to solve different problems. It is not "only knowing", but also "knowing how to do" certain operations. This second aspect of some scholars is "skills".

Knowledge originates in the person's mind and to become organizational knowledge both ideas and ideals play a fundamental role (Nonaka, 1991). In the organization, knowledge is often embedded not only in documents or archives, but also in organizational routines, processes, practices, and different norms. It can include data and information as well as understanding gained through experience, education, or reason (Hatak & Roessl, 2014). Knowledge is a productive force in action, a working knowledge that acts as part of the production system as a whole, connecting the producing subjects to a common future perspective, a goal to be achieved.

According to Polany (1967), two types of knowledge can be transferred within the succession process in the family business: explicit knowledge is formal and systematic so that it can be easily shared and communicated (Grant, 1996). This is universal and is articulated in the form of documents and databases (Nonaka & von Krogh, 2008). On the other hand, tacit knowledge is very personal, it is difficult to formalize and for the same to communicate. It is deeply rooted in a person's action and compromise with a specific context. It consists of technical skills (knowing how to do something) and mental models (deeply held beliefs and perspectives that, so often, we take for granted). As a consequence of being difficult to imitate and replace, tacit knowledge occupies a central role in the development of a sustainable competitive advantage. Tacit knowledge is detected through its applications. The tacit character can also indicate the unawareness on the part of the operator who is in possession of it, in the sense that the latter does not realize his peculiar skills in the execution of certain tasks. If this knowledge cannot be codified, and can only be observed through its application and acquired through practice, its transfer between people is slow, costly and uncertain (Grant, 1996). Both knowledge are complementary and do not flow easily within the company (Cabrera-Suarez et al., 2001). In the family business, knowledge lies in the different people who work in the company, and especially in the entrepreneur (Cabrera-Suarez et al., 2001; Durst & Edvarsson, 2012). It is precisely the combination of tacit and explicit knowledge possessed by the entrepreneur that is the most important strategic resource of the family business .

Knowledge is the result of a learning process and presupposes not only a certain amount of information and the ability to connect it, but also the same ability to apply it to business and environmental situations that may arise. One of the main causes that give rise to the non-survival of many companies is the difficulty of learning, of transmitting and integrating knowledge, with the aim of generating a product/service that creates value for the customer and allows the continuity of the company. It is through the learning process that the company integrates, modifies and updates its wealth of knowledge. For the family business, it is not enough to have a number of comparative advantages compared to non-family businesses: the focus is on the internal aspects that allow it to sustain these advantages, update them and improve them constantly.

3. Methodology

To understand university students' perceptions of family businesses, this study was based on an exploratory and inductive methodology. This allowed the collection of qualitative and quantitative data, through a

methodological process divided into three phases: definition of research items, pilot testing and administration of the questionnaire, data collection and analysis.

The first phase - definition of research items - was oriented, through an analysis of the literature, to identify the items most consistent with the dimensions of the phenomenon and the research objective. Based on the analysis of the literature, a questionnaire was constructed consisting of 4 sections, with a total of 20 items, divided into various types (closed, open or multiple with a Likert scale from 1 "strongly disagree" to 5 "strongly agree"), and organized into thematic sections. The first section is oriented to collect socio-demographic data and information and on the profile of the academic path (for example, age, gender, degree course, work experience, expected time to graduation). The second section aimed at collecting university students' perceptions of family businesses, through comparative assessments between family businesses and non-family businesses. The next section was created to collect information on the propensity for a career in family businesses. Finally, the fourth section aimed at understanding the perception of the adequacy of university education to work in a family business. The compilation was voluntary, anonymous and compliant with GDPR 2016/679, with a request for informed consent at the beginning of the form.

In the second phase, a questionnaire was administered to a random sample of university students to make further changes and simplifications. In particular, the pilot test allowed to reduce the main errors, namely: i) use of language and terminology consistent with the target; ii) definition of the average compilation time; iii) elimination of unclear, ambiguous, confusing or incorrect items and iv) reduction of the "ceiling" effect and the "floor" effect.

Furthermore, the average time to complete the questionnaire was estimated at 8-14 minutes. The questionnaire was administered to students at different Italian universities through an online platform. From January to April 2025, 197 questionnaires were collected.

3.1 Participants Profile Information

Part I of the questionnaire allowed us to collect socio-demographic information on the participants. Based on this information, it is possible to contextualize the phenomenon. The questionnaires collected were 197 (100%), only 138 (70.05%) were considered correct and valid, and therefore, 59 (29.95%) were considered invalid or incomplete.

The 138 (100%) questionnaires considered valid were filled out by 52 (37.68%) of the male gender, 71 of the female gender (51.45%) and 15 (10.87%) of the “other” gender.

Male (59.73%) and 89 female (40.27%). It should be noted that the questionnaire included the gender field “I prefer not to answer”, but no one selected this option. Table 1, below, reports the main information of the respondents.

Table 1: Age and university dimension of the respondents

AGE			UNIVERSITY DIMENSION		
18-22	68	49,28%	**Small**	40	28,99%
23-27	35	25,36%	**Medium**	39	28,26%
28-33	35	25,36%	**Big**	59	42,75%

Source: Elaborated by the authors

In Table 1, 3 age groups of respondents were constructed. The largest age group is 18-22 (49.28%), the other two age groups 23-27 and 28-33 years, are equally represented (25.36%). Furthermore, in Table 1 a classification was created regarding the size of the universities from which the respondents came. The majority of respondents (42.75%) come from a large university, almost similar the participation of medium-sized (28.26%) and small-sized (28.99%) students.

The data analyses were calculated the frequency distributions, the percentage distribution and the means. The Pearson correlation coefficient (Pearson's r) was used to test the research hypotheses.

4. Results and Discussions

The study presents interesting results from different perspectives. The preliminary results of this study show that the curricular internship of the university course of study, for the majority of university students (about to enter the job market), represents the first work experience.

In fact, over 57% of respondents stated that they had no other work experience besides the curricular internship.

This data must be related to the fact that only 6.52% of the interviewees who carried out the curricular internship in a family business.

Despite this, in order to understand the perception of university students on family businesses, they were asked to provide the main elements that characterize a family business.

The answers are reported in table 2.

Table 2: Main themes of the students' definition of family businesses

MAIN THEME	N	%	REFERENCE PHRASES
Founder and ownership in family hands	40	28,99	- A business in which the family is both owner and manager - A business founded and managed by members of the same family
Generations and generational change	28	20,99	- Multiple generations of the same family work in the business - Business handover from parents to children
family values and organizational culture	24	17,39	- A company based on shared values and family traditions - The company reflects the identity and principles of the family
Cohesive or informal work environment	20	14,49	- More familiar and less hierarchical working environment - Environment where we know each other well and support each other
Strategic control by the family	12	10,14	- The family decides the strategic guidelines of the company - Even if not all members work, the family maintains control
Other / Not specified	11	8,70	- I can't define what a family business is
TOT	138	100,00	

Source: Our Elaboration

Table 2 shows the main themes that emerged from the definitions of family business provided by university students responding to the questionnaire. Through a thematic analysis, it emerged that the most frequently cited theme (28.99%) is related to family ownership and managerial control. This theme is consistent with traditional definitions in the academic literature on family businesses (Astrachan & Shanker, 2003; Vesperi, et al., 2024).

The second theme (20.99%) concerns the simultaneous presence of multiple generations and the concept of generational succession. Therefore, university students strongly associate family businesses with intergenerational continuity. This concept is also a very common feature in the family business literature (Sonfield and Lussier, 2004; Erdogan, et al., 2020; Deferne, et al., 2023)

The next theme (17.39%) is the role of shared values between the business and the family and of organizational culture, focused on the family, echoing theories that emphasize identity, trust and long-term orientation as distinctive traits of family businesses (Erdogan, et al., 2020; Miroshnychenko, et al., 2022). A cohesive or informal work environment is also a theme that emerged for the respondents (14.49%).

Only a minority (8.70%) were unable to define a family business. Overall, this analysis highlights that university students can grasp the fundamental theoretical dimensions of family businesses, emphasizing relational and generational aspects compared to non-family businesses. At the same time, however, students from their answers reveal a lack of empirical experiences.

To understand the training needs perceived by university students, an open question was included in the questionnaire aimed at gathering suggestions on how the university could improve the preparation of those who wish to undertake a career within family businesses.

The aim is to explore not only the perceived gaps in current training, but also the expectations regarding the contents, teaching methods and practical experiences considered most useful to address the specificities of this organizational context.

Funding: This research received no external funding.

Conflict of interest/Competing interests: None of the authors have a conflict of interest to disclose.

Ethics declaration: Not applicable.

Consent to participate: Not applicable.

Consent for publication: Yes.

Availability of data and materials: Data from literature and a third party.

Code availability: Not applicable.

AI declaration: No AI tools were used for creation and/or revision of the manuscript.

Authors' contributions: The authors contributed equally to this work.

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Can Demographic Characteristics Play a Moderating Role in the Effect of Cultural Intelligence on Social Entrepreneurial Intention?

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Abstract: The research in which the moderating effect of demographic characteristics on the effect of cultural intelligence on social entrepreneurship intention was tested was conducted with 392 participants. The data obtained were subjected to frequency analysis, correlation analysis, reliability analysis and validity analyses. Then, the moderating effect of demographic variables such as age, marital status, education level, revenue level and gender between cultural intelligence and social entrepreneurship intention was tested through Process Macro Model 1. According to the findings obtained, firstly, it was determined that the scales and sub-dimensions were positively and statistically significantly correlated with each other. After regression analyses, it was found that age, marital status, revenue level and gender did not have a significant moderating effect, but education level had a moderating effect between cultural intelligence and social entrepreneurship intention. Based on this, it was concluded that demographic characteristics have a partial moderating effect.

Keywords: Cultural Intelligence, Social Entrepreneurial Intention, Demographic Characteristics

1. Introduction

It is noteworthy that the relationship between intelligence and culture has been conceptualised as 'cultural intelligence' and started to be empirically tested at the scaling level. Although the evaluation of culture as a factor in the measurement of intelligence is implicitly and undefined in many different ways in intelligence discussions, it is still very new to be included as a basic determinant in the explanation of intelligence (Göktürk, 2023). Cultural intelligence is a special form of intelligence that focuses on an individual's ability to comprehend and reason in situations characterised by cultural diversity (Göker and Öztürk, 2023). Cultural intelligence (Arastaman, 2018), first proposed by Earley and Ang (2003), is a person's ability to effectively adopt a new cultural context (Early & Ang, 2003). Cultural intelligence is the knowledge and skills developed in a specific cultural (intercultural) context. It is stated that metacognitive dimension should be added to the process in order for a culturally intelligent behaviour to occur (Thomas et al. 2008). Cultural intelligence complements cognitive intelligence as in emotional intelligence. Both are important for achieving success in business life and personal relationships. Cultural intelligence is accepted as a complementary type of intelligence to cope with cultural diversity in businesses (Göker and Öztürk, 2023). Thus, cultural intelligence consists of four sub-dimensions: metacognitive, cognitive, motivational and behavioural (Liu et al., 2022).

Social enterprises, on the other hand, use the market mechanism and combine it with the mission of social orientation in order to make substantial changes. This means providing sustainable social solutions through self-sufficient organisations (Durak, 2016). The term "social enterprise" includes two different phenomena, namely "social" and "enterprise". The understanding of entrepreneurship brings with it the ability to recognise problems and opportunities, to evaluate them correctly, to take risks and to solve them in innovative ways, just as in commercial enterprises. The understanding of "sociability" involves the adaptation of entrepreneurial principles to social problems instead of profit maximisation. Thus, social enterprises emerge as organisations that apply entrepreneurship-based or free market methods to solve social problems (Karğın et al., 2018). Social enterprises are initiatives that operate between non-profit and for-profit organisations (Durak, 2016). Today, the most important name of social entrepreneurship is Muhammad Yunus, a Bangladeshi academic and banker and Nobel Peace Prize winner. Yunus paved the way for small enterprises with micro-credits for the poor. At the same time, organisations such as Toms Shoes, Ashoka and Better World Books are examples of social enterprises that have made an impact in the world (Budak, 2015; Teasdale et al., 2023). Activities related to social entrepreneurship started to be seen especially in the 1970s, its importance increased in the 1980s and Work Integration Social Enterprises (WISE) was established under the roof of the European Union and it was aimed to popularise the subject (Karğın et al., 2018).

While defining the concept of social entrepreneurship, it is seen that social mission, social value, personality traits of social entrepreneur, social change, social problem, social impact, social wealth, social economy and social innovation are tried to be utilised (Aslan et al., 2012; Hietschold et al., 2022). Social entrepreneurship is the process of recognising social problems and developing sustainable suggestions for solving these problems (Budak, 2015). Social entrepreneurship is innovative and social value-creating activities that occur within or

outside of non-profit organisations, commercial enterprises or the public sector (Austin et al., 2006). Social enterprises are essentially businesses with a social or environmental mission and act with the aim of making a profit in order to sustain their existence. While they differ from charitable organisations in terms of profit-making, they also differ from traditional businesses in the way they utilise their profits (Çelik, 2023). Social entrepreneurship is the identification of opportunities to provide social impact and the development of strategies in this direction (Talukder, 2023).

As an example of social entrepreneurship, Boz and İrmiş (2023) examined women's co-operatives, while Durak (2016) investigated the ahilik organisations in the 13th century. In the literature, studies examining social entrepreneurship and social service (Apaydın and Altun, 2021; Uzunaslan and Tek, 2021), civil society (Aktaş et al., 2023), corporate social responsibility (Al-Omoush et al., 2023) and social innovation (Aydın, 2023) variables were encountered. In the literature, various studies on cultural intelligence and Erasmus programmes (Dolce et al., 2023), relational self (Göker and Öztürk, 2023), social intelligence and leadership (Yalçınyiğit and Aktaş, 2023) and emotional intelligence and knowledge management processes were also encountered. Yacub et al. (2022) found that cultural intelligence and intellectual capital have a positive effect on social entrepreneurship.

In the literature, there is no research in which demographic characteristics are examined in the effect of cultural intelligence on social entrepreneurship. In line with all this information, the model of the research was determined as in Figure 1.

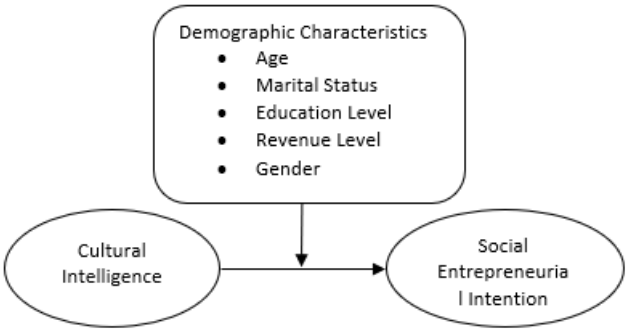


Figure 1: Model of the Study

The hypotheses put forward in line with the determined research model are as follows.

H_1: Demographic variables have a moderating role between cultural intelligence and social entrepreneurship intention.

H_{1a}: Age variable has a moderating role between cultural intelligence and social entrepreneurship intention.

H_{1b}: Marital status variable has a moderating role between cultural intelligence and social entrepreneurship intention.

H_{1c}: Education level variable has a moderating role between cultural intelligence and social entrepreneurship intention.

H_{1d}: Revenue level variable has a moderating role between cultural intelligence and social entrepreneurship intention.

H_{1e}: Gender variable has a moderating role between cultural intelligence and social entrepreneurship intention.

2. Research methods

The research was designed in quantitative design. The population of the research consists of people who have previously taken part in volunteering activities in any non-profit organisation (NGO, student community, association, etc.), but the exact number of the population is unknown. In determining the sample size, the number of people in the universe the formula valid when the number is not known It was calculated that the sample should consist of at least 384 people (Collins, 1986; Asıltürk Okutan, 2023). The data were collected face-to-face by the researchers through a questionnaire form in April-May 2024. The data collection form consists of 3 parts. In the first part, 5 questions (age, marital status, education level, revenue level, gender) including demographic information, in the second part, cultural intelligence scale and in the last part, social entrepreneurship scale were applied. Accordingly, 392 valid forms were obtained. In order to measure the cultural intelligence variable, the scale developed by Ang and Ng (2007) and adapted into Turkish by Arastaman

(2018) was used. The scale consists of 4 dimensions and 20 items. In order to measure social entrepreneurship intention, the scale developed by Hockerts (2015) based on the social entrepreneurship model created by Mair and Noboa (2006) and adapted into Turkish by Akar (2020) was used. The scale consists of 4 dimensions and 17 items. Items 2, 5, 13 and 17 consist of items containing reverse expressions. The scales were used in a five-point Likert type between "1-strongly disagree" and "5-strongly agree".

3. Findings

Frequency analysis was used to determine the frequency of participants in the study. Correlation analysis was used to determine the relationships between variables, Cronbach's Alpha for reliability and confirmatory factor analysis for construct validity. Hayes Process Macro, Model 1 was used to test the regulatory effect. The findings obtained as a result of frequency analysis are as shown in Table 1.

Table 1: Demographic Characteristics of the Participants (N=392)

	Number	%			Number	%
Marital Status				**Gender**		
Single	343	87.5		Female	198	50.5
Married	49	12.5		Male	194	49.5
				Education Level		
Revenue Level				High School	200	51.0
Low	92	23.5		Associate Degree	115	29.3
Middle	270	68.9		Bachelor's Degree	56	14.3
High	30	7.7		Postgraduate	21	5.4

According to Table 1, the majority of the participants were single (87.5%), female (50.5%), middle income group (68.9%) and had a high school education level (51.0%). At the same time, the age range of the participants is 18-54 and the average age is approximately 24. Table 2 shows the findings of the correlation analyses applied to the scales.

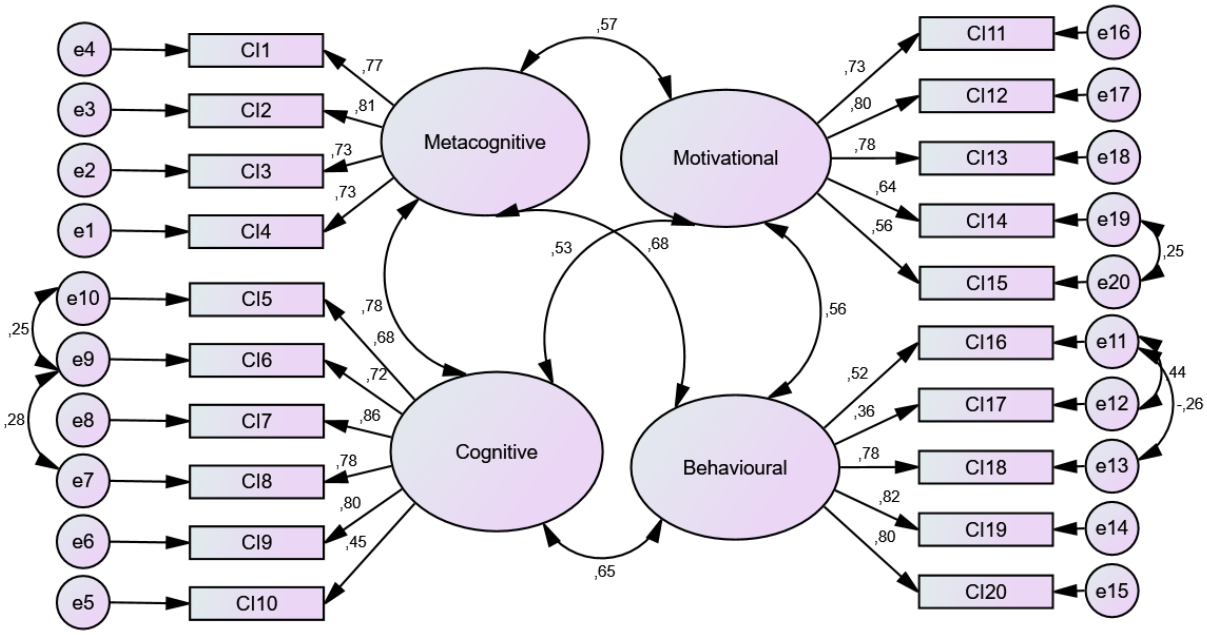
Table 2: Correlations

	Mean	S. D.	1	2	3	4	5	6	7	8	9	10
1-Cultural Intelligence	3.57	.719	(.917)									
2-Metacognitive	3.69	.956	.812**	(.846)								
3-Cognitive	3.67	.961	.846**	.624**	(.842)							
4-Motivational	3.51	.841	.775**	.499**	.464**	(.834)						
5-Behavioural	3.41	.776	.810**	.556**	.534**	.609**	(.785)					
6-Social Entrepreneurial	3.42	.733	.568**	.461**	.311**	.544**	.598**	(.936)				
7-Empathy	3.39	.834	.458**	.399**	.204**	.462**	.500**	.868**	(.862)			
8-Moral Obligation	3.47	.861	.503**	.434**	.246**	.496**	.535**	.887**	.779**	(.818)		
9-Self-Efficacy	3.42	.879	.524**	.407**	.308**	.500**	.541**	.878**	.622**	.687**	(.843)	
10-Social Support	3.39	.822	.484**	.352**	.334**	.420**	.495**	.820**	.541**	.593**	.750**	(.847)

**. Correlation is significant at the 0.01 level. Values in parentheses are Cronbach's Alpha coefficients. S. D.: Std. Deviation

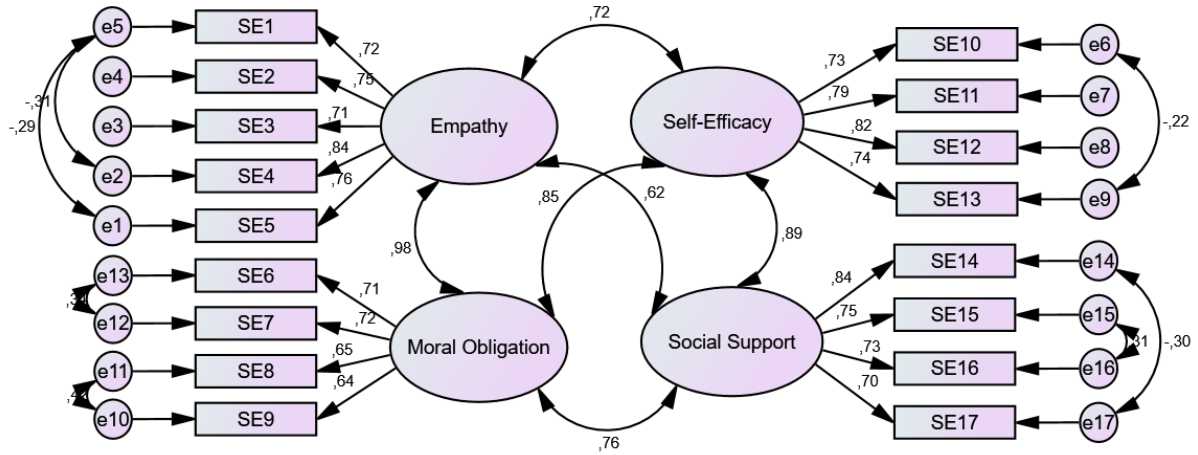
Accordingly, it was determined that there is a statistically significant and moderate positive relationship between cultural intelligence variable and social entrepreneurship intention. At the same time, it was found that all scales and sub-dimensions showed positive and significant correlations with each other at low, medium and high levels. In addition, the reliability levels are also high.

After this stage, the construct validity of the scales was tested with the help of the data obtained and confirmatory factor analysis before testing the hypotheses. Accordingly, the confirmatory factor analysis findings are as shown in Figure 1, Figure 2 and Table 3.



Note: CI: Culturel Intelligence, Numbers: Item Numbers, e: Error Variance

Figure 1: Confirmatory Factor Analysis Findings of Cultural Intelligence Scale



Note: SE: Social Entrepreneurial, Numbers: Item Numbers, e: Error Variance

Figure 2: Confirmatory Factor Analysis Findings of Social Entrepreneurial

Table 3: Confirmatory Factor Analysis Fit Indices of the Scales

Index	Cultural Intelligence	Social Entrepreneurial	Good Fit	Acceptable Fit
X^2/df	3.298	3.956	<3	3< (X^2/df)<5
RMSEA	.079	.080	<,05	<,08
SRMR	.015	.061	<,05	<,08
CFI	.911	.923	>,95	>,90

Note: X^2/df = CMIN, RMSEA = Root Mean Square Error of Approximation, SRMR = Standardized Root Mean Square Residual, CFI = Comparative Fit Index, Source: Gürbüz (2021: 38).

When figure 1 is analysed, it is observed that the factor loadings are in the range of .36-.86 for the cultural intelligence scale. also, the factor loadings of the social entrepreneurship scale in figure 2 are in the range of .64-.84. according to the goodness of fit indices in table 3, it is observed that the values obtained are at an acceptable level. in this case, it is seen that the construct validity of the scales is provided.

After determining that the validity and reliability of the scales with the data obtained, the hypotheses were tested in line with Hayes (2018) Process Model 1. According to the findings of the analyses, it is seen that age, marital status, revenue level and gender do not have a significant moderating effect (Confidence Interval / LLCI-ULCI zero values). in this case, hypotheses H_{1a}, H_{1b}, H_{1d} and H_{1e} are rejected. However, a significant result was obtained at the level of education and the findings are as in Table 4.

Tablo 4: Regression Analysis Results Showing the Moderating Effect for Education Level

Variables	*b*	Confidence Interval	Standard Error	t
Constant	3.42*	[3.36 - 3.48]	.029	117.46
Culturel Intelligence (X)	.56*	[.48 - .64]	.041	13.65
Educational Level (W)	.20*	[.14 - .27]	.031	6.16
X.W	.095**	[.01 - .18]	.041	2.29

Note: R=.62, R^2 =.386; *p<.001, **p<.05.

According to the results in Table 4, all predictor variables included in the regression analysis explained approximately 37% (R^2=.386) of the change in social entrepreneurship. Cultural intelligence has a statistically significant positive effect on social entrepreneurship (*b*=.56, p<.001). Similarly, it was determined that education level has a statistically significant positive effect on social entrepreneurship (*b*=.20, p<.001). In addition, the interactional effect of cultural intelligence and education level variables on social entrepreneurship was found to be significant (*b*=.095, p<.05). The slope analysis graph organised in line with these findings is as shown in Figure 3.

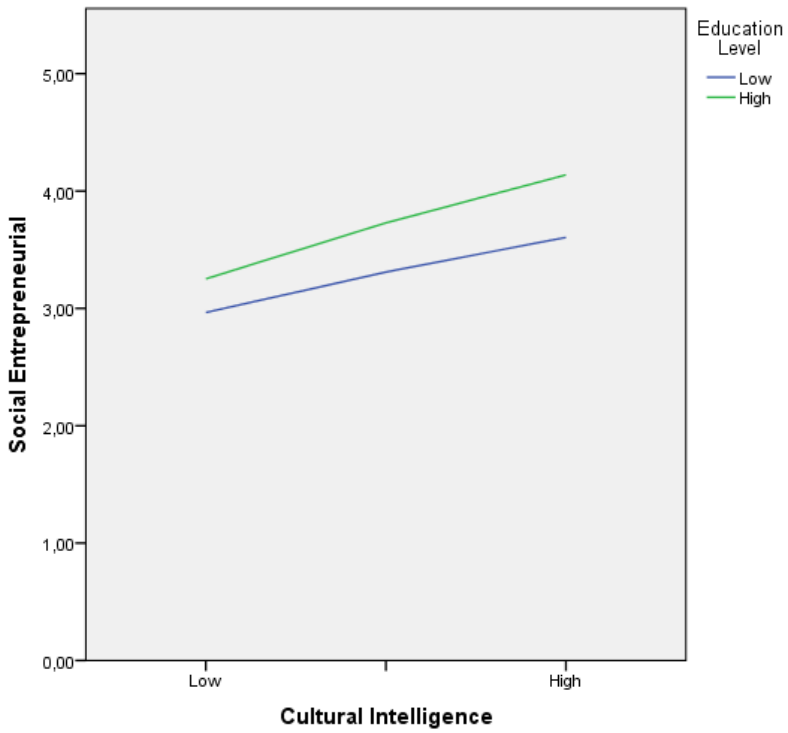


Figure 3: Graphical Representation of the Regulatory Effect of Education Level

When the details of the moderating effect in Figure 3 are analysed, it is found that cultural intelligence increases social entrepreneurial intention when the level of education is low (*b*=.49, p<.001) and high (*b*=.68, p<.001). However, this relationship is even stronger when the level of education is high. In other words, as the level of education increases, the effect of cultural intelligence on social entrepreneurship intention increases. This means that the relationship between cultural intelligence and social entrepreneurship is regulated by the level of education. In line with these findings, H_{1c} is accepted. In line with all these findings, it can be said that the hypothesis H_1 is partially accepted.

4. Conclusion

The research in which the moderating effect of demographic characteristics on the effect of cultural intelligence on social entrepreneurship intention was tested was conducted with 392 participants. Accordingly, it was

determined that there is a statistically significant and high level positive relationship between cultural intelligence variable and social entrepreneurship intention. At the same time, all scales and sub-dimensions were found to be positively and significantly correlated with each other in various degrees. In addition, the reliability levels are also high. Then, it was determined that the scales were valid and reliable in line with the data obtained, and a moderating effect analysis was applied to demographic characteristics with Hayes (2018) Process Macro Model 1. According to the findings obtained from the analyses, firstly, age variable does not have a significant moderating effect between cultural intelligence and social entrepreneurship. In this case, H_{1a} is rejected. Marital status variable does not have a significant moderating effect between cultural intelligence and social entrepreneurship. In this case, H_{1b} is rejected. When the revenue level variable was analysed, a significant moderating effect of this variable between cultural intelligence and social entrepreneurship could not be detected. In this case, $H1d$ is rejected. Similarly, gender variable does not have a significant moderating effect between cultural intelligence and social entrepreneurship. In this case, H_{1e} is rejected. However, the situation is different in the education status variable. It has been determined that the educational status variable has a significant moderating effect between cultural intelligence and social entrepreneurship. In other words, as the level of education increases, the effect of cultural intelligence on social entrepreneurship intention increases. This means that the relationship between cultural intelligence and social entrepreneurship is regulated by the level of education. In line with these findings, H_{1c} is accepted. In line with all these findings, it can be said that the hypothesis H_1 is partially accepted.

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