

Knowledge Management in Public Transport: A Portuguese Empirical Study

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Abstract: This paper aims to investigate knowledge management processes in a metro company. We focused on core knowledge and its impact on the overall performance of a public transport operator. It presents a case study from the Lisbon-based public transport operator Metropolitano de Lisboa, E.P.E. The challenges of knowledge management in a metro company, such as time savings and efficiency, can be mitigated by the creation of a structured and target-oriented knowledge framework and information architecture that enables knowledge reuse throughout KM aims the company or/and in specific communities of practices. The current study seeks to investigate the role of signalling experts in knowledge management in a metro company through the use of a case study based on accessing the documentation required to deliver their technical outputs. Qualitative methods were used to conceive, design, and implement the specific experience under analysis. The approach involved semi-structured interviews with a sample of five core operational managers and an online questionnaire directed at the study's core knowledge actors (90 experts) and a Delphi Study applied to the five signalling experts. The results showed that optimizing knowledge management leads to increased operator efficiency and decision-making. The findings of the empirical case analysis combined with the literature review provide useful insights to construct a target-oriented knowledge management methodology in a metro company. One of the study's key findings is the relationship between decision-making and knowledge management tools. The findings of the empirical case analysis, combined with the literature review, provide useful insights into the awareness of an urgent target-oriented knowledge management framework in a metro company. This study was built on the available data from Railway signalling metro experts, which may be perceived as limited in the overall context. We consider that there is no special bias associated with this area of expertise and that the overall approach could be adopted and further tested in any other metro company, regardless of size. This essay added novel information to the available body of knowledge by providing an in-depth analysis of a core discipline of metro mode by addressing the accessibility to information by Railway signalling professionals.

Keywords: Knowledge management, Case-based learning, Core knowledge, Organisational performance, Public transport operator

1. Introduction

There is worldwide consensus on unsustainable mobility patterns and the need for a standard shift towards smart, sustainable solutions that can anticipate current and future mobility challenges in cities (Collins and Chambers, 2005; Gerald et al., 2008; Stern, 2011).

Public transport aims to contribute to the quality of life in every city. Improving urban mobility requires strategies and proposals for intervention in management decisions and Knowledge Management (KM), both of which affect the overall performance of the public services provided.

There are four fundamental phases in KM life cycle: knowledge creation, storage, sharing, and application (Alavi and Leidner, 2001; Kayworth and Leidner, 2003; Zaim, 2006; Fong and Choi, 2009; Turner, Zimmerman and Allen, 2012).

KM aims to extract information from organisations to increase productivity, add value, competitiveness and knowledge exchange (Davies, 2000). Knowledge management has been accepted as a crucial strategic pillar for the success of a company (Gupta & McDaniel, 2002; Halawi et al., 2005).

The objectives of this empirical study are to identify key knowledge and evaluate the impact between accessing information and the decision-making process.

To the best of our knowledge, this is the first study to assess the impact of knowledge management in a metro company.

2. Literature Review

2.1 Knowledge Management

Several authors have shown the relevance of immaterial asset management as a factor in the competitiveness and sustainability of companies (Matos et al., 2019). Not applying intellectual capital management policies may jeopardise the future of old companies, especially when the retirement age for highly specialized managers in some core functions of the business becomes close.

On the other hand, knowledge must be retained within the companies (Edvinson, 1997). It is necessary to implement measures to prevent employees from leaving with core knowledge and without transferring their knowledge capital.

The value added to the company in the short term is no longer reflected in the medium term because the knowledge created is not retained, and there is no concern to transfer it to other company colleagues (Matos & Lopes, 2009).

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2.2 Knowledge Management and Value Creation

The goal of Knowledge Management is to disseminate ideas, experience, and information; to ensure that these are accessible wherever and whenever you need so that you can take advantage and take documented decisions; improve efficiency by reducing the need to reuse knowledge.

The ISO management systems standard for knowledge management aim is to support organisations to develop a management system that effectively develops and enables value-creation through knowledge, as defined in the ISO Knowledge Management Systems framework (ISO, 2018).

Alternatively, knowledge must be intentionally created, consolidated, applied, and reused faster than the rate of change. Workforce friction and turnover in today's society have implications for knowledge management. Moreover, in many organisations, critical knowledge is often managed in silos and/or retained or even hidden by experts, at the risk of being lost when the organisation changes or these experts leave. Organisational factors affect knowledge retention (Lin, Chang and Tsai, 2016; Levallet and Chan, 2019; Azaki & Rivett, 2022).

Usually, the effects of particular decisions on the performance of a company are analysed, such as investment, operational decisions or the adoption of specific management practices. Wu and Chen (2006) demonstrated the benefits of IT and ICT investments, whereas Devaraj and Kohli (2003) discovered the effects of technology on organisational performance. In addition, some empirical studies proved the relationship between "Knowledge capital" and innovation and productivity (Czarnitzki, Kornelius, 2004, Co and Chew, 1997). Some studies relate Human Resources (HR) practices and organisational performance (Wright et. al., 2005; Sels et. al., 2006). When referring to the concept of performance, we refer to how a company quantifies the efficiency and effectiveness with which it carries out its business activities, according to Dumay (2016).

2.3 Knowledge Management in Public Transport

The Research Report (TCRP, 2017) systematizes a framework for transit agencies to manage all stages of the Information Lifecycle Management (collection, retention, and transfer). A Transit agency is a public entity responsible for administering and managing transport services.

This report outlines the common functional domains that require KM: finance, human resources, vehicle maintenance, facilities maintenance, and operations service design. However, there is no focus on specific business knowledge, i.e. which areas are core and non-core.

Considering that the scope of this report is transit agencies, which include different types of transport (bus, trains, metros, Bus Rapid Transit, etc.), the core areas for each mode of transport would also differ according to each one.

Metro de Lisboa is a member of the International Benchmarking Group COMET¹ and the most recent study on the subject of Knowledge Management was conducted in 2001. The following benefits were identified:

- Better decisions-time-cost-accuracy.
- Increased profits and reduced costs.
- Reduce waste through unnecessary rework.
- Sharing lessons learned among members helped reduce costs.

¹https://en.wikipedia.org/wiki/Community_of_Metros

One of the identified challenges was the difficulty to develop a business case in KM.

The mobility sector demonstrated how knowledge management (KM) influenced the decisions of the company and consequently its results (STCP, 2014). Management practices of any organisation have a vital impact on its global performance. As a result, it is of the highest importance to assess the magnitude of the management of knowledge transfer and decision-making. Despite the vast literature on Knowledge management, there are limited studies in the transport sector. Even though there are studies mainly focused on knowledge management's lifecycle (Raymundo et al, 2014; Radhika et al, 2016).

A new approach is required, which focuses on the individual and collaborative sharing and knowledge building (Becker, 2015). Given the growing importance of railway systems, with huge investments and technological progress, it is essential to have talents with the skills to operate and collaborate across a variety of functions. To overcome this challenge, it is necessary to improve recruiting efforts and retain the best talents at an international level (Amirault, 2015).

The review of the literature reveals a lack of use of knowledge management to leverage the performance of public transport companies. Based on the assessed literature, no evidence-based research has ever been conducted on the core knowledge of a metro company, and previous studies have only examined this phenomenon on a bus company to analyse political and/or management decisions, i.e. macro-level decisions.

3. Case Study: Metropolitano de Lisboa, EPE (ML)

The public transport case study presented here is about the company that operates the Lisbon metro system. This study explores the impact of knowledge management on network expansion investment decisions.

Metropolitano de Lisboa (ML) is the public metro operator in Lisbon, the capital of Portugal and the core city of Lisbon Metropolitan Area (LMA), which includes 18 municipalities with an overall area of 3.015 km² and almost 3 million inhabitants (IMob2017). The area of ML's operations comprises of 3 municipalities with Lisbon being the central one. The company's history dates to 1948, but the operation only started in 1959. Now, ML operates 4 metro lines comprising 56 stations and 44, 5 km of network and is currently expanding its network.

Considering the importance of knowledge to efficiency, productivity, and the subsequent impact on service quality, Knowledge management was selected as a critical goal to manage. We believe that employee knowledge influences a company's ability to remain competitive in the market and that KM contributes to companies' market positioning. Due to the company's current period of network expansion, the analysis of the subject of knowledge management and namely of core specialties is critical for sustainable public transport management.

4. Methodology

4.1 Data Collection and Analysis Methods

This work aims to assess how information availability affects the technical documentation that signalling experts have to deliver in their core discipline. The following five key research questions were derived from the objective:

- Does information access impact the time it takes to develop technical outputs?
- Does information access impact the quality of their technical outputs?
- Do the technical outputs impact the metro network expansion?
- How much time is necessary to access the required information to deliver their technical outputs?
- How long does it take to access information from other technical disciplines to generate technical outputs?

Both quantitative and qualitative methodologies have pros and cons (Saunders et al., 2007). The disadvantage of qualitative research is that it is based on case studies and is difficult to generalize to the entire population. On the other hand, when the data for the quantitative studies is collected in random samples, it can be extrapolated to the population. Nevertheless, qualitative research is also appropriate when we need to deepen a phenomenon or a problem in an organization, assessing specific relationships and concepts. This study was divided into three sections based on the qualitative technique. Firstly, in-depth semi-structured interviews were conducted to gain a better insight into the issues facing knowledge management. Secondly, an online survey was carried out in 2022. Of a total of 90 surveys, 42 valid surveys were obtained for this study, representing approximately 50% of the response rate.

In the third stage, a Delphi study was conducted with the signalling experts. Table 1 shows a summary of descriptive statistics for the sample of experts under study.

Table 1: Sociodemographic Characterization of the Respondents

Area of expertise	Number of experts	Gender (F)	Age (min-avg-max) Un: years	ML seniority (min-avg-max) Un: years	ML Business unit areas
Railways signalling	5	0	42-52-60	22-27-32	Maintenance, Civil works, Security & Safety
Energy distribution network	7	2	49-57-64	29-32-34	Maintenance, Civil works
Track	1	0	62	39	Maintenance
Electromechanical equipment	2	0	41-45-49	3-8-12	Maintenance, Civil works
Electronics	2	0	40-47-53	16-23-29	Maintenance
Telecommunications networks	5	1	45-50-55	17-28-32	Maintenance, Civil works, Security, Operations
Civil works	10	4	47-47-59	21-21-22	Civil works
Architecture	4	2	42-49-58	17-27-35	Heritage, Civil works, Maintenance
Rolling Stock	1	0	41	3	Maintenance
Total respondents (including all the expertise areas)	42	10	26-51-64	3-25-39	Maintenance, Civil works, Security, Operations, Clients, Security & Safety

This portrait of ML experts cannot be complete because we are only considering those who responded. However, regarding the knowledge areas that are the core business, they are much better represented than the others.

The managers responsible for core areas identified the technical experts with critical knowledge for the business and that work in their areas. In terms of Railway signaling experts, the selected sample represents the entire community of experts in this field in the Lisbon Metro.

Although the entire Knowledge Management framework that can be applied to any transportation company is presented in the report TCRP (2017), the core and non-core knowledge are not differentiated.

An ideal solution in a metro company is to tackle KM (core and non-core) as a whole. Implementing KM in a metro company may seem overwhelming or difficult. This difficulty triggered the present work in a core area of expertise by starting on core areas and then expanding to other core and non-core areas of expertise. On the other hand, the implementation methodology MASK (Method for Analysing and Structuring Knowledge) (Ermine, 2013), starts with the strategy and drills down to certain operational solutions in a cohesive alignment and can be adapted to a future KM framework. One of the four phases that realize the Knowledge Cycle for KM is the capitalization of the key Knowledge domains, which the present study deepens and broadens the body of knowledge in metro companies.

4.2 Interviews

The data was collected by interviewing five managers with extensive experience in the following areas of expertise: Maintenance, Operations, Civil Works & Expansion Projects, Customer Management, Safety and Security.

4.3 Survey

An online survey was carried out and the author distributed and delivered the survey by email and divided it into the following sections:

- Socio-demographic information

- Areas of expertise
- Professional Associations
- How to develop own knowledge
- How to set up and sustain a Knowledge Network
- How to transfer and manage knowledge
- Future challenges (short and medium-term)

4.4 Delphi Technique

Several research instruments could have been used such as focus groups and interviews but it was decided to analyse straightforward questions and answers by a more sophisticated technique. A Delphi Study to collect the necessary data and following some other studies that also used this methodology (Remenyi, 1996; Day and Bobeva, 2005; Guglyuvatyy and Stoianoff, 2015; Grime and Wright, 2016).

The Delphi technique is a group consensus process and a valuable tool in attempting to produce agreement in the opinions of a group of experts. It is designed to assist in the collection and analysis of expert opinion to obtain a deeper understanding of issues and/or trends. It is a reiterative process requiring a questionnaire to be completed several times, and the completion time should be quite short. This technique is triggered by the respondents seeing the average scores for each question in the previous round. The standard deviation may also be supplied. The number of rounds may vary but, in this case, and following the literature (Remenyi, 1996), we used 3 rounds of questions.

Using the first-round results, the administrator calculates the arithmetic means and the standard deviations for each question. The participants are offered the questionnaire again along with the result of these calculations.

The participants are expected to reconsider their opinions/scores in light of their reflection on the opinions of others expressed through the means and standard deviations supplied.

It is expected that the opinions of the participants will tend to move towards the mean and the standard deviation.

The participants are offered the questionnaire again (for the third time) together with the result of the calculation made by the administrator after the second round.

Structured questions were used with the specification of a number in a range between 1 and 5. The number of questions is carefully limited considering that it is aimed at experts and because of the time limit to complete the questionnaire. Each round needs to be completed relatively promptly – one to two weeks.

It is important that each proposition expressed is unambiguous. Another relevant aspect of the study is the selection of the experts' panel.

The following flowchart portrays the structure of the master plan for the Delphi study (Figure 1):



Figure 1: Methodological Delphi Technique

5. Analysis of Results

The modelling approach presented above aims to understand the impact of accessing information and the time necessary for decision-making. In establishing the Delphi Study, a list of understood aspects of signalling decision-making was developed and ended with six Questions and a open-ended question that would allow participants to make their comments. The five experts who participated in this study represent the whole community of Railway signaling experts in ML.

The participants were invited to complete the online questions and submitted their answers. The first three questions regarding the impact of non-accessibility of the information were calibrated on a 1 to 5 scale with 1 being Strongly Disagree and 5 being Strongly Agree. The other three questions measuring the time delay resulting from the lack of access to information, were calibrated on a 1 to 5 scale with 1 being 1 month; 2 being 2-3 months; 3 being 3-6 months; 4 being 1 year; 5 being 1-2 years.

A total of 5 responses were received for the First Round, 5 responses for the Second and 5 responses for the Third keeping the number of responses in the 3 rounds.

One of the interesting aspects of the Delphi process is that it combines quantitative and qualitative data. Although quantitative analysis employed relatively elementary techniques such as the calculation of means and standard deviations as well as ranking scores. Due to limited comments in the open-ended question, it was not possible to generate a topic model.

The scores for each of the items in the Delphi instrument have been monitored over the three rounds with Means and Standard Deviations calculated. This is shown in Table 2.

Table 2: Summary of the Scores from the 3-Round Delphi Study (General Analysis)

Questions	Mean Round 1	Standard Deviation	Mean Round 2	Standard Deviation	Mean Round 3	Standard Deviation
Information access impacts time to produce the technical output	4,8	0,45	4,8	0,45	4,8	0,45
Information access impacts the final quality of output	4,8	0,45	4,6	0,55	4,6	0,55
3.The technical output impacts ML's expansion	4,8	0,45	4,6	0,55	4,6	0,55
4.How long should it take to access information (based on past experience of 10 years)	1,4	0,55	1,4	0,55	1,4	0,55
5.How long it takes to access the necessary information (based on past experience of 10 years)	2,2	0,84	1,8	0,45	1,6	0,55
6.How long it takes to access other technical information areas (based on past experience of 10 years)	3,2	1,10	3,2	1,10	3,2	1,10

As the sample is composed totally of males (as we can confirm in Table 1) it was not possible to assess differences based on gender.

To establish if there is a consensus over the three rounds of the Delphi Study, the Mean scores at the end of each round were examined and a line graph of the Mean scores for each round was plotted in Figure 2.

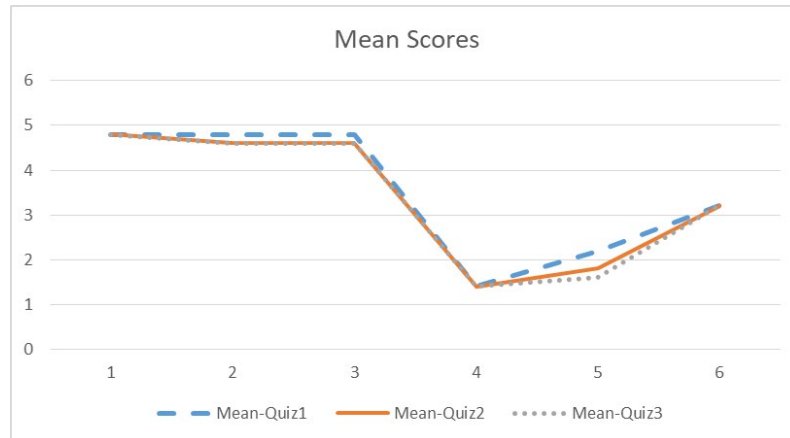


Figure 2: Mean Scores for all Questions of the 3 Rounds

In Figure 2 we can verify that there are small changes in the scores assigned from one round to the next one.

On the face of this information, it appears that respondents did not change their scores from round to round. To confirm this, it was necessary to examine the Standard Deviations. These statistics are shown in Figure 3.

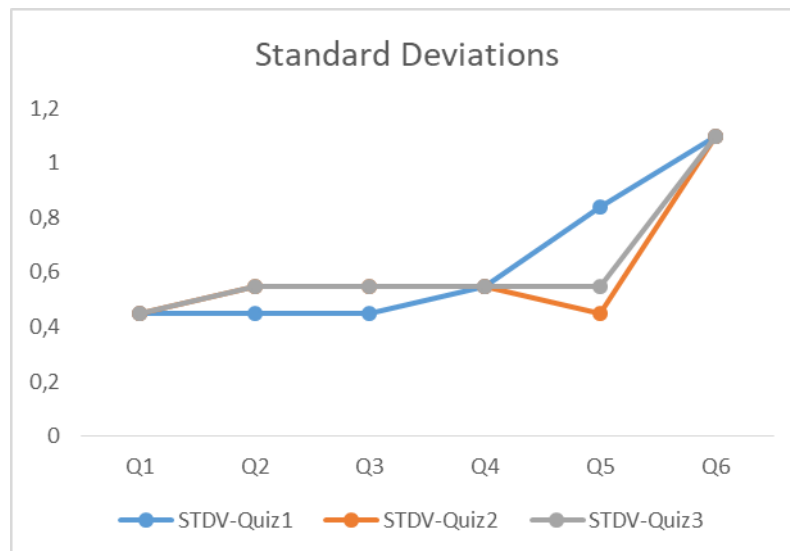


Figure 3: Standard Deviations Scores of all Questions in Each of the 3 Rounds

Considering the low degree of variation in the scores and how the Standard Deviations hardly varied, a one-round study would have produced a similar result as far as the scores are concerned.

Questions 1, 2, 4 and 6 were always stable during the 3 rounds. Question 3 changed in the 2nd round and then remained stable. Question 5 was the most unstable question during the 3 rounds, suggesting uncertainty in the timeline necessary to respond to the signalling specifications and worried by the challenges they have to face. In the 1st round, they assumed it would take longer, and in the 3rd round, they were already reducing the time.

To establish which issues the respondents may have considered relatively more important it was examined more closely the questions scored higher than the Mean.

Recalling the research question, which is the impact of accessing key information in the decision-making process and a wake-up call to the impact of KM framework and the metrics to track its impact.

This study was built on the available data from signalling metro experts, which can be perceived as limited in the overall context. This fact can restrict the results due to the possible different realities and contexts between metro companies. Yet, we consider that there is no special bias linked to this area of expertise and that the results could be adopted and tested in any other area of expertise and metro companies.

Additional data for different core areas of expertise would be an experimental improvement, as these interventions and evaluations should be performed on different areas of expertise. Nevertheless, the Delphi study developed here can be further used in the future with more comprehensive datasets and estimate reliable impacts on the performance of the company.

6. Conclusions and Limitations

This approach enabled the author to record internal requirements and pain points in the current knowledge management, set priorities and evolve to a new knowledge framework that alleviates managers' and core knowledge actors' pain points and supports them in their daily business and long-term decisions.

The panel of experts was unanimous on the importance of access to information. It was mentioned that the difficulty in accessing information influences the time and quality of the technical work that needs to be produced for the expansion of the network. Concerning question 6, where the standard deviation is higher, this may be because some of the technicians have more experience in Projects than others. Of the five specialists, two have more experience in Projects and three in Maintenance.

The main limitation of this study was the limited participation of the five experts representing the whole cluster of Railway signalling in ML. Although numbers/scores are collected they should be regarded as descriptive indicators and thus essentially qualitative in nature.

For future research, the author advocates that the focus should be on developing the appropriate KM framework and assessing the impact using metrics.

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