Digital Integration Insights: Exploring Highlights and Challenges of Numeracy Lecturers in Higher Education

Dominique Marié Nupen[1] and Jayseema Jagernath[2]
[1]IIE's Varsity College, Waterfall, South Africa
[2]IIE's Varsity College, Cape Town, South Africa

dnupen@varsitycollege.co.za
jjagernath@varsitycollege.co.za

Abstract: The pervasive influence of digital technology continues to bring about significant changes in higher education (HE). In the case of numeracy modules, lecturers find themselves at a crossroads of tradition and innovation. Here, they must navigate a complex terrain where students require support in foundational aspects of numeracy proficiency and the rapidly changing aspects of technological innovation to prepare them for the 4th and 5th Industrial Revolutions. The Technological Pedagogical Content Knowledge (TPACK) framework and the Substitution, Augmentation, Modification, and Redefinition (SAMR) model, along with Bloom's Digital Taxonomy and constructivist learning theories provide a valuable theoretical framework for this study to examine critical factors encountered in integrating digital technology and numeracy in the context of a South African private HE Institution. Employing a qualitative methodology, this study investigates the dynamic intersection between teaching and learning, assessment strategies, digital technologies, and numeracy education in the digital age. Fifteen semi-structured interviews explore lecturers' experiences navigating this intersection. Highlights and challenges when integrating digital technology into pedagogical strategies are identified and explored. Findings highlight the potential for integrated technologies to enhance students' analytical thinking and develop confidence in their ability to use digital tools. Contributing factors facilitating digital technology integration, such as innovative teaching strategies, active learning methodologies, and ongoing professional development, are identified. Numerous challenges to integrating technology exist, far surpassing the number of highlights, even in the presence of facilitating factors. Challenges are linked to the nature of numeracy modules, student engagement, infrastructure, skills, time limitations, and improper use of Artificial Intelligence (AI). There is a pressing need to continuously upskill lecturers and students for success in the digital age, and for a highly intentional approach to technology integration. This study will interest a range of academic stakeholders, including lecturers, information specialists, educational technologists, and teaching and learning specialists.

Keywords: Digital technology, Numeracy education, Pedagogical strategies, Technological Pedagogical Content Knowledge (TPACK) framework, Substitution Augmentation Modification Redefinition (SAMR) model

1. Introduction and Background

In the dynamic landscape of higher education (HE), integrating digital technologies into pedagogical practices is imperative, especially in preparing students for both the 4th Industrial Revolution (4IR) and the 5th Industrial Revolution (5IR) (Oke and Fernandes, 2020; Schwab, 2016). Developing technologies such as Artificial Intelligence (AI), the Internet of Things (IoT), and advanced data analytics are further transforming pedagogical practices (Iqbal, et al., 2024). The digital age does, however, present both significant challenges and opportunities for higher education institutions (HEIs). In the case of numeracy modules, where educators strive to enhance students' numeracy proficiency amid rapid technological advancements (Amin and Mizra, 2020), the Technological Pedagogical Content Knowledge (TPACK) framework offers a comprehensive approach to integrating technology, pedagogy, and content knowledge, ensuring that digital tools enhance teaching practices effectively (Mishra and Koehler, 2006). Additionally, the Substitution, Augmentation, Modification, and Redefinition (SAMR) model further complements the TPACK framework by providing a structured method for integrating technology into teaching strategies from basic substitution to the redefinition of learning activities (Puentedura, 2006).

Further to understanding technology adoption, it is also necessary for lecturers to respond to the transformation of education through digital technologies, from Web 1.0 to Web 4.0, which has shifted teaching strategies. While numeracy content has remained stable, the roles of lecturers and students have evolved towards collaborative knowledge creation (Alaghbary, 2021; Amin and Mizra, 2020; Firat and Firat, 2021). To this end, Bloom's Digital Taxonomy and constructivist learning theories provide structured approaches for designing meaningful learning experiences that leverage technology in alignment with teaching and learning (T&L) principles.

This study focuses on integrating technology within the facilitation of numeracy modules such as Accounting, Financial Management, Statistics, and Economics, within a South African private HEI (PHEI). It emphasises the need to align digital tools with effective teaching strategies and institutional frameworks. Despite advancements, there is a need for greater insight into the effective use of digital technology in numeracy education. Through the lens of the TPACK framework and SAMR model, Bloom's Digital Taxonomy, and social constructivism, this study explores the experiences and challenges faced by numeracy lecturers, the digital tools and platforms they are using to construct knowledge and scaffold cognitive thinking skill development and offers insights into effective strategies for integrating technology for enhanced numeracy education.

2. Evolution of Pedagogy Through Digital Technology

In the evolution of pedagogy through digital technology, shifts in the digital landscape and educational frameworks have been pivotal (Schrum & Levin, 2013). During the 1990s and early 2000s, traditional pedagogy emphasised rote memorisation and instructivism, with educators as primary knowledge sources (Alaghbary, 2021). This era relied on textbooks, teacher-led activities, and static Web 1.0 pages, where students played passive roles (Levin and Scrum, 2013). From the late 2000s, the advent of Web 2.0 facilitated collaborative learning through social media and user-generated content, aligning with constructivist pedagogy (Hartshorne and Ajjan, 2009; Matthias, 2009). By the mid-2010s, Web 3.0 introduced personalised learning via data analytics, emphasising networked learning environments (McLoughlin and Lee, 2008; Miranda et al., 2014). Looking ahead to Web 4.0, immersive simulations and smart classrooms are poised to transform content delivery (Jagatheesaperuma et al., 2024). Concurrently, Bloom's Taxonomy has been adapted, with the 2001 revision reordering cognitive skills and emphasising action-oriented verbs (Anderson et al., 2001). Churches' 2008 introduction of Bloom's Digital Taxonomy further tailored cognitive processes for digital learning integration (Churches, 2008).

3. The Digital Context of South African Private Higher Education

As the 4IR develops into the 5IR, technologies such as Artificial Intelligence (AI), robotics, and the Internet of Things (IoT), are driving transformative changes in academic practices and student learning experiences (George and George, 2020). Higher education institutions are increasingly compelled to incorporate digital technologies into their teaching methodologies to align with their mandate of preparing technology-enabled citizens for Industry 5.0 (UNSECO, 2021). Numeracy educators are realising the importance of utilising digital tools to enhance students' foundational numeracy skills, furthering their readiness for future employment opportunities (Bates, 2015). In South Africa, HEIs play a pivotal role in achieving the objectives of the National Development Plan (NDP) 2030, which seeks to eliminate poverty and inequality by 2030 (South African Government, 2024). This plan emphasises the educational and socio-economic disparities prevalent in the country, often amplified by unequal access to digital technologies particularly in the current technological environment (Assan & Thomas, 2023). The integration of digital technology into T&L strategies is essential to address this disparity by providing students with exposure and fostering the development of critical technological competencies. This integration does not, however, occur without challenges (Zawacki-Richter et al., 2019). In the context of South African PHEIs, a significant hurdle to be addressed is the lack of government funding which is made available solely to public Universities.

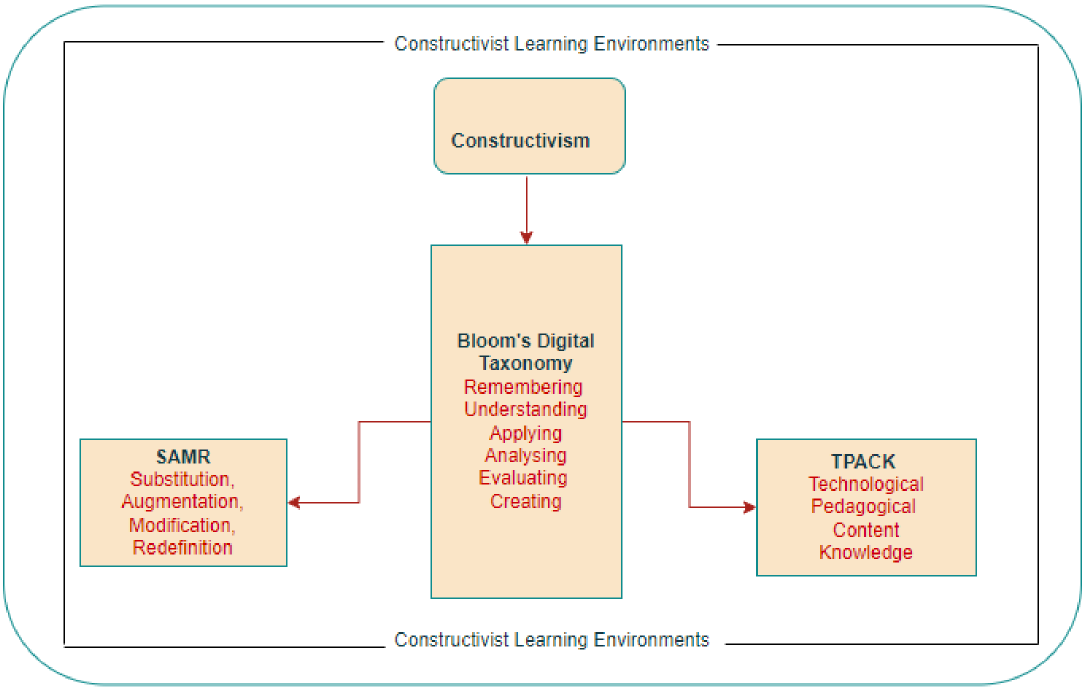
4. Opportunities and Challenges

Digital technology in HE presents significant opportunities, including enhanced accessibility, asynchronous learning, and personalised teaching through adaptive technologies and open educational resources, contributing to achieving SDG 4 (UNESCO, 2021; Zheng, 2017). However, challenges such as the digital divide and socioeconomic disparities in technology access persist, particularly in South African contexts (Arfzal, 2023; Oyedemi, 2021). Addressing these challenges requires improving digital literacy and infrastructure and overcoming cultural resistance among educators (Ghavifekr and Rosdy, 2015). Moreover, ethical concerns regarding data security and the responsible use of AI technologies must be prioritised (Mitchell, 2009). Higher education institutions must proactively manage these complexities to integrate digital technologies effectively (Reddy-Moonsamy and Naidoo, 2022).

5. Theoretical Framework

This study is grounded in the TPACK framework, the SAMR model, Bloom's Digital Taxonomy, and constructivist learning theory. The PHEI where this research was conducted uses Bloom's revised taxonomy and social constructivism as part of its T&L philosophy. The TPACK framework emphasises integrating technological, pedagogical, and content knowledge, highlighting their complex relationship to support effective teaching (Mishra and Koehler, 2006). The SAMR model categorises technology integration into four levels: Substitution, Augmentation, Modification, and Redefinition, aiding educators in enhancing and transforming educational practices (Puentedura, 2006). Bloom's Digital Taxonomy aligns cognitive processes with digital tools, providing a structured approach for designing technology-enhanced learning experiences that promote higher-order thinking skills (Churches, 2006). Constructivist learning theory, which suggests that learners construct knowledge through experiences and interactions, underpins this study by emphasising active, student-centered learning environments (Vygotsky, 1980). By integrating TPACK, SAMR, Bloom's Digital Taxonomy, and constructivist principles, this study considers the intentional integration of educational strategies, digital technologies, and cognitive skills within a social constructivist context.

The inclusion of both Bloom's Digital taxonomy and the social constructivist context to the abovementioned frameworks is reflected in Figure 1. Note that, as the study is independent of age and gender, no moderating variables are included in the analysis. The study also does not aim to quantify relationships between the models depicted.



Author's creation, 2024.

Figure 1: Theoretical framework

6. Methodology

This study utilised an interpretivist exploratory approach to explore the challenges and insights experienced by lecturers when implementing technology-enabled strategies within their numeracy modules in a South African PHEI. Employing a qualitative research design, the researchers conducted 15 semi-structured online interviews via Microsoft Teams. The target population consisted of lecturers facilitating learning on undergraduate numeracy modules in Higher Certificate and Bachelor of Commerce qualifications. The study used non-probability purposive sampling. Interviews were analysed using thematic analysis to identify trends in the integration of digital technology into T&L practice. For the purposes of this study, participants selected any one of their assigned modules and one group of students within that module as the basis for their responses. This study was conducted in accordance with all relevant ethical considerations. Approval was received by the Independent Institute of Education, in accordance with its ethics review and approval procedures R.000134. Participants were afforded 24 hours post-interview to retract the entire interview or specific segments thereof. This option was not exercised by any participants. Data recording, handling, and storage adhere to the provisions of the Protection of Personal Information Act (POPI Act).

7. Results and Discussion

A thematic analysis of the 15 interviews revealed 377 unique codes. These codes are discussed under the umbrella of 3 key themes: 1) Digital technology tools and pedagogical strategies, 2) Highlights and challenges of integrating digital technology in numeracy education, and 3) Enablers of effective technology integration.

7.1 Digital Technology Tools and Pedagogical Strategies

Participants in the study highlighted diverse uses of digital technology in T&L. Definitions and types of tools varied, with some considering basic tools like PDFs and Microsoft Office as digital technology, while others included more advanced tools like Smartboards and Kahoot. Usage fell into three main categories: resource storage, enhancing traditional teaching methods, and assessing student knowledge. The Blackboard LMS was widely used for materials and auto-graded assessments, with Excel and smart whiteboards replicating traditional methods effectively. Tools like Kahoot gamified learning, improving engagement and providing insights into student understanding. Online platforms such as YouTube and Khan Academy supplemented asynchronous learning. For assessments, informal methods predominated due to concerns over plagiarism risks with formal assessments using digital tools.

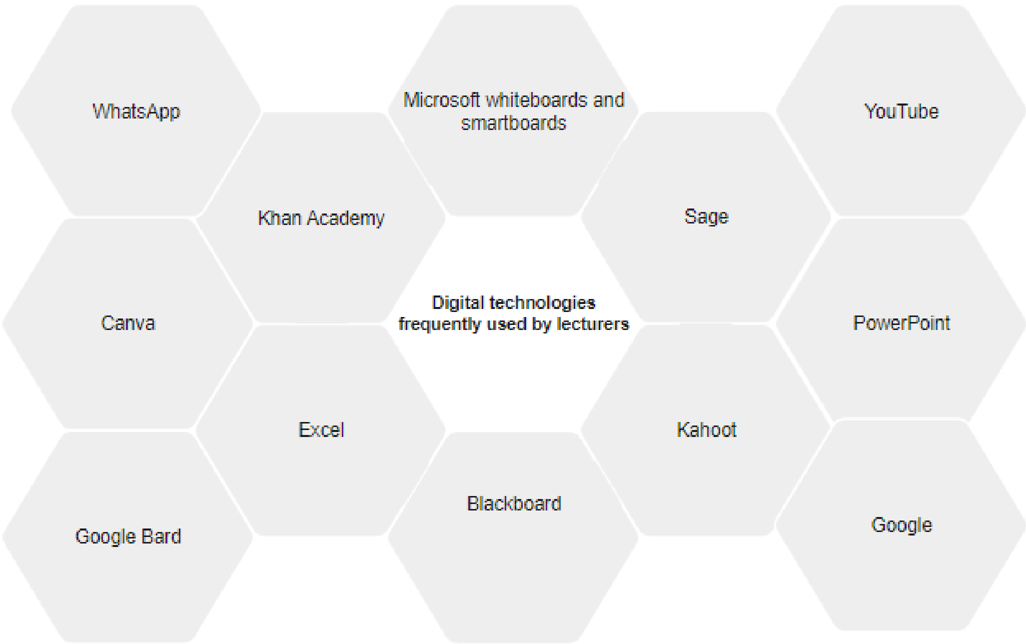


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Figure 2: Digital technology tools most frequently used by lecturers when facilitating numeracy modules

In addition to identifying the types of technologies used, participants were requested to reflect on Bloom's taxonomy and evaluate their use of digital technology against the cognitive levels, also called thinking skills. Lower-Order Thinking Skills (LOTS) refer to the student's ability to remember, understand, and apply knowledge (Alaghbary, 2021). Higher-Order Thinking Skills (HOTS) comprise the ability to analyse, evaluate, and create knowledge. As reflected in Table 1, lecturers noted that they integrate digital technology tools predominantly for LOTS rather than HOTS. Table 2 shows that only 20% of the participants reported utilising digital tools at the "Creating" cognitive level. Only a third of participants could employ these tools at the "Evaluating" and "Analysing" levels. Of the participants who reported using technology to develop HOTS, only 13.3% reported using digital tools at the highest cognitive level of "Applying".

Table 1: Use of digital technology and the cognitive levels of Bloom's Taxonomy (based on total participants interviewed)

Cognitive level	LOTS			HOTS		
Cognitive level descriptor	Remembering	Understanding	Applying	Analysing	Evaluating	Creating
Usage	100%	100%	100%	87%	53%	20%

Table 2: Frequency of usage of digital technologies at HOTS levels (based on the number of participants that reported using technology at these levels)

		Frequency	Per cent	Valid per cent	Cumulative per centage
Valid	Applying	2	13.30%	13.30%	13.30%
	Analysing	5	33.30%	33.30%	46.70%
	Evaluating	5	33.30%	33.30%	80.00%
	Creating	3	20%	20%	100%
Total		15			100%

A further crosstabulation of HOTS and the frequency with which digital technology is being used was conducted based on a 3-point Likert scale of Sometimes (1), Often (2), and Always (3), as depicted in Table 3. This revealed that the majority of participants (87%) agreed that digital technologies had a meaningful impact on the teaching and assessment of numeracy concepts, with the highest agreement occurring when technology is used at the level of "Evaluating" (33.3%). A small percentage of participants (7%) were either neutral in their responses or disagreed. This suggests a strong overall positive perception of the impact of digital technologies across various cognitive levels, particularly at higher-order thinking levels, to develop skills for evaluating and analysing knowledge. It can be concluded that, despite lecturers recording a lower frequency of use of digital technology at higher cognitive levels, there is a high degree of intentionality when technology is used at these levels.

Table 3: Blooms Cognitive Levels and Frequency of Use

Bloom level × Frequency of use (new)						
			Frequency of use (new)			
			Sometimes	Often	Always	Total
Blooms level	Applying	Count	0	2	0	2
		Total %	0.00%	13.30%	0%	13%
	Analysing	Count	1	2	2	5
		Total %	7%	13.30%	13.30%	33.30%
	Evaluating	Count	3	0	2	5
		Total %	20.00%	0%	13.30%	33.30%
	Creating	Count	2	0	1	3
		Total %	13.30%	0.00%	7%	20%
Total		Count	6	4	5	15
		Total %	40%	27%	33%	100%

A final theme identified in participant responses concerning digital tools and pedagogical strategies is that the use of digital technologies for teaching and assessment should only be used for defined learning aims and not incorporated purely for the sake of using these tools. The use of technology must be purpose-led and in alignment with the institution's T&L philosophy.

7.2 Highlights of Integrating Digital Technology in HE Numeracy Modules

The integration of digital technology was generally viewed by participants as a positive factor in transforming traditional teaching methods, making learning more dynamic, accessible, and aligned with the skills required in dynamic professional environments. Specifically, two key themes emerged when participants were asked to indicate highlights associated with integrating digital technology into their T&L practices. A prominent theme was the enhanced confidence and empowerment among students regarding their technological abilities. Participants noted that students felt more competent and self-assured in using digital tools, which improved their immediate learning outcomes and enriched their skill sets in ways that are advantageous for their future careers. This empowerment is considered crucial in fostering a sense of autonomy and readiness for the technology-driven job market.

Another significant benefit identified was the efficiency and clarity that digital technology brings to the learning process. Specifically, participants appreciated the ability of digital tools to demonstrate the impact of changing a single value on complex calculations quickly and effectively. This immediate feedback loop was invaluable in helping students understand the underlying principles of numeracy, allowing for a more interactive and engaging learning experience. Additionally, this capability enhanced students' analytical thinking and problem-solving skills, as they could experiment with different variables and instantly see the results of their manipulations.

7.3 Challenges of Integrating Digital Technology in HE Numeracy Modules

Alongside the highlights of technology integration, participants did note many challenges experienced when using digital technologies for numeracy-related T&L. Challenges can be summarised into six key themes: 1) Challenges inherent in teaching numeracy subjects predominantly via technology, 2) Students' lack of interaction and participation, 3) Practical technological issues, 4) Skill set issues, 5) Lack of time, and 6) Use of AI.

A consistent theme across all participants was the difficulty of effectively teaching practical and application-based modules using technology to replace most or all synchronous time with students. In the contact mode, lecturers agreed that the step-by-step guidance provided in face-to-face interactions can be crucial for developing students' comprehension of key processes and concepts, developing students’ confidence, and fostering engagement. In addition, while digital technologies such as interactive whiteboards and Microsoft Whiteboard were acknowledged as useful tools for enhancing in-person instruction, participants were clear that these technologies are only ever a support for, rather than a replacement of, skilled facilitation and direct personal engagement necessary in teaching numerical subjects. The hands-on nature of these subjects, coupled with the need for immediate feedback and nuanced instruction, makes intentional and synchronous teaching indispensable for learning. In terms of the online mode of study, lecturers noted that synchronous sessions hosted via Blackboard did provide an effective substitute for a physical classroom and are crucial for teaching numeracy subjects, supported by asynchronous learning material and or interactive digital tools.

Another prominent theme that emerged is that, while some student interactions improve when digital platforms such as WhatsApp groups are used for communication, student attendance and participation significantly decline when teaching is conducted online or recorded and made available as an online resource. Lecturers noted that the online nature of the work creates the perception amongst students that it is not as important to attend and engage in class. Ironically, while digital technology provides unprecedented opportunities for dynamic, active learning, it is also making it easier for students to become passive observers rather than active participants in the learning process. This passivity undermines the interactive and collaborative aspects of learning, which are crucial for deep comprehension and skills development. Consequently, lecturers expressed concern that the reliance on digital tools without robust T&L strategies could impede the effectiveness of learning, hindering critical student engagement and participation.

Lecturers further highlighted challenges associated with logistics or resourcing, as well as technological skills. Many students do not have reliable access to the necessary hardware and software, and those that do must often navigate poor or intermittent connectivity and frequent loadshedding (planned power outages). Lecturers also reported that students who do have access to devices such as laptops often do not always bring these to class, hampering their ability to participate when digital tools are used. This lack of necessary equipment and reliable infrastructure creates significant barriers to effectively integrating digital technology in T&L. In addition to logistical challenges, significant disparities in students' technological skills mean that lecturers are working with students who are highly proficient with digital tools and students who have little to no experience with these tools, in one classroom. This wide range of skill levels challenges lecturers who must ensure that all students benefit from digital technology. Addressing varying levels of digital literacy adds complexity to lesson planning and instructional delivery.

Time constraints further exacerbate these challenges. While digital technology offers numerous benefits, lecturers often lack sufficient time to thoroughly investigate the most beneficial technologies and integrate them effectively into the syllabus. Additionally, experimenting with new digital tools can require more class time than simply following traditional methods of facilitation. In addition, lecturers noted health challenges stemming from the extensive use of technology such as eye strain, headaches, and fatigue. AI tools, such as ChatGPT, have also introduced new challenges. Lecturers reported issues with plagiarism and improper use of AI by students, who often rely on these tools to complete assignments rather than learn how to use them appropriately. This misuse of AI can result in students having a false sense of the level of their numeracy knowledge, which can lead to difficulties during exams when they are unable to rely on these tools. The inappropriate use of AI, therefore, undermines the learning process, as students are not engaging with the material meaningfully.

All participants highlighted the importance and benefits of using digital technology in their teaching and learning strategies but also identified the significant challenges associated with its effective use. Regarding the use of digital technologies for assessments, participants reported this to be less beneficial for assessment of learning because of the practical nature of the modules. The more traditional methods of sit-down tests and exams have been found to be more beneficial.

7.4 Enablers of Effective Technology Integration

Participants were asked to share their experiences and perceptions of factors enabling the integration of digital technology into T&L. A key theme that emerged was the need for ongoing professional development and skills development for lecturers and students. Most lecturers expressed confidence in their abilities to use digital technologies, noting that frequent use has significantly enhanced their confidence. However, they also acknowledged the need for continuous training to improve their skills and adapt to new technologies. Lecturers indicated that institutional support in selecting appropriate resources and providing training would be greatly beneficial.

Additionally, the importance of collaboration between lecturers and students was highlighted. Lecturers pointed out that many students possess expert knowledge in certain valuable digital tools, suggesting that a collaborative approach could enhance the learning experience. The respondents also emphasised the institution's crucial role in facilitating the use of digital tools by ensuring the availability of reliable hardware and software for digital learning. While there was recognition of the support received from the institution, respondents noted a specific need for the focused development of tools tailored to numeracy education. This includes ensuring that the digital infrastructure is robust enough to support the specific demands of numeracy T&L.

7.5 Intentional Integration of Digital Technology for Teaching and Learning

Table 4 shows key findings through the lenses of the TPACK framework and the SAMR model. It highlights the types and levels of digital tool integration, their alignment with Bloom's Taxonomy, and the enablers and challenges faced by the participants. This analysis highlights how basic and advanced tools contribute to different levels of cognitive engagement and pedagogical efficiency, highlighting the importance of thoughtful integration and institutional collaboration.

Table 4: Key findings in the context of the TPACK framework and SAMR model

Key Findings	TPACK Framework	SAMR Model
Types of technological tools and their integration levels	Basic tools such as PDFs and Microsoft Office demonstrate limited integration with pedagogy and curriculum knowledge, aligning more with traditional teaching methods. Advanced tools such as Smartboards and Kahoot support interactive learning, requiring more deliberate integration.	Basic tools such as PDFs and Microsoft Office align with substitution while more advanced tools like Smartboards and Kahoot support interactivity, aligning with augmentation and modification
Bloom's Taxonomy	The lack of integration of technology at the HoTS levels highlights the challenges in successfully merging technological tools with pedagogical strategies aimed at developing higher-order thinking skills.	The limited use of digital tools at the HoTS levels signifies difficulty in reaching the modification and redefinition stages of the SAMR model, therefore resulting in challenges in transforming thinking processes
Enablers and Challenges	Effective use of digital technology requires balancing TPACK elements (technology, pedagogy, and content knowledge) and addressing challenges related to technology integration, such as skill disparities and logistical issues.	Enablers of effective integration align with achieving modification and redefinition, challenges such as technology substitution and engagement issues highlight the need to progress beyond basic SAMR levels.

Author's creation, 2024.

8. Recommendations

The findings of this study highlight the necessity for ongoing professional development for lecturers and sustained collaboration among peers. Lecturers should receive targeted training on discipline-specific tools to effectively balance innovation with traditional pedagogical approaches. They require support in exploring tools tailored for numeracy education and guidance in seamlessly integrating these tools into their teaching practices. Additionally, there is a critical need for further research and guidance in intentionally selecting tools and crafting technology-enhanced T&L strategies that promote higher-order thinking skills. Lecturers would benefit from assistance in maintaining a hybrid teaching style that deliberately incorporates technology. Furthermore, fostering collaborative communities among colleagues can significantly enrich pedagogical practices. To enhance student engagement with content and technology, institutions must invest in infrastructure to support students lacking access to technology. Comprehensive digital literacy training should accompany these efforts to support all students effectively. Further investigation is needed to develop effective engagement strategies and to gather learner feedback on their preferences and usage patterns. In addition, institutions should conduct workshops that emphasise the ethical considerations essential for the responsible use of technology tools in education, thereby preventing misuse. The study highlights the need for continuous support for lecturer development, collaborative practices, and ethical integration of technology, which are crucial for advancing educational outcomes in HE settings.

9. Conclusion

This study explored the highlights and challenges of integrating digital technology in numeracy education within a South African PHEI setting. Through thematic analysis, it became evident that while lecturers widely utilise digital tools to augment traditional teaching methods and enhance student engagement, significant challenges such as practical application in online settings, challenges with student interactions and digital literacy persist. Addressing these challenges necessitates ongoing professional development for lecturers, holistic institutional support for infrastructure and digital literacy, and collaborative efforts to tailor tools to numeracy education needs in alignment with institutional T&L strategies. Future research should focus on refining engagement strategies, gathering comprehensive learner feedback, and promoting ethical technology use to enhance educational benefits and foster holistic student development in an increasingly digital environment.

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