



UNIVERSIDADE
DE LISBOA



Universidade de Lisboa

ISEG – Lisbon School of Economics and Management

Knowledge Management and Knowledge Sharing in Maintenance Department of Knowledge-Intensive Industries

Hamid Roham

Orientador: Professor Jorge Filipe da Silva Gomes

Jury:

President: Professor Doctor Evuardo Couto

Members:

Professor Doctor Nelson Jorge Campos Ramalho

Professor Doctor Anna Sabino

Professor Doctor Maria João Santos

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ABSTRACT

In the rapidly evolving landscape of knowledge-intensive industries, effective knowledge management (KM) and knowledge sharing (KS) within maintenance departments are crucial pillars for sustained operational excellence and innovation. This thesis thoroughly explores KM and KS practices in the context of knowledge-intensive maintenance, unraveling the intricacies and complexities inherent in this dynamic environment.

Background and Context: Knowledge-intensive maintenance, characterized by the maintenance of sophisticated equipment, demands cutting-edge technical expertise and strategic approaches to knowledge dynamics. As technology advances, the challenges and opportunities within this context underscore the need for a nuanced understanding of KM and KS practices.

Rationale for the Study: Firm competition in knowledge-intensive sectors has shifted toward a knowledge-based economy, where the competitive advantage of knowledge-intensive industries hinges on their ability to generate and deploy novel knowledge solutions. This study is grounded in the rationale that enhancing KM and KS practices in knowledge-intensive maintenance is imperative for organizational resilience and competitiveness.

Research Objectives and Questions: The primary objectives of this research are to comprehensively understand existing KM and KS practices, identify gaps, propose targeted strategies for improvement, and synthesize findings. Key questions guide the exploration, addressing prevailing practices, the facilitation or hindrance of KS, and the specific challenges and opportunities associated with knowledge dynamics in knowledge-intensive maintenance.

Significance of the Study: This study contributes significantly to academic discourse by addressing the complexities of KM and KS in highly specialized knowledge-intensive

maintenance contexts. Practically, the findings offer actionable insights for organizations striving to optimize maintenance practices through more effective knowledge utilization, transcending theoretical boundaries.

Structure of the Thesis: The thesis unfolds through four meticulously conducted studies, each delving into critical aspects of KM and KS in knowledge-intensive maintenance. The chapters encompass an introduction, an extensive literature review, and in-depth analyses of four key papers. The conclusion chapter synthesizes and integrates diverse insights, offering a holistic understanding through its comprehensive summary of key findings, theoretical implications, and proposed avenues for future research.

This thesis, with its comprehensive examination of KM and KS in knowledge-intensive maintenance, offers a roadmap that is directly relevant to the professional or academic interests of organizations seeking to enhance operational efficiency and innovation capabilities within this dynamic technological landscape.

Keywords: Knowledge management, knowledge sharing, industrial maintenance, novices.

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LIST OF ACRONYMS

KM	Knowledge Management
CMMS	Computerize Maintenance Management System
KS	Knowledge Sharing
SPSS	Statistical Package for Social Sciences
KMS	Knowledge Management System
KIFs	Knowledge Intensive Firms
AR	Augmented Reality
VR	Virtual Reality

CHAPTER 1: INTRODUCTION

1.1 Background and Context

In the ever-evolving landscape of knowledge-intensive industries, the seamless functioning of maintenance departments is intricately tied to the effective management and sharing of knowledge. As technological advancements surge, complex, sophisticated equipment maintenance demands a proactive and adaptive approach to knowledge dynamics. The intricate nature of high-tech machinery requires maintenance teams to be well-versed in cutting-edge technologies and possess a keen understanding of how to harness and disseminate knowledge effectively.

1.2. Motivation and purpose of the study

In the rapidly evolving landscape of knowledge-intensive industries, the significance of effective KM and KS cannot be overstated, particularly within the maintenance departments of knowledge-intensive companies. This study is motivated by the recognition that these departments are not only repositories of crucial operational insights but also fertile grounds for cultivating a culture of continuous learning and improvement, offering immense potential for growth and advancement.

Maintenance demands a sophisticated approach to managing and sharing knowledge in the context of intricate systems and rapidly advancing technologies. The motivation for this research extends beyond understanding the current state of KM and KS in such environments; it seeks to address a critical aspect — the transition of novices from passive recipients of knowledge to active contributors within these processes.

Novices often find themselves on the periphery of KM and KS initiatives, absorbing knowledge without actively participating in the creation or dissemination processes. This study aims to delve into strategies and frameworks that bridge this gap, bringing novices from the passive side of KM and KS to the forefront. By empowering novices to actively contribute, share insights, and engage in collaborative knowledge creation, the thesis aspires to not only enhance the efficiency of maintenance operations but also cultivate a culture of innovation and shared expertise.

Through an in-depth exploration of KM and KS dynamics in knowledge-intensive companies' maintenance departments, this research seeks to unearth best practices and challenges. By addressing the specific needs of novices and proposing actionable interventions, the goal is to contribute insights that enable organizations to harness the full potential of their workforce. Ultimately, this study aims to play a pivotal role in transforming maintenance departments into vibrant hubs of knowledge creation, sharing, and innovation within the broader landscape of knowledge-intensive industries. In sum, this thesis aims to contribute to both the theory of KM and KS and to the practice of KM in maintenance departments in knowledge-intensive companies. A brief view of these contributions is provided in section 1.5 below.

1.3. Rationale for the study

The rationale behind this research journey is recognizing knowledge as the lifeblood of knowledge-intensive maintenance. As industries grapple with the relentless pace of technological innovation, the ability to manage and share knowledge within maintenance departments becomes not just a necessity but a strategic imperative. Understanding the intricacies of this imperative is crucial for organizations seeking not only to maintain their

cutting-edge equipment but to do so in a manner that fosters continuous learning and innovation. This study seeks to unravel the complexities of KM and sharing within knowledge-intensive maintenance, providing nuanced insights into its various facets.

1.4. Research objectives and research questions

The overarching objectives of this research are to offer a comprehensive analysis of the current state of KM and KS within knowledge-intensive maintenance departments, to identify potential gaps or inefficiencies in existing practices, and to propose targeted strategies for enhancement. To guide this exploration, the following research questions will be addressed:

1. What are the prevailing practices of KM within knowledge-intensive maintenance departments?
2. What are the specific challenges and opportunities associated with knowledge dynamics in the context of high-tech maintenance, and how can these be addressed for improved operational outcomes, potentially leading to significant improvements?
3. How is KS facilitated or hindered within these knowledge-intensive maintenance contexts, and what role do novices play in this dynamic?

1.5. Significance of the study

This study holds significant academic and practical value, particularly within the realm of KM and KS in knowledge-intensive industries. Academically, it contributes to the ongoing discourse by exploring and integrating theories related to tacit and explicit knowledge transfer, organizational learning, and innovation diffusion within high-tech maintenance. The study

examines how these theoretical frameworks intersect with the complexities of maintaining advanced industrial systems, offering a nuanced understanding of how knowledge is managed and shared in these environments.

Practically, the findings provide actionable insights for organizations looking to enhance maintenance practices by leveraging more effective knowledge utilization. By addressing barriers and enablers of KS among maintenance employees and KM experts, the study offers strategies for improving the flow of critical knowledge, which is essential for operational efficiency and innovation within knowledge-intensive sectors. This research not only contributes to theoretical advancements but also has the potential to shape the future of knowledge-centric maintenance strategies, influencing both policy and practice in the industry.

1.6. Thesis structure overview

This thesis is structured across seven chapters, each contributing to a comprehensive exploration of KM and KS within the maintenance departments of knowledge-intensive industries.

Chapter 1: introduction

The introductory chapter is a prologue, inviting readers into the evolving technological landscape where effective KM becomes a strategic imperative. It outlines the research's aims, research questions, conceptual framework, and justification, setting the stage for the subsequent chapters.

Chapter 2: literature review

This chapter undertakes an extensive literature review to establish a robust theoretical foundation, dissecting relevant concepts, frameworks, and empirical studies. This chapter

provides the theoretical underpinning for the research and identifies gaps in existing knowledge, laying the groundwork for subsequent empirical investigations.

Chapters 3 to 6: research studies

Chapters 3 to 6 present the findings of the empirical studies conducted as part of the research project, with each study presented individually, providing detailed insights into specific aspects of KM and sharing within maintenance departments. This chapter presents four empirical studies conducted as part of the research project:

- Study 1: Unlocking the Potential of Knowledge Management and Sharing in Knowledge-Intensive Companies' Maintenance Departments: Barriers, Enablers, and Recommendations. This study was presented at the Second Australian International Conference on Industrial Engineering and Operations Management, held in Melbourne, Australia, from November 14-16, 2023, and published in the conference proceedings.
- Study 2: Bringing Novices from Passive Roles to Active Roles in Knowledge Sharing. This study was presented at the 24th European Conference on Knowledge Management, held in Lisbon, Portugal, on September 7-8, 2023, and published in the conference proceedings. Additionally, this study won second place in the 9th Knowledge Management and Intellectual Capital Excellence Awards at the ECKM competition.
- Study 3: Knowledge Management and Sharing in Maintenance Departments of High-Tech Industries. This study was submitted to the *Journal of Quality in Maintenance Engineering* and was accepted with minor revisions by three reviewers. After making the revisions, two reviewers approved the paper for publication, while the third

reviewer suggested a few additional minor revisions, which have since been addressed.

The paper will be published in the journal very soon.

- Study 4: Innovative Approaches to Knowledge Management: The Role of Novices in Knowledge-Intensive Maintenance Environments. This study was accepted and presented at the 7th European Conference on Industrial Engineering and Operations Management, held in Augsburg, Germany, from July 16-18, 2024, and published in the conference proceedings. Additionally, this paper won first place in the doctoral dissertation competition at the conference.
- The following graphical representation (Figure 1) illustrates the interconnected flow of relationships among the four empirical studies conducted within this thesis. Each study offers unique insights into the dynamics of KM and KS within knowledge-intensive maintenance departments. Through this visualization, the interplay between individual factors, organizational dynamics, and the effectiveness of innovative training approaches, such as "training by novices," becomes apparent, highlighting the holistic understanding achieved through the collective findings of the research.

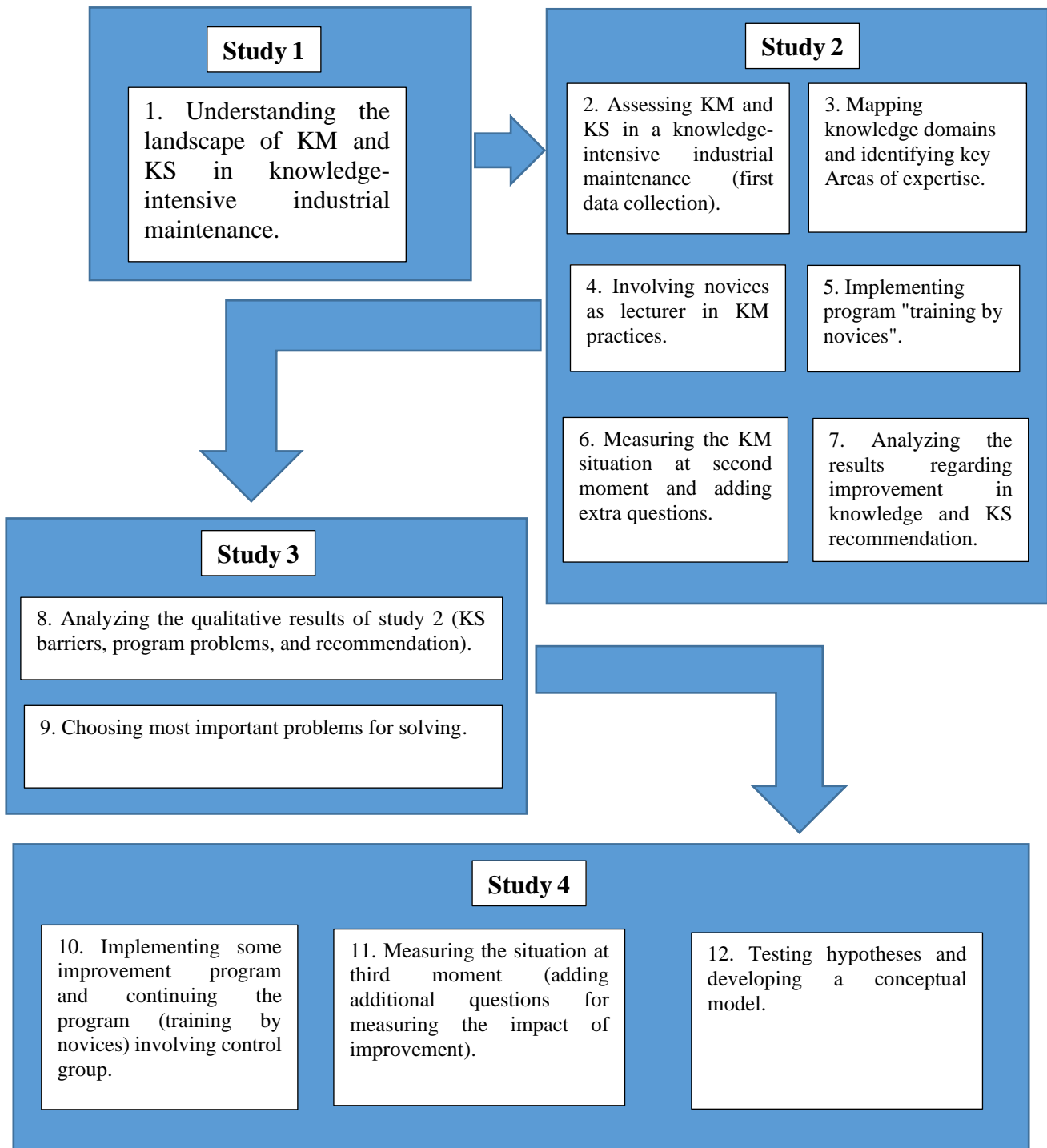


Figure 1: Road map of studies.

Chapter 7: Conclusion

Chapter 7 serves a dual purpose, combining both the discussion of research findings and the concluding remarks. This chapter reflects on the empirical studies' findings, integrates theoretical and practical implications, and synthesizes the research outcomes.

The discussion section begins by reflecting on the key themes and patterns emerging from the empirical studies, providing insights into specific aspects of KM and sharing within maintenance departments. It analyzes the implications of these findings in the context of existing literature, highlighting their significance and contributions to the field.

Following the discussion, the chapter transitions into the conclusion, which encapsulates the essence of the study. It summarizes the key findings, theoretical implications, and practical recommendations derived from the research. Additionally, the conclusion outlines potential avenues for future research, identifying areas for further exploration and development in KM and KS.

CHAPTER 2: LITERATURE REVIEW

This chapter systematically explores the multifaceted landscape of KM and KS within the maintenance departments of knowledge-intensive industries. It begins by defining knowledge in its various forms—procedural, declarative, tacit, explicit, general, and specific—laying the foundation for understanding the complexities of managing and sharing knowledge in these specialized environments. The discussion then moves to the core concepts of KM, including key models and processes such as knowledge discovery, capture, sharing, and application, all crucial for enhancing maintenance operations. The importance of KS is examined next, detailing formal and informal methods, tools, and factors affecting KS at organizational, team, and individual levels. Understanding these elements is vital for addressing the enablers and barriers that impact KS in high-tech maintenance settings.

Furthermore, the chapter addresses the challenges unique to maintenance work practices, such as the absence of standardized language, difficulties in codifying tacit knowledge, and the need for incentives for documenting experiences. By tackling these challenges, the chapter emphasizes the need for effective KM and KS strategies that can optimize maintenance practices and prevent knowledge loss, especially in environments where the expertise of senior technicians is at risk of being lost. The exploration concludes with a discussion on experience management and reuse, highlighting the potential for transforming maintenance operations through improved KM and KS practices.

Reflecting on these topics, it becomes evident that effective KM and KS are not just operational necessities but are crucial in sustaining the competitive edge and efficiency of knowledge-intensive industries. This chapter, therefore, not only synthesizes the existing literature but also paves the way for addressing the critical research questions that guide this study, ultimately contributing to both academic discourse and practical advancements in the field. The study

holds significant academic and practical value, particularly in its potential to transform maintenance operations through improved KM and KS practices.

2.1. Definitions of knowledge

The concept of knowledge lacks a singular, universally accepted definition, as evidenced by a review of the literature. Nevertheless, this study has compiled a list of frequently cited definitions of knowledge from existing literature, which are presented in Table 1.

Table 1: Definitions of knowledge

Author(s)	Definition
Nonaka et al. (1995)	“Information anchored in the beliefs and commitment of its holder.”
(Davenport & Prusak, 1998)	“A Fluid mix of Framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers. In organizations, it often becomes embedded not only in documents or repositories but also in organizational routines, processes, practices, and norms.”
(Davenport & Prusak, 1998)	“Knowledge is information combined with experience, context, interpretation, and reflection. It is a high-value form of information that is ready to apply to decisions and actions.”
(Bhatt, 2000)	“A changeable reality created through interaction and information exchange.”
(McInerney, 2002)	“Knowledge is the awareness of what one knows through study, reasoning, experience or association, or through various other types of learning.”
(Bennet & Bennet, 2004)	“Knowledge is the capacity (potential or actual) to take effective action in varied and uncertain situations.”
Merriam Webster's Collegiate Dictionary	“Acquaintance with or understanding of a science, art, or technique.”
Oxford learners Dictionary	“The information, understanding, and skills that you gain through education or experience.”

This study presents a novel definition of knowledge as the dynamic and contextual understanding that emerges from integrating information, experience, and insights. It is a blend of explicit content—such as documented facts, theories, and data—and tacit elements—such as personal expertise, intuition, and experiential learning. Knowledge is not merely a static repository of facts but a fluid, evolving construct shaped by interactions, contexts, and applications. It encompasses interpreting, adapting, and utilizing information meaningfully to address complex problems and foster innovation. This definition highlights knowledge as an active process of sense-making and application, reflecting its role in driving informed decision-making and continuous learning within organizational and societal contexts. This novel definition is specific to this study, tailored to align with the research focus and findings, and emphasizes knowledge's interactive and transformative nature in achieving organizational goals and fostering growth.

2.2. Various types of knowledge

Knowledge has been categorized and characterized from various perspectives (Alavi & Leidner, 2001). This section delves into some of the most relevant classifications of knowledge.

2.2.1. Procedural or declarative knowledge

A notable distinction in the literature lies between declarative knowledge, which concerns factual information, and procedural knowledge, exemplified by skills like riding a bicycle (Kogut & Zander, 1992). Declarative, or substantive, knowledge centers on beliefs about relationships among variables, while procedural knowledge focuses on beliefs about sequences of actions leading to desired or undesired outcomes (Becerra-Fernandez & Sabherwal, 2014).

Declarative knowledge can be understood as "knowing what," whereas procedural knowledge can be seen as "knowing how".

2.2.2. Tacit or explicit Knowledge

Another significant categorization of knowledge is into tacit or explicit forms (Polanyi & Sen, 2009). Explicit knowledge refers to information that has been articulated into words and can be readily shared in a formal and systematic manner through various mediums such as data, manuals, drawings, multimedia, and patents (Becerra-Fernandez & Sabherwal, 2014). In contrast, tacit knowledge encompasses intuitions, impressions, and insights that are challenging to articulate and formalize, making them inherently difficult to share (Khoshsima et al., 2004). Tacit knowledge is often rooted in personal experiences and activities, representing expertise that is highly personalized and may be too costly to document explicitly, leading organizations to rely on the expertise of individuals.

2.2.3. General or specific knowledge

Another classification of knowledge pertains to its breadth of applicability, distinguishing between general and specific knowledge (Sabherwal & Becerra-Fernandez, 2005). General knowledge is widely possessed and easily transferable between individuals, whereas specific knowledge is possessed by a limited number of individuals and is challenging and costly to transfer (Sabherwal & Becerra-Fernandez, 2005). Specific knowledge further divides into three types: technology-specific, context-specific, and context-and-technology-specific knowledge. Technology-specific knowledge encompasses in-depth understanding of a particular domain, including the tools and techniques relevant to address issues within that domain, often acquired

through formal training and enhanced by practical experience. Context-specific knowledge refers to familiarity with the unique circumstances and conditions in which tasks are carried out, specific to the organizational setting or operational environment. Context-and-technology-specific knowledge combines specialized technical expertise with an acute awareness of the contextual nuances, thereby integrating scientific knowledge with a deep understanding of the specific operational context.

2.3. KM

KM involves optimizing the utilization of an organization's resources, including its human, material, financial, and knowledge assets, within the context of its operating environment (Liebowitz & Frank, 2016). KM addresses how knowledge resources are leveraged, examining their nature, interactions with other organizational assets, and responses to environmental dynamics (Liebowitz & Frank, 2016). As we transition from the industrial age to the information and knowledge era, the significance of knowledge in business operations has escalated (Schwartz, 2005). Indeed, knowledge is increasingly recognized as a primary driver of organizational effectiveness (Barley et al., 2018), with successful KM practices directly contributing to organizational success (Liebowitz & Frank, 2016).

2.3.1. Definition of KM

Definition of KM encompasses various perspectives. According to Nonaka et al. (1995), it involves systematically capturing, structuring, managing, and disseminating knowledge across an organization to enhance efficiency, promote the reuse of best practices, and minimize redundant work. Alternatively, (McInerney & Koenig, 2011) describe KM as the process of

disseminating valuable knowledge within an organization. Simply put, KM can be understood as optimizing the utilization of knowledge resources to achieve organizational objectives (Becerra-Fernandez & Sabherwal, 2014) while KM can benefit individuals, its primary focus is on organizational knowledge enhancement; as an increasingly vital discipline, KM facilitates the creation, sharing, and exploitation of an organization's knowledge assets (Becerra-Fernandez & Sabherwal, 2014). Table 2 presents some of the most commonly cited definitions of KM.

Table 2: Definitions of KM

Author(s)	Definition
(Wiig, 1997)	“It is a set of distinct and well-defined approaches and processes. The overall purpose of KM is to maximize the enterprise's knowledge related effectiveness and returns from its knowledge assets and to renew them constantly.”
(Quintas et al., 1997)	“It is the process of continually managing knowledge of all kinds to meet existing and emerging needs, to identify and exploit and acquire knowledge assets and to develop new opportunities.”
(Davenport & Prusak, 1998)	“It consists of processes to capture, distribute, and effectively use knowledge.”
(Ruggles, 1998)	“It is an approach to adding or creating value by more actively leveraging the know-how, experience, and judgment resident within and, in many cases, outside of an organization.”
(Lee & Yang, 2000)	“It is an emerging set of organizational design and operational principles, processes, organizational structures, applications and technologies that helps knowledge workers dramatically leverage their creativity and ability to deliver business value.”
(uit Beijerse, 2000)	“It is the management of information within an organization by steering the strategy, structure, culture and systems and the capacities and attitudes of people with regard to their knowledge. It is the achievement of the organization's goals by making the factor knowledge productive.”
(Tsoukas & Vladimirou, 2001)	“The dynamic process of turning an unreflective practice into a reflective one by elucidating the rules guiding the activities of the practice, by helping to give a particular shape to collective understandings, and by facilitating the emergence of heuristic knowledge.
(McInerney, 2002)	“KM is an effort to increase useful knowledge within the organization. Ways to do this include encouraging communication, offering opportunities to learn, and promoting the sharing of appropriate knowledge artifacts.”
(Carlucci et al., 2004)	“The KM is a managerial paradigm which considers knowledge as a resource at the basis of a company's competitiveness. It identifies the capabilities to generate value for a company's stakeholders with the explicit and systematic implementation of approaches, techniques and tools for the assessment and management of intellectual capital.”
(Jashapara, 2004)	“The effective learning processes associated with exploration, exploitation and sharing of human knowledge (tacit and explicit) that use appropriate technology and cultural environments to enhance an organization's intellectual capital and performance.”
(Leidner et al., 2006)	“The generation, representation, storage, transfer, transformation, application, embedding and protection of organizational knowledge.”
(Jasimuddin, 2012)	A discipline that promotes an integrated approach to identifying, capturing, storing, retrieving and transferring an organization's knowledge to enhance its competitive advantage.

This research proposes the following definition of KM: It is a strategic and systematic process involving the creation, organization, dissemination, and utilization of knowledge assets within an organization to enhance its effectiveness, innovation, and competitive advantage. KM integrates individual and organizational efforts to capture and leverage both explicit and tacit knowledge, fostering a culture of continuous learning and collaboration. This process encompasses a range of practices, technologies, and cultural elements designed to optimize the flow of knowledge, align it with organizational goals, and support informed decision-making. By harmonizing motivational drivers, cultural dynamics, and technological tools, KM enables organizations to transform their knowledge resources into actionable insights and sustainable performance improvements.

2.3.2. KM models

KM models can be classified into four main categories, as outlined by (Sensuse & Cahyaningsih, 2018):

1. **Process-based KM:** This category delineates KM models based on processes, elucidating the stages or activities involved in the KM process, contingent upon the model's objectives and functions.
2. **Strategy-based KM:** KM models in this category are instrumental in defining KM strategies. These strategies are intricately linked to organizational processes and infrastructure, aiming to foster knowledge creation and sharing to inform strategic decision-making (Zack, 2002).
3. **Knowledge-type-based KM:** Here, KM models categorize knowledge types by mapping them into distinct categories such as tacit, explicit, organizational, individual, and social knowledge.

4. Implementation Maturity-based KM: This category of KM models is employed to gauge the maturity level of KM implementation within an organization.

The delineation of these four categories assists organizations in selecting the most appropriate KM model tailored to their specific needs. Furthermore, KM research necessitates rigorous analysis to validate existing models and theories, thereby informing the development of new models. By aligning KM methods with organizational strategies, processes, and activities, organizations can leverage tools to enhance productivity, quality, and innovation while capitalizing on their competitive advantages. Organizations may also opt to adapt, combine, or customize existing models to suit their unique requirements and organizational learning processes, underscoring the dynamic and iterative nature of KM implementation.

2.3.3. Processes of KM

In recent decades, researchers have introduced several KM processes encompassing diverse activities that pertain to both tacit and explicit knowledge, as outlined by (Wong et al., 2015). These processes include acquisition and retrieval, internalization, creation and generation, application and utilization, codification and storing, and transferring and sharing.

Knowledge acquisition, retrieval, and accumulation involve knowledge workers obtaining valuable information necessary for their job tasks, such as attending seminars, workshops, or sourcing it from repositories, suppliers, or customers (Wong et al., 2015). In the Knowledge creation and generation process, intellectual properties such as new ideas, best practices, or patents are developed (Morey, 2001). Knowledge codification and storing entail documenting knowledge and storing it in organizational repositories like archives, databases, and filing systems, ensuring accessibility for workers (Shannak, 2009).

Earlier, KM was defined as the execution of activities involved in discovering, capturing, sharing, and applying knowledge to enhance the impact of knowledge on the unit's goal achievement cost-effectively. According to (Becerra-Fernandez & Sabherwal, 2014), KM relies on four primary processes, including knowledge discovery or capture, sharing, and application (Table 3). This study particularly focuses on this categorization among various classified processes.

Table 3: KM processes and sub-processes

Item	KM Process	KM Sub-process
1	discovery	Combination
		Socialization
2	capture	Externalization
		Internalization
3	sharing	Socialization
		Exchange
4	application	Direction
		Routine

2.3.3.1. Knowledge discovery

Knowledge discovery can be defined as the process of cultivating fresh tacit or explicit knowledge, stemming either from data and information or through the synthesis of existing knowledge. The quest for new explicit knowledge predominantly relies on combination, wherein multiple bodies of explicit knowledge, along with data and information, are amalgamated to form more sophisticated sets of explicit knowledge. Conversely, the exploration for new tacit knowledge primarily depends on socialization, as articulated by (Nonaka & Takeuchi, 2018). This involves integrating various streams to generate novel

knowledge through collaborative activities rather than through written or verbal instructions. Socialization (Becerra-Fernandez & Sabherwal, 2014) entails the synthesis of tacit knowledge among individuals through joint endeavors (Becerra-Fernandez & Sabherwal, 2014).

2.3.3.2. Knowledge capture

Knowledge resides within various entities, including individuals, groups, artifacts (such as practices, technologies, or repositories), and organizational structures (comprising units, organizations, and inter-organizational networks). Furthermore, knowledge can take the form of either explicit or tacit knowledge. Sometimes, knowledge may exist within an individual's mind without their awareness or ability to articulate and share it with others. Similarly, knowledge may be present in explicit form within a manual, yet remain unnoticed by many. Obtaining both tacit knowledge from individuals' minds and explicit knowledge from manuals is essential for effective KS. This process is the essence of knowledge capture, which involves retrieving either explicit or tacit knowledge residing within people, artifacts, or organizational entities (Becerra-Fernandez & Sabherwal, 2014).

Externalization entails converting tacit knowledge into explicit forms, such as words, concepts, visuals, or figurative language (e.g., metaphors, analogies, and narratives; (Nonaka & Takeuchi, 2018)). This process facilitates the translation of tacit knowledge into explicit forms that can be readily comprehended by others within the group. However, externalization poses challenges due to the inherent difficulty in articulating tacit knowledge (Becerra-Fernandez & Sabherwal, 2014). Knowledge internalization, on the other hand, involves converting explicit knowledge acquired during knowledge acquisition activities into tacit knowledge and

assimilating it into one's own understanding (Uit Beijerse, 1999). This process aligns with the conventional notion of learning.

Japanese scholars present a concise framework comprising four modes of knowledge creation, illustrating the interplay between internal and external knowledge within a company, as well as the dynamic between tacit and explicit knowledge (Holden & Glisby, 2010). Figure 2 illustrates these processes, known as socialization, externalization, combination, and internalization (SECI).

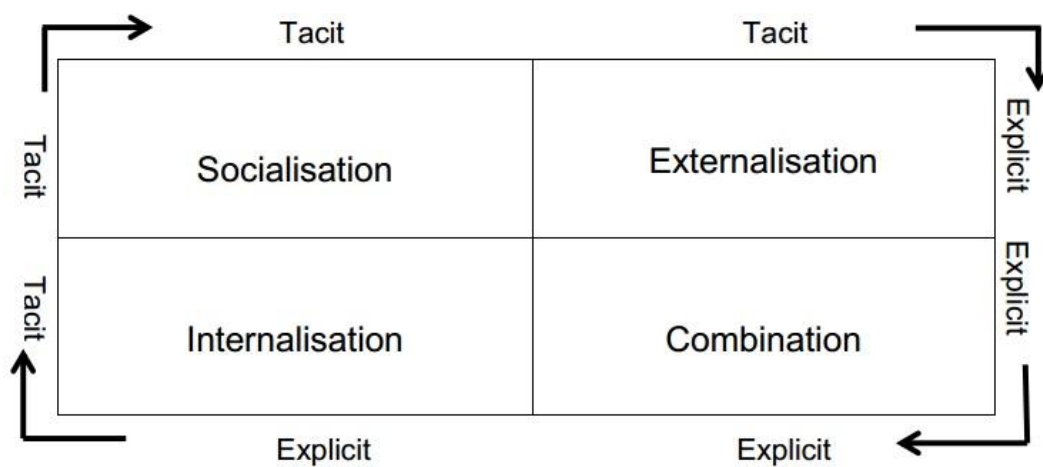


Figure 2: Four modes of knowledge creation.

Source: (Nonaka et al., 1995).

Socialization (tacit to tacit) involves the sharing of tacit knowledge or experiences through direct, interpersonal communication. Externalization (tacit to explicit) involves translating tacit knowledge into explicit concepts, such as designs for new products. Combination (explicit to explicit) entails integrating newly generated explicit knowledge with existing explicit knowledge, such as merging approved designs with manufacturing expertise. Internalization, a form of organizational learning, occurs when newly acquired explicit knowledge becomes ingrained as company-specific tacit knowledge.

This renowned model, rooted in the practices of Japanese companies, is widely regarded as universally applicable. However, some argue that its full significance can only be grasped within the cultural context that gave rise to it (Holden & Glisby, 2010).

2.3.3.3. KS

According to Lin et al. (2009), KS embodies a social interaction culture wherein employees exchange knowledge, experiences, and skills throughout the entire department or organization. Similarly, (Harder, 2008) characterizes KS as a voluntary and social process aimed at transferring, absorbing, and reusing existing knowledge to fulfill organizational objectives. Cheng et al. (2009) elaborate on KS as the transmission of knowledge between at least two individuals, extending to multiple colleagues within a workplace. Additionally, the same authors propose that individuals disseminate their acquired knowledge to those with shared interests and those who can benefit from it. This process of KS encompasses activities such as collecting, organizing, and exchanging knowledge from one individual to another.

KS is the process by which explicit or tacit knowledge is communicated to others. This transfer and dissemination of knowledge throughout an organization is facilitated by activities such as attending seminars and workshops, and assigning mentors to new recruits (Wong et al., 2015).

KS involves the effective transfer of knowledge, enabling the recipient to understand it well enough to take action (Jensen & Heckling, 1995). Importantly, KS entails transferring knowledge itself, rather than merely recommendations based on that knowledge. The former ensures that the recipient acquires and can act on the shared knowledge, while the latter only involves utilizing the knowledge without internalizing it. KS can occur between individuals, as well as across groups, departments, or organizations (Alavi & Leidner, 2001). The processes

used for sharing depend on whether explicit or tacit knowledge is being shared. Socialization processes, which facilitate the sharing of tacit knowledge, are crucial both when new tacit knowledge is created and when it is not. While there is no intrinsic difference between the socialization process for knowledge discovery and KS, the specific application of the process may vary.

2.3.3.4. Knowledge application

Knowledge application involves the utilization of knowledge within an organization to facilitate decision-making and task performance, thereby enhancing organizational effectiveness. This entails effectively using created knowledge, such as implementing best practices within the organization (Wong et al., 2015). Direction, on the other hand, refers to the process wherein an individual guides the actions of another without transferring the underlying knowledge. In this context, direction involves conveying instructions or decisions rather than transferring the knowledge necessary to make those decisions, leading to what is termed as knowledge substitution. Routines, meanwhile, entail the application of knowledge ingrained in procedures, rules, and norms that govern future actions. Routines streamline communication more efficiently than directions since they are integrated into procedures or technologies. Given that KS is the focal point of this study, it will be thoroughly explored in the following section.

2.4. Importance of KS

The success of KM initiatives largely hinges on KS (Wang & Noe, 2010), making it a crucial component of KM. Increasingly, both researchers and practitioners are focusing on the concept of KS due to its potential benefits for individuals and organizations (Yi, 2009). Organizations must consider the transfer of expertise and knowledge from experienced individuals to novices who require it (Hinds et al., 2001). As a key knowledge-centered activity, KS is the primary way employees can contribute to knowledge application, innovation, and ultimately, the organization's competitive advantage (Jackson et al., 2006).

KS among employees and across teams enables organizations to leverage knowledge-based resources (Cabrera & Cabrera, 2005). Research has demonstrated that KS and knowledge combination positively impact reductions in production costs, faster completion of new product development projects, team performance, firm innovation capabilities, and overall firm performance, including sales growth and revenue from new products and services (Mesmer-Magnus & DeChurch, 2009).

Given the potential benefits of KS, many organizations have significantly invested in KM initiatives, including the development of KMS, to facilitate the collection, storage, and distribution of knowledge (Wang & Zheng, 2010). However, despite these investments, it is estimated that Fortune 500 companies lose at least \$31.5 billion annually due to inadequate KS (Babcock, 2004). One key reason for the failure of KMS to facilitate effective KS is the lack of consideration for how organizational and interpersonal contexts, as well as individual characteristics, influence KS (Voelpel et al., 2005).

KS involves providing task information and know-how to assist others and collaborating to solve problems, develop new ideas, or implement policies and procedures (Dorsey, 2003). KS, knowledge transfer, and knowledge exchange have distinct differences (Wang & Noe, 2010).

Knowledge transfer includes both the sharing of knowledge by the source and the acquisition and application of that knowledge by the recipient (Wang & Noe, 2010). It describes the flow of knowledge among different departments or organizations rather than individuals (Szulanski et al., 2004). While "knowledge exchange" is often used interchangeably with "KS" (Cabrera et al., 2006), it encompasses both KS (employees providing knowledge to others) and knowledge seeking (employees searching for knowledge from others).

2.4.1. KS definitions

Zheng (2017) identified the fundamental characteristics of KS as follows: 1) KS is a significant individual behavior; 2) KS is a voluntary and proactive behavioral awareness; 3) KS is regulated by environmental systems or procedures, including legal and ethical standards, codes of conduct, and habits; 4) the outcome of KS is shared by two or more parties. Table 4 presents the most common definitions of KS.

Table 4: Definitions of KS.

Author(s)	Definition
(Dyer & Nobeoka, 2000)	KS is the activity of working to exchange knowledge among people and enable them to achieve their individual aims.
(Bartol & Srivastava, 2002)	KS is the activity of helping organizational members to share their data, information, ideas, experiences, and suggestions within the organization.
(Argote et al., 2003)	KS is the process by which one unit is affected by the experience of another.
(Ipe, 2003)	KS is the process of converting knowledge from individuals who possess it into individuals who accept the knowledge and absorb it.
(Van Den Hooff & De Ridder, 2004)	KS is the process by which knowledge is exchanged and created at the same time.
(Bock et al., 2005)	KS refers to the behavior of individuals in sharing their knowledge with each other within an organization.
(Lin, 2007)	KS is a culture of social interaction that includes the exchange of knowledge, experiences, and skills among employees.
(Xiong & Deng, 2008)	KS refers to the exchange and communication of knowledge and information between members.
(Sohail & Daud, 2009)	KS represents the exchange and sharing of the events, thoughts, and experiences of people.
(Islam et al., 2011)	KS is the process of social exchange that occurs between individuals, from individuals to organizations, and from organization to organization.
(P. Lee et al., 2010)	KS refers to the interaction of tacit and explicit knowledge that is relevant to the task in hand.
(Masrek et al., 2011)	KS is described as a process by which individuals mutually exchange their tacit and explicit knowledge and jointly generate new knowledge.
(Jahani et al., 2011)	KS includes the activities by which knowledge is transferred from one person, group, or organization to another.
(Hitam & Mahamad, 2012)	KS is the exchange of knowledge, experiences, and skills among members through various departments in the organization.
(Hau et al., 2013)	KS is the activity by which information, skills, and insights are exchanged among organizational members.
(Vij & Farooq, 2014)	KS is the basic means by which workers can contribute to the development of technology, creativity and ultimately the competitive advantage.
(Razmerita et al., 2016)	KS is a process of exchanging both implicit and explicit information to produce new knowledge.
(Rutten et al., 2016)	KS is described as individuals' willingness to share their knowledge with others within the organization

In this study KS is defined as the deliberate and voluntary exchange of knowledge and expertise among individuals or groups within an organization, aimed at fostering mutual learning, innovation, and collective problem-solving. KS involves both the dissemination and absorption of knowledge, encompassing various forms such as formal training, informal discussions, collaborative projects, and digital platforms. Effective KS is driven by intrinsic motivations (e.g., personal satisfaction, professional growth), extrinsic incentives (e.g., rewards, recognition), and a supportive organizational culture that encourages trust, collaboration, and open communication. It is influenced by factors such as individual intentions, organizational norms, and the availability of tools and systems that facilitate the seamless transfer of knowledge. KS is integral to enhancing organizational capabilities, driving continuous improvement, and achieving strategic objectives through the shared understanding and collective intelligence of its members.

The essence of KS can be encapsulated in the formula: "share = pass + absorb" (Zheng, 2017). This formula outlines the fundamental process underlying KS. Subsequently, the KS process unfolds through two primary sub-processes. Firstly, KS presupposes that the knowledge owner engages in externalization behavior (Zheng, 2017). Externalization takes various forms and is not necessarily a deliberate action aimed at sharing knowledge with others. Secondly, KS assumes that the recipient of knowledge adopts internalization behavior (Zheng, 2017). Internalization manifests in diverse forms, such as experiential learning, reading, or efforts to comprehend explicit knowledge within a knowledge base.

However, numerous obstacles impede the internalization of external knowledge. These barriers can arise from constraints related to time and space, as well as from differences in social, cultural, linguistic, spiritual, and conceptual frameworks (Hendriks, 1999). Such challenges underscore the complexity inherent in the process of absorbing external knowledge into one's own cognitive framework.

2.4.2. KS tools

KS can occur via written correspondence or face-to-face communications through networking with other experts, or documenting, organizing and capturing knowledge for others (Cummings, 2004). The most common KS tools and their definitions could be seen at table 5.

Table 5: KS tools and techniques

Author(s)	Construct	Definition
(Razak et al., 2016)	Formal Training	A mechanism that characterized with a standardization of training content for all team members. It can be utilized verbally or visually to share explicit knowledge
(Lee et al., 2016)	Written Report	A tool that used to document explicit knowledge where it can be a hardcopy or softcopy
(Al Saifi et al., 2016)	Periodic Meeting and Workshop	A traditional tool in which individuals or team members learn about an issue by discussing it face to face in a specific room called meeting room
(Sammarra et al., 2017)	Mentoring and Coaching Program	An effective management tools that support interpersonal processes and direct interactions among team members to reinforce KS
(Tan, 2016)	Face to Face Interaction	A personal communication by means of verbalized and body language discussions
(Islam & Afroze, 2020)	KS Systems	Refer to the IT that supports KM activities. Such as video conferencing, groupware and online communities
(Stoddart, 2020)	Email	Is one of the most widely used technique to share knowledge among organizations internally and externally
(Hartmann et al., 2017)	Cloud Computing	Refers to a modern technology that provides a large data center that enable users to access on data anywhere

2.5. KS methods

Methods of KS can be categorized into formal and informal approaches. Formal methods are those that businesses can explicitly manage and implement, whereas informal KS methods are voluntary, and management can only influence or support them (Van Greunen, 2017). It's crucial to recognize that three key components—people (the foundation of knowledge), processes (encompassing organizational culture, climate, methods, and channels of KS), and technologies (utilizing information technology as a tool for sharing knowledge)—are fundamental for effective KS. When selecting the appropriate method for KS, these components must be taken into account. Given that businesses operate in diverse contexts with unique requirements, different methods may be employed. The optimal value of KS can only be achieved through the synergy between organizational culture and the suitable knowledge-sharing methods tailored to each business (Van Greunen, 2017).

2.5.1. Formal KS

Formal methods for sharing knowledge encompass a range of structured approaches, such as intranets, extranets, peer assists, after-action reviews, retrospect, knowledge fairs, coaching, knowledge networks, and group-based KS.

2.5.1.1. Intranets and extranets

An intranet serves as a secure internal website where users within a business can share documents, calendars, and other information. On the other hand, an extranet extends a part of

the intranet to external stakeholders like customers, partners, and clients, granting them access to business information through secure authentication methods. In addition to facilitating group work, intranets provide a safe platform for internal employees to engage in discussions and exchange commentary. By utilizing an intranet, businesses not only keep their employees informed about internal developments but also foster a sense of belonging and participation, thereby nurturing a culture of KS within the organization. The collaborative features of both intranets and extranets play a pivotal role in promoting knowledge exchange (Van Greunen, 2017).

2.5.1.2. Peer assist

A peer assist, as described by Leask et al. (2008), is a meeting convened to gather feedback from a group of peers regarding a particular problem, activity, or project. The primary objective of such meetings is to leverage the collective knowledge and expertise of participants to address the specific issue at hand. These sessions can prove invaluable in both the pre-project planning phase and during the execution of a project, offering insights that help steer the project in the right direction.

Moreover, peer assists are instrumental in problem-solving and guiding the development of products and services (Van Greunen, 2017). By fostering an environment conducive to the exchange of innovative ideas, they facilitate the creation of optimal solutions. Through the sharing of diverse perspectives and experiences, employees have the opportunity to learn from one another. It's crucial for employees to recognize that their contributions are valued. Dixon (2012) further underscores the importance of peer assists as a mechanism for building relationships and tapping into the tacit knowledge of experts involved in specific projects.

2.5.1.3. After-action review

An after-action review, as described by Young (2010), is a post-event or post-project meeting designed to articulate the lessons learned rather than to solve problems or assign blame. It serves as a comprehensive summary of the event or project, focusing on sharing insights into what aspects succeeded or failed. Through participation in after-action reviews, individuals can glean valuable insights from each other, gaining diverse perspectives on the specific activity at hand. This collaborative approach allows businesses to benefit from a range of viewpoints, enhancing their understanding of both successful strategies and areas for improvement.

2.5.1.4. Retrospects

Retrospects, as delineated by Serrat (2017), diverge from after-action reviews by delving deeper into the lessons gleaned from an event. Unlike after-action reviews, which primarily summarize lessons learned, retrospects entail a thorough discussion aimed at capturing insights acquired throughout the event's duration. This comprehensive approach prompts participants to reflect on the event, analyze its successes and shortcomings, and discern valuable lessons for future endeavors. While after-action reviews focus solely on lessons learned and encountered problems, retrospects aim to address these issues and bridge gaps to enhance future project outcomes (Rao, 2012).

2.5.1.5. Knowledge fair

The objective of a knowledge fair is to spotlight a designated theme through diverse mediums like kiosks, presentations, showcases, panels, scale models, and demonstrations. By hosting knowledge fairs, businesses can tap into external professionals' expertise to shed light on specific topics (Dalkir, 2013). While emphasizing external KS, knowledge fairs do not diminish the significance of internal knowledge exchange; rather, they offer novel viewpoints that might have been disregarded previously. With their adaptable nature, knowledge fairs foster interactive engagement among individuals, enabling them to explore each other's contributions and insights (Denning, 2000).

2.5.1.6. Coaching

The aim of coaching as a method of KS is to enhance an employee's tacit understanding of business processes (Van Greunen, 2017). It is explicitly directed at fostering the development of new skills, qualifications, and abilities aligned with the organization's objectives. It's important to distinguish coaching from mentoring: mentoring involves experienced employees guiding their less experienced counterparts, while coaching focuses on honing specific skills and qualifications. The coach's role is not to impose personal visions but to address the employee's predefined needs relevant to their job, ultimately aiming to enhance performance towards organizational goals (Hunt & North, 2000).

2.5.1.7. Structured knowledge networks

A knowledge network serves as a structured team within an organization, focusing on essential knowledge domains vital for its operations. These networks operate with well-defined responsibilities integrated into employees' regular roles, supported by performance agreements aligned with organizational goals, fostering action-oriented collaboration to achieve tangible outcomes. The primary objective of a knowledge network is to identify the critical knowledge needs of a business and strategize on how to effectively capture and utilize this knowledge (Denner, 2012).

One example of a formal knowledge network is an organizational hierarchy's official channels established by management to strategically drive knowledge creation and sharing within the company. The knowledge generated can be leveraged to develop new products, strategies, and policies. Another type is a task force specifically assembled to accomplish a particular project or task, aiming to generate knowledge necessary for its completion within the organization. Participation in such networks is typically by invitation and is contingent upon individuals' or organizations' expertise, skills, and attitudes (Denner, 2012).

2.5.1.8. Formal group-based KS

Methods of group-based KS, including small meetings, discussion groups, and large forums, offer valuable opportunities for knowledge exchange (Liu & Lai, 2011). Emphasizing relationship-building among employees, these methods foster micro-level connections that contribute to workplace dynamics and facilitate KS and learning. For instance, individuals who excel in collaborating with their colleagues are essential for fostering an innovative, open culture within an organization. Increased interaction among employees can lead to enhanced

engagement not only internally but also with external stakeholders such as customers and suppliers (Michailova & Sidorova, 2011).

2.5.2. Informal KS methods

In this section, informal methods of KS are explored, which encompass weblogs, mentoring, storytelling, chat shows, communities of practice, and unstructured knowledge networks.

2.5.2.1. Weblog

A weblog, commonly known as a blog, is a regularly updated website where entries are arranged chronologically, with the most recent ones displayed first. It serves as a simple yet effective platform for sharing knowledge, allowing individuals and teams to document and exchange information on various topics (Schwartz, 2005). Due to its voluntary nature, a weblog represents an informal avenue for knowledge dissemination, offering individuals a space to express their thoughts, ideas, and expertise. Additionally, a weblog facilitates the codification of knowledge, making it readily accessible for business use. However, it's essential to monitor weblogs to prevent the unintentional or deliberate disclosure of sensitive information, which could potentially harm a business's reputation (Salloum et al., 2018). Integrating weblogs into a business's intranet or extranet can provide some level of oversight. Moreover, incentivizing weblog usage through recognitions like "Weblog of the Month" or "Most Innovative Weblog of the Month" can further encourage participation (Young, 2010).

2.5.2.2. Mentoring

Mentoring entails a learning partnership between two employees, where the mentor, typically an experienced individual, imparts knowledge to a less experienced counterpart (Dalkir, 2013). While mentoring shares similarities with coaching, the former is less formal and centers on individual development, whereas coaching is more structured and aligned with organizational objectives. It's worth noting that individuals may be more inclined to share knowledge when they perceive personal growth as a priority over organizational goals. This dynamic can foster the development of tacit knowledge, ultimately benefiting the business (Hunt & North, 2000).

2.5.2.3. Storytelling

Storytelling, among the oldest methods of knowledge dissemination, involves conveying complex concepts, lessons learned, or key messages (Connell, 2008). It's an informal practice often observed during tea breaks or corporate gatherings. Creating a familial atmosphere where employees feel connected is crucial for maximizing the efficacy of KS. Storytelling fosters this sense of community, enhancing the exchange of insights among team members (Young, 2010).

2.5.2.4. Chat shows

A chat show provides an informal and enjoyable platform for knowledge exchange, resembling the format of television chat shows. Typically, a host and three to four guests engage in conversation while coworkers watch and participate as the audience. Through a series of questions on specific topics, participants not only share insights but also foster camaraderie among colleagues. The emphasis of a chat show lies in its casual nature, steering clear of

serious discussions, with the primary goal being team building and interaction development (Hewitt, 2008).

2.5.2.5. Communities of practice

A community of practice stands out as a vital informal avenue for both KS and problem-solving within a business context (Van Greunen, 2017). While formal methods prioritize the business's objectives with employees benefiting as a secondary outcome, informal approaches like communities of practice prioritize individual growth with the business reaping additional advantages (Coakes & Clarke, 2005). Such communities comprise individuals united by a shared interest or profession who regularly interact to enhance their collective expertise. Whether online or in-person, these groups facilitate the exchange of insights, ideas, and best practices among professionals either within a single business or across multiple enterprises. Despite varying levels of familiarity among members, participants experience a sense of community as they confront similar challenges and share common interests. Like other KS methods, the effectiveness of communities of practice hinges on employees' willingness to collaborate (Young, 2010).

2.5.2.6. Unstructured knowledge networks

Informal, unstructured knowledge networks typically emerge serendipitously, often rooted in personal connections or friendships (Denner, 2012). Members gravitate towards these networks to access knowledge, expertise, experiences, and skills. Various informal network types, such as learning networks, advice networks, and market networks, may arise, each characterized by

shared interests, expertise, and backgrounds (R. Lee et al., 2010). Participation in these networks is voluntary, leading to fluctuating membership and often short lifespans. However, when strongly affiliated, these networks may persist beyond their initial purpose (Johnson, 2009).

In contrast to communities of practice, informal networks lack specific problem-solving objectives or explicit tasks. They rely on evolving member relationships rather than predefined goals. Despite some members never encountering each other directly, they can still exchange knowledge (Van Greunen, 2017). Similarly, Erwee (2005) notes that community of practice members engage based on personal resonance with the community's theme, whereas informal knowledge networks prioritize continuous relationship building, often existing briefly to gather and share information.

These networks operate independently of hierarchical structures, with individuals' ranks holding little significance. The emphasis lies on collaborative KS to achieve common objectives. Rather than attempting to manage such networks directly, managers should foster an environment conducive to their formation and growth (Denner, 2012). While management can deploy various knowledge-sharing methods to promote engagement, individual participation remains a crucial aspect of the knowledge-sharing process.

In summarizing the exploration of formal and informal KS methods, it is evident that each approach serves distinct yet complementary roles in fostering effective knowledge exchange within knowledge-intensive industries. Formal methods such as intranets, peer assists, and structured networks provide structured, systematic platforms for KS, often supported by organizational policies and technologies. These methods are crucial for capturing and

disseminating explicit knowledge, ensuring consistency, and fostering a culture of continuous learning.

On the other hand, informal KS methods, including mentoring, storytelling, and communities of practice, play a critical role in facilitating the exchange of tacit knowledge. These methods leverage personal relationships and social interactions, allowing for the nuanced transfer of expertise and insights that are often difficult to codify. Informal methods also enhance trust and collaboration among team members, which is essential for effective knowledge sharing in dynamic and complex maintenance environments.

By integrating both formal and informal KS methods, organizations can establish a comprehensive knowledge-sharing ecosystem. This approach not only captures and distributes explicit knowledge but also fosters the organic flow of tacit knowledge. Such a dual approach is particularly critical in the maintenance domain of high-tech industries, where the preservation and transfer of specialized knowledge are essential for operational excellence and long-term sustainability.

2.6. Factors affecting KS

Factors influencing KS can be classified into three levels: organizational, team, and individual.

2.6.1. Organizational level

2.6.1.1. Management support

Effective management plays a pivotal role in fostering efficient KS practices. Active engagement and support from management are essential for establishing a culture of KS and for evaluating the effectiveness of KS processes (Rohman et al., 2020). When top management actively supports KS initiatives, it enhances employees' willingness to communicate and exchange knowledge within the organization (Wee, 2012). Studies have identified management support as a key factor influencing employees' perceptions and behaviors related to KS (Wang & Noe, 2010). Research by (Lee et al., 2006) demonstrated that support from top management positively impacted productivity and the level of KS by influencing employee commitment to KM. Similarly, (Wang & Noe, 2010) highlighted that management support is a strong predictor of employee KS behavior. These findings underscore the significant influence of top management support on KS initiatives.

2.6.1.2. Incentives/Rewards

Incentives and rewards play a crucial role in motivating KS efforts within organizations (Rohman et al., 2020). Theories of social exchange and social capital support the notion that organizational incentives, including salary increases, bonuses, and promotions, are positively associated with KS behaviors among employees. (Nelson et al., 2006) emphasize the significance of recognition and rewards in fostering a culture of KS and establishing a supportive network within the organization. In summary, these studies underscore the impact of incentives and rewards on KS initiatives.

2.6.1.3. Leadership

Leadership plays a pivotal role in shaping the direction and objectives of an organization, guiding its growth and adaptation. Within academic discourse on information systems and management, leadership holds a central position (Rohman et al., 2020). Leadership style refers to the manner in which a leader interacts with their followers and provides direction. Various leadership styles exist, including authoritarian, egalitarian, transactional, and transformational. A proficient leader not only serves as a role model but also fosters a culture that encourages KS and provides incentives for such behavior (Søndergaard et al., 2007). Chen and Lin (2004) have identified transformational leadership behavior as a significant predictor of KM.

2.6.1.4. Organizational culture

Organizational culture encompasses a company's behaviors, beliefs, and values, shaping how individuals within the organization approach problem-solving and decision-making (Brijball, 2010). O'Neill et al. (2001) describe organizational culture as a collective schema shared among employees, shaped by and shaping fundamental assumptions and norms. This culture is expressed through shared meanings conveyed via narratives, myths, and practices, leading to distinctive behavioral patterns unique to the organization. Over time, each business develops its own unique culture, reflecting its identity through espoused values, philosophies, and implicit norms that guide employee behavior and perceptions (Brijball, 2010). Fostering a culture conducive to KS is imperative for businesses, as it requires an environment that encourages employees to engage in sharing knowledge as an integral part of their daily activities, thereby capturing their thoughts, minds, and behaviors (Brijball, 2010). While organizational culture defies precise definition, it can be discerned through various dimensions

such as management style, reward orientation, attitude towards change, locus of authority (organizational structure), and employee participation, each playing a pivotal role in shaping organizational behavior (Jacobs & Roodt, 2011).

2.6.1.5. Technology

Technology plays a supporting role in KM, enhancing the efficiency of KS processes. However, it's essential to recognize that technology alone cannot compel individuals to share knowledge willingly (Zheng, 2017). While information technology may not be the primary driver of KM, it can significantly improve the effectiveness of KS initiatives (Zheng, 2017). Many organizations opt to leverage information technology to facilitate KS, ensuring the retention of organizational knowledge and the seamless transition of knowledge from individual to organizational levels (YI et al., 2008).

2.6.1.6. Competitive culture

A culture that promotes individual competition tends to hinder KS, as highlighted by (Wang & Noe, 2010). In such environments, where success is often measured by individual achievements, the spirit of collaboration necessary for effective KS may be stifled. Conversely, fostering a culture of organizational cooperation fosters trust, which is essential for successful KS initiatives (Wang & Noe, 2010).

2.6.2. Team level

2.6.2.1. Shared mental models

A shared mental model refers to the alignment or compatibility of knowledge structures among team members regarding pertinent aspects within the team's domain (Zheng, 2017). This shared understanding facilitates members' abilities to articulate, interpret, and anticipate events within their context, guiding interactions among team members accordingly (Zheng, 2017). Empirical studies have consistently demonstrated that a shared mental model fosters coordination, integration, and mutual cooperation among team members, ultimately enhancing team effectiveness. Consequently, a shared mental model positively influences KS within the team (Zheng, 2017).

2.6.2.2. Team members' diversity

Regarding independent variables, researchers employ various classification methods to delineate team diversity, including demographic variables and individual characteristics. Demographic variables encompass enduring features such as gender, race, and age, while individual characteristics pertain to subjective attributes like cognition and attention (Zheng, 2017). However, due to the challenges associated with measuring subjective characteristics, many researchers opt to utilize demographic variables as proxies (Hambrick et al., 2007). Effective KS hinges on robust interaction, ample communication opportunities, and a willingness to engage. Excessive divergence among team members may impede KS by diminishing communication (Liu & Jia, 2012). When team members perceive themselves as being in the minority based on demographic factors such as gender, marital status, or education level, they may exhibit reduced propensity for KS (Zheng, 2017).

2.6.3. Individual level

2.6.3.1. Personality

Individual characteristics such as age, education level, and work experience are likely to influence the dynamics of knowledge promotion and processes (Svetlik & Stavrou-Costea, 2007), with personality playing a significant role in KS (Zhimin et al., 2014). Studies indicate that individuals with high levels of openness exhibit a greater propensity to seek out others' ideas and opinions, fostering knowledge exchange. Conversely, individuals with high introversion traits may experience feelings of isolation, struggle with communication, and exhibit a tendency to avoid social interactions, which can hinder KS (Zhimin et al., 2014). Another personality trait influencing KS is proactive personality, characterized by a stable inclination to transcend existing environments and actively explore new avenues to impact the external environment (Zheng, 2017). Research by (Cabrera & Cabrera, 2002) suggests that individual initiative contributes significantly to the successful implementation of KM Systems (KMS).

2.6.3.2. Perceived benefits/costs

Perceived benefits and costs represent key factors influencing KS behaviors and have been extensively studied in literature. According to social exchange theory, individuals assess the perceived balance between benefits and costs, shaping their decisions to engage in KS activities with expectations of receiving rewards such as respect, recognition, and tangible incentives (Wang & Noe, 2010). Studies consistently demonstrate a positive correlation between

perceived benefits and KS, whereas perceived costs tend to exert a negative influence on KS behaviors.

2.6.3.3. Individual attitudes

Individual attitudes play a pivotal role in shaping KS behaviors within organizations. Studies indicate that individuals who perceive their knowledge as valuable and believe that sharing it can enhance interpersonal relationships exhibit positive attitudes toward KS, consequently influencing their intentions and actual sharing behaviors (Bock et al., 2005). Moreover, managerial encouragement has been found to positively correlate with employee sharing behaviors, highlighting the significance of leadership support in fostering a knowledge-sharing culture. Additionally, organizational attitudes, including job satisfaction and commitment, have been identified as key determinants of KS within the workplace (Van Den Hooff & De Ridder, 2004). Overall, it is evident that both individual and organizational attitudes significantly impact KS, with positive attitudes not only directly influencing sharing behaviors but also indirectly affecting them by positively shaping intentions to share (Bock et al., 2005).

2.6.3.4. Intrinsic motivation

Based on self-determination theory, research indicates that satisfying three basic psychological needs—competence, relatedness, and autonomy—can positively influence knowledge-sharing behavior. Competence and relatedness had a significant positive impact, while autonomy had a positive but not significant effect (Yoon & Rolland, 2012). Meeting these psychological

needs can promote intrinsic motivation, enhancing the willingness to share knowledge and generating a positive impact (Zheng, 2017).

Furthermore, one key motivating factor is fear. Knowledge holders often possess a monopoly and exclusive mentality, which is the primary reason for their reluctance to share. They fear losing superiority and special interests through KS and worry about inequities in the "knowledge exchange," making KS difficult (YI et al., 2008).

2.6.3.5. Individual self-efficacy

Self-efficacy, concerning individual expectations about their ability to perform tasks, is a key motivational cognitive mediator (Bandura, 2000) and an indicator of KS (Lee & Ahn, 2007). This mechanism provides crucial insights into how individuals prefer to convey specific knowledge. For example, as individuals develop self-efficacy expectations about their success in a particular area, this perception is reflected in their trust systems (Lee & Ahn, 2007). Thus, self-efficacy in the ability to share information can significantly impact KS. Higher self-efficacy in individuals' willingness to share information may lead to personal challenges, greater engagement, perseverance, and increased happiness and achievement (Bandura, 2000). The self-efficacy principle suggests that stronger self-efficacy makes individuals more confident in their performance.

2.6.3.6. Interpersonal trust

Interpersonal trust plays a crucial role in facilitating KS within organizational settings. Trust, a complex construct encompassing beliefs and expectations regarding the reliability, honesty,

and intentions of others, fosters an environment conducive to knowledge exchange (Cheng et al., 2008). Employees are more inclined to share knowledge in environments where trust is prevalent, as demonstrated by findings indicating that trust among coworkers significantly influences knowledge-sharing behaviors (Abrams et al., 2003). Moreover, research underscores the importance of trust in enabling effective KS, with studies emphasizing the necessity of mutual trust among individuals for successful knowledge dissemination (Bakker et al., 2006). Overall, these findings highlight the pivotal role of interpersonal trust in facilitating and promoting KS within organizations.

2.7. Enablers for KS

Factors that facilitate KS vary across organizations, each requiring individualized approaches. However, there exist certain overarching enablers that can promote KS initiatives (Riege, 2005). A recent empirical study conducted by (Gatiti, 2021) identified several key enablers for KS, although acknowledging that not all barriers and enablers were captured comprehensively.

2.7.1. Strategy

Managers and leaders play a crucial role in establishing conducive conditions for facilitating KS and are accountable for devising organizational strategies and mechanisms closely associated with knowledge exchange (Goh, 2002). Firstly, they must delineate strategies and objectives for KS within the organization. Subsequently, these strategies and objectives need to be seamlessly integrated into the organization's broader business strategies and objectives (Riege, 2005). Additionally, management wields influence over the organizational culture,

infrastructure, and other supportive conditions necessary for fostering KS (Goh, 2002). Most importantly, they are tasked with articulating the myriad benefits of KS and ensuring that sufficient time is allocated for its pursuit (Riege, 2005).

2.7.2. Culture

One key enabler of KS is organizational culture. For an organizational culture to effectively facilitate KS, it should be characterized by collaboration, cooperation, trust, and innovation (Razmerita et al., 2016). Organizational culture plays a crucial role in the exchange of information both within and outside the organization (Lee & Ahn, 2007). A culture that promotes KS can contribute significantly to an efficient KM network. Al-Alawi et al. (2007) found that sharing knowledge is an integral part of an organization's culture, while Connelly and Kelloway (2003) assert that employees can exchange knowledge more effectively in a stimulating environment. Research shows that KS significantly increases within a supportive organizational culture. A qualitative study of 50 companies by De Long and Fahey (2000) indicated that the benefits of new technology infrastructure are limited if long-standing organizational values and practices do not support KS, highlighting the significant role of organizational culture in KS.

2.7.3. Motivation

Motivation is a crucial enabler for KS; if individuals are not motivated, they are less likely to share their knowledge with others (Rybo Molin & DAHLBERG, 2018). Motivation can be intrinsic, driven by an interest or enjoyment in helping others, or extrinsic, driven by economic

rewards for KS (Razmerita et al., 2016). Incentives and financial rewards can effectively optimize KS within an organization (Rybo Molin & DAHLBERG, 2018). Conducting individual audits to evaluate and reward employees based on their knowledge-sharing performance—how well they capture, share, and use others' knowledge—can enhance motivation (Riege, 2005). Additionally, distributing team-based rewards can foster collaboration and teamwork, encouraging individuals to share knowledge as a means to achieve the collective reward (Bartol & Srivastava, 2002).

2.7.4. Infrastructure

A pivotal determinant for fostering successful KS lies in having appropriate infrastructure to support it (Goh, 2002). Communication stands out as a fundamental enabler within this infrastructure, encompassing both verbal and written communication proficiency, as well as the horizontal dissemination of information (Goh, 2002). Embracing flat organizational structures with collaborative cross-functional teams and minimal hierarchical layers represents one strategy for promoting horizontal communication. Additionally, technology, including IT systems and software tools, plays a vital role in facilitating communication and knowledge transfer within organizations (Goh, 2002).

2.8. KS barriers

KS barriers can be categorized into four main groups: (1) Individual, (2) Cultural, (3) Technological, and (4) Organizational. Husted et al. (2012) suggest that KS typically does not

occur voluntarily and requires managerial encouragement or promotion. Seheult (2016) expands on this by categorizing KS barriers into six distinct areas:

1. Personal factors: Personal beliefs, including trust, significantly influence an individual's willingness to share knowledge.
2. Technological factors: The design and user-friendliness of KMS impact KS.
3. Cultural norms and context: Organizational culture, including sharing expectations and the overall environment, affects KS behavior.
4. Time availability: Employees' busy schedules often limit the time they can devote to KS activities.
5. Personal vulnerability: Knowledge is often seen as a source of competitive advantage and power, making employees reluctant to share it.
6. Leadership style: Leaders who focus solely on tasks without encouraging and engaging employees can hinder KS.

Identifying and understanding KS barriers, whether they are ingrained in an organization's culture or not, is crucial for the success of a KM strategy (Riege, 2005). KS practices often fail because organizations try to adapt their culture to fit their KM goals and strategies, rather than aligning their strategies with the existing culture. A primary reason many companies fail to achieve their KS goals is the lack of a clear connection between the KM strategy and overall company objectives, as KS is frequently seen as a separate activity (Riege, 2005).

At the individual or employee level, knowledge-sharing barriers often include factors such as inadequate communication skills and social networks, cultural differences, an overemphasis on position status, and a lack of time and trust (Riege, 2005). Organizational-level barriers are

typically linked to economic viability, insufficient infrastructure and resources, limited access to formal and informal meeting spaces, and the physical work environment (Riege, 2005). Technological barriers are associated with reluctance to use applications due to a mismatch with needs, unrealistic expectations of information systems, and challenges in building, integrating, and modifying technology-based systems (Riege, 2005). People hoard knowledge for various reasons, and these contexts are often multi-dimensional (Riege, 2005). The following discussion provides a comprehensive overview of more than three dozen potential sharing barriers, categorized into individual, organizational, and technological barriers. Note that the order of barriers discussed does not indicate their relative impact or effectiveness on knowledge-sharing practices (Riege, 2005).

2.8.1. Potential individual barriers

Nearly every book on KM discusses the challenge of distributing the right knowledge from the right people to the right people at the right time as one of the biggest hurdles in KS (Riege, 2005). Barriers arising from individual behavior, perceptions, and actions can affect both individuals and groups within or between business functions (Riege, 2005). At the individual level, numerous barriers have been identified, highlighting the importance of over a dozen obstacles to KS, including:

1. General lack of time to share knowledge and to identify colleagues who need specific knowledge;
2. Fear that sharing knowledge may reduce or jeopardize job security;
3. Low awareness and recognition of the value and benefits of one's knowledge to others;

4. Preference for sharing explicit knowledge over tacit knowledge, which requires hands-on learning, observation, dialogue, and interactive problem-solving;
5. Use of strong hierarchy, position-based status, and formal power;
6. Insufficient capture, evaluation, feedback, communication, and tolerance of past mistakes that could enhance individual and organizational learning;
7. Differences in experience levels;
8. Lack of contact time and interaction between knowledge sources and recipients;
9. Poor verbal/written communication and interpersonal skills;
10. Age differences;
11. Gender differences;
12. Lack of social networks;
13. Differences in education levels;
14. Ownership of intellectual property due to fear of not receiving proper recognition and accreditation from managers and colleagues;
15. Lack of trust in people, fearing they may misuse knowledge or take undue credit for it;
16. Lack of trust in the accuracy and credibility of knowledge due to its source; and
17. Differences in national culture or ethnic background, along with associated values and beliefs (including language).

Although these barriers are discussed separately, many are interconnected. Different combinations of knowledge-sharing barriers are likely to be found in organizations (Riege, 2005).

2.8.2. Potential organizational barriers

One of the key challenges in KS within an organizational context is creating the right corporate environment and conditions. The introductory discussion suggested various effective methods for sharing individual, social, and organizational knowledge (Riege, 2005). The literature identifies at least a dozen organization-based barriers to KS, summarized as follows (Riege, 2005):

1. Lack of integration between KM strategy and the company's goals and strategic approach.
2. Insufficient leadership and managerial direction in clearly communicating the benefits and value of knowledge-sharing practices.
3. Lack of formal and informal spaces for sharing, reflecting, and generating new knowledge.
4. Absence of transparent rewards and recognition systems to motivate KS.
5. Existing corporate culture does not sufficiently support sharing practices.
6. Inadequate focus on retaining highly skilled and experienced staff.
7. Lack of appropriate infrastructure to support sharing practices.
8. Insufficient company resources to provide adequate sharing opportunities.
9. High external competitiveness within business units or functional areas and between subsidiaries (e.g., not invented here syndrome).

10. Restricted communication and knowledge flows, often limited to specific directions (e.g., top-down).
11. Physical work environment and layout that impede effective sharing practices.
12. High internal competitiveness within business units, functional areas, and subsidiaries.
13. Hierarchical organizational structure that inhibits or slows down sharing practices.
14. Large size of business units, which can be unmanageable and hinder ease of sharing.

While these barriers are discussed separately, it is likely that combinations of these barriers exist in most organizations (Riege, 2005).

2.8.3. Potential technology barriers

KS is as much about people and organizational culture as it is about technology (Riege, 2005). Many companies struggle to create an environment where employees are both willing to share their knowledge and eager to utilize the knowledge of others (Riege, 2005). Technology can offer instant access to vast amounts of data and facilitate long-distance collaboration, promoting a team approach across and within business functions and subsidiaries (Riege, 2005). While technology can significantly enhance KS by making it easier and more effective, the critical challenge is selecting and implementing technology that aligns well with the needs of both people and organizations (Riege, 2005). Technology that succeeds in one organization may fail in another. Below is a list of potential technology barriers to KS (Riege, 2005):

1. Lack of integration of IT systems and processes disrupts workflows.

2. Insufficient technical support (internal or external) and immediate maintenance of integrated IT systems hinder work routines and communication flows.
3. Unrealistic expectations from employees regarding the capabilities and limitations of technology.
4. Lack of compatibility between diverse IT systems and processes.
5. Mismatch between individuals' needs and the capabilities of integrated IT systems and processes restricts sharing practices.
6. Reluctance to use IT systems due to lack of familiarity and experience.
7. Insufficient training for employees to become familiar with new IT systems and processes.
8. Poor communication and demonstration of the advantages of new systems over existing ones.

2.9. KM and KS at knowledge-intensive industries and industrial maintenance

In various industries and factories, the applicability and significance of KM vary across different departments. In some areas, such as those following routine procedures, KM may not be extensively utilized, as tasks are straightforward and well-defined. Conversely, in departments like production, while KM is relevant, it may not pose significant challenges. Here, adherence to established instructions and repetitive tasks often prevails, minimizing the need for frequent changes in procedures.

However, in departments such as repair and maintenance, engineering, and knowledge-based organizations, the landscape is markedly different and more intricate. Implementation of KM,

particularly KS, presents considerable hurdles, especially in high-tech industries. The technical nature of these departments, coupled with the abundance of tacit knowledge, amplifies the complexities. For instance, in maintenance departments, where the effective reuse of experience is critical, the challenges are particularly pronounced.

Moreover, the assimilation of knowledge among novices in high-tech industries remains a formidable task. Despite advancements in Information Technology (IT) that have facilitated communication, numerous barriers persist at individual, group, organizational, and cultural levels. Addressing these multifaceted barriers is imperative for enhancing KM and KS practices within technical departments, ensuring the efficient utilization and dissemination of valuable expertise.

2.9.1. Definitions and perspectives on industrial maintenance

Maintenance, a ubiquitous term, often conjures images of fixing, restoring, replacing, or rejuvenating. While these actions are indeed part of the maintenance process, they only scratch the surface of its broader significance. At its core, maintenance is about preservation and protection, aiming to keep assets in an existing state or safeguard them from failure or decline.

In the industrial context, maintenance encompasses a comprehensive set of technical, administrative, and managerial actions conducted throughout an asset's lifecycle. It is defined as "the combination of all technical, administrative, and managerial actions performed during the lifecycle of an item intended to retain it in, or restore it to, a state in which it can perform the required function" (Márquez, 2007). This definition underscores the holistic approach required to ensure the optimal functioning of industrial assets. Maintenance management extends beyond individual assets to encompass the management of all assets owned by a

company. It is centered on maximizing the return on investment in these assets (Wireman, 2005). Approaching maintenance as a strategic asset management practice underscores its vital role in achieving organizational objectives and enhancing overall operational efficiency.

From a systems perspective, a maintenance system can be conceptualized as a complex input-output mechanism. Inputs encompass manpower, management, tools, and equipment, while the output is well-configured and reliably functioning equipment. Key activities within this system include maintenance planning, organization, and control, each vital for ensuring operational effectiveness and efficiency (Duffuaa et al., 1999).

Ultimately, the primary objective of maintenance is to ensure that equipment operates at its original optimal level. By eliminating losses that impact equipment performance, maintenance efforts not only enhance reliability but also contribute to a reduction in production costs (Mansor et al., 2012). Embracing a proactive and holistic approach to maintenance is essential for sustaining operational excellence and driving organizational success in industrial settings.

2.9.2. Industrial maintenance: a knowledge-intensive field

The realm of industrial maintenance is multifaceted and knowledge-intensive, playing a strategic role in modern industrial environments (Aromaa et al., 2015). As industries evolve, the complexity and importance of maintenance continue to garner significant attention (Chebel-Morello et al., 2017). What once may have been considered a purely technical function has now transcended disciplinary boundaries, with individuals from diverse backgrounds assuming responsibility for maintenance tasks (Ben-Daya et al., 2009).

With escalating competitive pressures and increasing automation, maintenance management has emerged as a critical area of focus for industrial managers (Cooke, 2002). Within maintenance departments, a plethora of knowledge is generated daily, underscoring the knowledge-intensive nature of maintenance processes (Kovacs et al., 2019a). This knowledge encompasses both explicit information and tacit knowledge acquired through hands-on experience (Cárcel-Carrasco & Cárcel-Carrasco, 2021).

Despite its significance, maintenance costs can constitute a substantial portion of overall production costs (Dunn, 1987). As such, there is a growing imperative to optimize maintenance practices and mitigate disruptions to production activities (Cooke, 2002). Researchers have thus focused on developing innovative techniques to enhance equipment utilization and reduce maintenance expenditures (Cooke, 2002).

KM holds immense potential in optimizing maintenance operations by addressing key sources of inefficiency. At maintenance departments, KM strategies can target various forms of losses, including breakdowns, setup delays, and production speed reductions (Mansor et al., 2012). Moreover, effective maintenance hinges on the availability of accurate and timely information regarding equipment condition (Bjorling et al., 2013).

In the era of Industry 4.0, access to knowledge is paramount for maintaining service quality and productivity (Aromaa et al., 2015). However, managing maintenance knowledge poses unique challenges, given the predominantly tacit nature of expertise within maintenance departments (Cárcel-Carrasco et al., 2020). Nonetheless, the advent of computerized maintenance management systems (CMMS) has revolutionized data management and decision-making in maintenance (Ben-Daya et al., 2016). CMMS is utilized for managing data and information within maintenance departments. CMMS comprises a set of integrated

software programs designed to aid in the management of maintenance activities. These activities include planning, scheduling, monitoring, controlling, reporting, and other related administrative functions, all aimed at achieving effective and efficient maintenance management (Ben-Daya et al., 2016).

Traditional approaches to maintenance have gradually shifted towards knowledge-based maintenance paradigms (Mansor et al., 2012). Yet, integrating KM practices within maintenance departments remains a formidable task, particularly due to entrenched practices rooted in experiential learning (Cárcel-Carrasco et al., 2020). Effectively harnessing maintenance knowledge requires concerted efforts to capture, process, and disseminate tacit expertise (Pistofidis et al., 2016).

Despite its pivotal role, maintenance is often overlooked or viewed as a routine aspect of operations (Waeyenbergh et al., 2001). However, maintenance is a dynamic and creative process that continually generates new knowledge (López-Ramos et al., 2019). Preserving and transferring this knowledge is essential for sustaining operational excellence and overcoming dependency on individual experts (Isworowati et al., 2019).

In essence, industrial maintenance represents a nexus of technical expertise, managerial acumen, and experiential knowledge. By embracing KM principles, organizations can unlock new efficiencies and enhance the resilience of their maintenance operations in an ever-evolving industrial landscape.

The field of industrial maintenance is both complex and knowledge-intensive (Aromaa et al., 2015). Its strategic role in the industrial environment continues to attract significant interest (Chebel-Morello et al., 2017). Maintenance has evolved into a multidisciplinary field, often involving individuals whose training is not in engineering (Ben-Daya et al., 2009). Increasing

competitive pressure and advancing automation have compelled managers to focus more on maintenance management (Cooke, 2002). Within maintenance departments, diverse knowledge is generated daily. Maintenance is a knowledge-intensive process where participants (organizations or groups of individuals), whether internal or external stakeholders, create, reuse, and share specialized professional knowledge, while also enriching their implicit and experiential knowledge (Kovacs et al., 2019a). Knowledge derived from personal experience (tacit knowledge) gained through problem-solving and maintenance activities is essential for maintenance technicians in companies with significant physical assets (Cárcel-Carrasco & Cárcel-Carrasco, 2021). Due to its organization and inherent nature, maintenance activities primarily generate tacit knowledge based on experience, at much higher levels than explicit knowledge, which is often recorded in a fragmented manner (Cárcel-Carrasco et al., 2020). The mechanisms for transmitting and managing knowledge are primarily developed through maintenance and operational activities of large buildings and industrial facilities. However, these mechanisms are poorly studied due to the challenge of capturing the tacit knowledge gained through the experience of maintenance staff (Cárcel-Carrasco et al., 2020). These professionals are highly skilled and adept at solving technical problems, even under pressure and losing these professionals also means losing a valuable asset for the company (Cárcel-Carrasco et al., 2020).

The need to create and add value has introduced new challenges for the maintenance department in continuous production and operational industries such as power, manufacturing, process, aerospace, and defense (Iheukwumere-Esotu & Yunusa Kaltungo, 2020). Employees' tacit knowledge and experience related to maintenance activities cannot be retained by the company when these employees retire (Isworowati et al., 2019). The absence of a learning process in maintenance leads to knowledge loss, increased dependency on certain experts, and

hinders the evolution of the maintenance process (López-Ramos et al., 2019). Transferring tacit knowledge within a maintenance organization requires three key KM steps: capturing the tacit knowledge, processing the captured information for sharing, and effectively communicating it (Aromaa et al., 2015).

2.10. Identified challenges in maintenance work practices: barriers to KM and KS

Research into maintenance activities has revealed several barriers to effective KM and KS within the field. Some of these barriers have been reported as follows:

2.10.1. Absence of standardized language in reporting breakdowns

When reporting machine failures in a Computerized Maintenance Management System (CMMS), production operators often provide vague descriptions of the issues encountered. Instead of detailing specific problems, operators may use generic statements such as "machine malfunction" or "possible hydraulic issue" (Chirumalla et al., 2015). However, these descriptions lack specificity and fail to provide crucial details about the nature of the problem. For example, a report stating "hydraulic problem" could encompass various issues, including a faulty motor or elevated hydraulic temperature, making it challenging to pinpoint the root cause of the malfunction (Chirumalla et al., 2015). The absence of a standardized taxonomy for categorizing machine problems exacerbates this issue, leading to inconsistent terminology usage among operators.

To address this challenge, it is essential to implement clear reporting protocols that encourage operators to provide detailed information, including any alarm codes displayed on machine

panels. Additionally, efforts should be made to standardize terminology and encourage operators to describe the specific nature of the problem rather than offering vague assessments. Furthermore, upgrading older machine panels to display alarm codes can enhance the accuracy of maintenance reporting and facilitate more efficient problem identification.

2.10.2. Challenges in searching historical similar problems across time

Difficulty arises when attempting to search for similar historical problems across different time periods within the Computerized Maintenance Management System (CMMS). Research indicates that identifying identical machine issues or faults can be challenging due to the vast array of working orders generated over time, particularly as equipment ages (Chirumalla et al., 2015). Maintenance technicians and engineers often rely on operators' comments or descriptions of machine problems to determine if a new issue correlates with any past incidents, albeit in varying ways due to differences in how problems are recorded. However, the "free text search" mechanism within CMMS systems is frequently inadequate or absent, necessitating manual searches through past experiences and relevant documentation. Consequently, individuals often resort to seeking assistance from colleagues or personal networks, either by directly asking someone familiar with the issue or consulting an expert within their professional circles. Moreover, maintenance personnel may reach out to colleagues in other production areas to inquire about similar problems they may have encountered. This collaborative approach allows for the exchange of knowledge and experiences, particularly from seasoned experts with several decades of experience who can provide valuable insights.

Furthermore, formal meetings provide another avenue for addressing unresolved issues, as individuals can present their problems to identify potential solutions or seek out individuals with relevant expertise or past experience in tackling similar issues.

2.10.3. Insufficient Contextual Information in Post-Incident Reports or Descriptions

Enhancing the reusability of past interventions faces significant hurdles, largely stemming from the absence of sufficient contextual information. Key details such as the nature of the fault, its underlying causes, and the processes involved in its detection and resolution are often missing (Chirumalla et al., 2015). Maintenance personnel prioritize resolving machine issues over documenting them comprehensively, leading to incomplete records. To address this challenge, management is promoting greater documentation in the CMMS. They have introduced a standardized format for work orders, incorporating "5 Why" questions to gather additional insights from operators during machine repairs. Additionally, technicians are encouraged to routinely capture images, particularly in single-point lessons and Root Cause Analysis (RCA) reports. Despite these efforts, adherence to documentation practices remains inconsistent. Many technicians neglect to include visual evidence or provide detailed RCA reports. Engineers cite difficulties in completing RCA templates, finding them more complex in practice than in theory. Moreover, administrative procedures associated with documenting RCA, such as obtaining approvals and coordinating with various stakeholders, pose further challenges.

2.10.4. Difficulty in codifying experiences or tacit knowledge

Researchers have also highlighted another significant challenge: the difficulty in translating experiences into written form (Chirumalla et al., 2015). They underscored the complexity of articulating experience, noting the struggle to find the appropriate words and convey thoughts effectively. Maintenance technicians echo this sentiment, expressing the challenge of translating their mental processes into written documentation. As explained by maintenance technicians, when troubleshooting a machine, countless thoughts race through their minds. They may have a clear understanding internally, but expressing it on paper is a daunting task. This challenge is compounded when the issue involves intricate technical details such as electrical components or programming, which may require specialized knowledge to comprehend and communicate effectively. Furthermore, there is a pressing need to capture the wealth of knowledge possessed by older employees, often referred to as baby boomers, much of which exists in tacit form within their minds. With many of these experienced individuals nearing retirement age, there is a growing concern about the potential loss of valuable knowledge and expertise in the future.

2.10.5. Lack of incentive for documenting and sharing experiences

Observations reveal that the exchange of experiences primarily occurs through informal dialogues and word-of-mouth interactions. Many organizations implement practices like visual boards and one-point lessons to facilitate KS among colleagues. However, the effectiveness of such methods often relies on proactive communication. For instance, while one-point lessons may be relevant to multiple machines, their utility remains limited unless highlighted in meetings or discussions (Chirumalla et al., 2015). According to studies, while experiences are

often documented on boards, they are seldom read by individuals. Verbal sharing is deemed more effective, as it tends to leave a stronger impression (Chirumalla et al., 2015). For instance, when someone verbally recounts a week-long issue and the subsequent machine recalibration, it is more likely to be remembered. This indicates a preference for direct communication over formal documentation. Additionally, informal conversations during breaks or at machines provide valuable opportunities for exchanging insights and preventive measures for future incidents.

Studies have shown that experience exchange predominantly occurs through informal conversations and word-of-mouth. While many companies implement practices such as visual boards and one-point lessons to facilitate KS, these methods are not always effective. Although one-point lessons can be applicable across multiple machines, their usefulness is often overlooked unless discussed in a meeting. This statement highlights that knowledge contributors do not always see the benefit of documenting experiences formally, preferring other communication channels.

2.10.6. Challenges in educating and training novices

New employees are typically partnered with senior colleagues for a period ranging from 1 to 2 years, depending on their individual skills and educational background. Given the intricacies of working with complex machinery and programs, novices must engage with these systems extensively, troubleshooting various issues before gaining significant experience (Chirumalla et al., 2015). Novices described that they often accompany senior colleagues because these experienced maintenance employees possess invaluable insights. Their deep understanding of

the machines allows them to quickly identify problems. When novices work alongside them, they have the opportunity to learn from their expertise.

However, this approach presents challenges for the maintenance organization, as it requires redirecting experienced technicians, some of whom may be in their 60s, from their regular duties to focus on mentoring new hires. A significant hurdle is the lack of procedural documentation outlining how to train novices effectively. Without adequate training materials to support novices, organizations must assess their skills through trial periods before assigning them tasks.

2.10.7. Diverse approaches and mindsets in the workplace

Observations indicate that the maintenance profession traditionally prioritizes problem-solving, which can impede the swift adoption of new work practices and procedures. Maintenance issues are often addressed in an ad hoc manner, tailored to the specific problem, individual experience, and problem-solving approach. To promote standardization, management has introduced protocols such as checking for instructions and consulting the CMMS for past experiences before each repair (Chirumalla et al., 2015). However, not everyone adheres to these protocols, with urgent repair needs often taking precedence over consultation with the CMMS. While following instructions can streamline workflow and prevent costly mistakes, time constraints sometimes lead technicians to bypass this step. This hurried approach is also reflected in after-action reporting, where time pressures can deter thorough documentation. Furthermore, there is a prevailing mindset among maintenance personnel that documentation can be improved, but time constraints often inhibit comprehensive reporting. Additionally, technicians are accustomed to working autonomously

and may be hesitant to engage in collaborative problem-solving, particularly from a value stream perspective.

2.11. Experience management and experience reuse in maintenance

The simplest definition of experience is the knowledge or skill gained from performing a job or activity, or the process of acquiring this knowledge (Longman online dictionary, 2020). Therefore, knowledge encompasses awareness or understanding obtained through experience, familiarity, or learning (Canals et al., 2008). Experience management (EM) is a discipline that focuses on the processing and management of experiences, encompassing stages such as discovery, capture and collection, modeling, storage, evaluation, adaptation, reuse, transformation of experience into knowledge, and maintenance (Bergmann et al., 1998). In the field of maintenance, researchers highlight the value of EM in aiding maintenance management by generating explicit knowledge from past experiences or identifying relevant experiences for subsequent repair actions (Ruiz et al., 2014). According to Cooke (2002), the maintenance workforce can contribute to organizations by providing feedback on asset performance to departments responsible for designing, selecting, or installing new equipment, and by making new or existing technology more suitable for the working environment. Similarly, Refaiy and Labib (2009) examined the relationship between the sharing of tacit knowledge and maintenance performance, demonstrating that sharing tacit knowledge can positively influence team maintenance performance.

In the realm of KM, the concepts of experience reuse and knowledge reuse are often used interchangeably, owing to their close association (Sun & Finnie, 2005). Knowledge reuse entails sharing best practices or assisting others in resolving common technical issues (Markus,

2001). This process comprises four key activities: formulating the search query, identifying experts or expertise, selecting the most suitable expert or expertise, and applying the acquired knowledge (Markus, 2001). To effectively reuse knowledge, users must comprehend the rich context in which it originated and be able to engage with it accordingly (Markus, 2001). Additionally, users should provide pertinent information about the problem's background, root causes, and applicability to future scenarios (Chirumalla et al., 2015). However, challenges in knowledge reuse abound, including issues such as misidentification of problems, improper problem definition, lack of awareness about available knowledge, and difficulties in adapting and applying knowledge (Petter et al., 2007), all of which can lead to failed attempts and associated frustration.

(Mannonen & Hölttä, 2013) delved into the impediments hindering the collection and reuse of problem-solving information in maintenance. Their findings revealed that maintenance workers tended to focus on individual tasks and did not perceive the value of comprehensive documentation of problems and their solutions. Moreover, at the organizational level, emphasis was placed on easily quantifiable actions, with a dearth of motivation or reward systems to incentivize workers to both generate and reuse experience. Furthermore, evidence suggests that individuals often rely on their personal networks to address problems and acquire knowledge (Mannonen & Hölttä, 2013). Studies have shown that individuals learn vicariously through the experiences of others when those experiences are shared through oral or written narratives, as narratives offer crucial context in an easily communicable and memorable format, particularly beneficial for novices (Petter et al., 2007).

Challenges such as misidentification of problems and lack of awareness can hinder successful knowledge reuse. Organizations have developed various practices to assist in reusing past

experiences, including reporting in CMMS, root-cause analysis, weekly letters, collaboration portals, visual boards, formal meetings, and personal networking. These practices help capture, document, and share experiential knowledge, fostering a culture of continuous learning and improvement in maintenance operations. Despite the implementation of these practices, studies indicate that experience reuse and management in maintenance have not always been effective, highlighting ongoing challenges and the need for further improvement strategies.

2.12. Summary of literature review

The comprehensive review of existing literature highlights that, although significant strides have been made in the fields of KM and KS within the maintenance domain, there remains a considerable gap necessitating further investigation. Numerous studies have underscored the importance of effective KM and KS practices in enhancing maintenance operations and overall organizational performance. However, the complexity and specific challenges associated with these practices in the maintenance context have not been fully addressed.

One of the critical findings from the literature is that KS does not occur voluntarily and is often hindered by various obstacles. Cultural barriers, lack of trust, inadequate communication channels, and insufficient recognition and reward systems are some of the common impediments to effective KS identified in previous studies. These barriers are particularly pronounced in the maintenance setting, where the seamless transfer of knowledge is essential for timely and effective problem-solving.

Moreover, the literature indicates that novices in the maintenance workforce are disproportionately affected by inadequate KM implementation and suboptimal KS practices. Novices, who rely heavily on the knowledge and expertise of more experienced colleagues,

often find themselves at a disadvantage when KM and KS systems are not well-designed or effectively utilized. This can lead to repeated mistakes, prolonged equipment downtime, and overall inefficiencies in maintenance operations.

Given these challenges, it is imperative to identify and address the specific barriers and enablers of KM and KS within the maintenance setting. This involves a thorough understanding of the unique dynamics of maintenance work, including the types of knowledge required, the most effective ways to share that knowledge, and the organizational and interpersonal factors that influence KS behaviors. By pinpointing these factors, organizations can develop targeted strategies to foster a culture of KS and continuous learning.

Furthermore, focusing on innovative approaches that actively involve novices in KM and KS processes could be particularly valuable. By empowering novices and creating an environment that encourages their active participation, organizations can ensure that valuable knowledge is not only preserved but also effectively disseminated across the workforce.

In conclusion, while the existing literature provides a solid foundation for understanding KM and KS in the maintenance domain, it also reveals significant areas that require further exploration. Addressing the barriers to effective KS, particularly those affecting novices, and leveraging innovative approaches to involve them in KM processes, are crucial steps towards enhancing maintenance practices. Future research should continue to explore these avenues, aiming to develop robust, practical solutions that support the efficient and effective transfer of knowledge in maintenance settings.

To conclude the literature review and smoothly transition into the detailed discussion of the four studies that comprise this thesis, it is essential to synthesize the findings and objectives addressed in each study, as well as to highlight the progression and contributions of each

research phase. The following sections provide an overview of the studies undertaken and set the stage for the detailed exploration of each.

The initial study aimed to understand the landscape of KM and KS within the context of knowledge-intensive industrial maintenance. This foundational understanding was crucial for identifying the existing challenges and opportunities within the field, serving as a basis for the subsequent studies. This study, detailed in Chapter Three, explores the following research question: What are the barriers and enablers of KM and KS within the maintenance domain of knowledge-intensive industries, as perceived by maintenance employees and KM experts?

Building on the insights from the first study, the second study assessed the current state of KM and KS practices through the first data collection phase. Knowledge domains were mapped, and key areas of expertise within the industrial maintenance sector were identified, providing a detailed overview of the critical knowledge required. An innovative approach was introduced by involving novices as lecturers in KM practices, fostering a unique perspective and engagement in knowledge dissemination. The "training by novices" program was implemented, aiming to enhance KS. A second measurement of the KM situation was conducted, incorporating additional questions to capture the impact of the training program. The results were analyzed to evaluate improvements in KM and KS practices, offering recommendations for further enhancement. In sum, this study was the subject of chapter four, and it intended to answer the following questions: How can KM and KS be effectively implemented in industrial maintenance settings, particularly among novices? What role can novices play in enhancing KS practices within high-tech maintenance departments? What impact do targeted training programs have on improving KS and overall KM in these environments?

The third study delved into the qualitative aspects of the second study, focusing on identifying KS barriers, program-related problems, and recommendations for improvement. The most significant problems were selected for further investigation and resolution, ensuring that the key issues impeding effective KM and KS were addressed. In sum, this study, discussed in chapter five, aimed to address the following questions: How can the involvement of novices as trainers improve KM and KS within industrial maintenance departments? What impact does the “training by novices” program have on enhancing knowledge exchange between novice and experienced employees? How does this approach contribute to fostering a culture of continuous learning and collaboration in knowledge-intensive industries?

An improvement program was implemented in the fourth study, continuing the "training by novices" initiative and introducing a control group to measure the effectiveness of the interventions. The KM situation was measured for a third time, with additional questions added to assess the impact of the improvements made. Hypotheses were tested, and a conceptual model was developed to encapsulate the findings and provide a framework for future research and practice in KM and KS. To summarize, this study, detailed in chapter six, sought to answer the following questions: How can empowering novices as active facilitators improve knowledge management and sharing within maintenance departments of knowledge-intensive industries? What role do individual and organizational factors play in influencing KS, and how does the “training by novices” program moderate these effects? Lastly, how can organizations leverage the untapped potential of their workforce to drive innovation and efficiency through enhanced knowledge dynamics?

These four studies collectively offer a comprehensive examination of KM and KS practices within the knowledge-intensive industrial maintenance sector. They illustrate a progressive

approach, starting from understanding the landscape, assessing current practices, identifying barriers and opportunities, implementing innovative training programs, and finally measuring and modeling the impact of these interventions. The following chapters will provide an in-depth analysis of each study, presenting detailed methodologies, findings, and implications for both theory and practice in the field of KM and KS.

CHAPTER 3 (Study 1): Unlocking the Potential of Knowledge Management and Sharing in Knowledge Intensive Companies' Maintenance Departments: Barriers, Enablers, and Recommendations.

Hamid Roham, Jorge F.S. Gomes

Amir Reza Safdar Tourehei, Elham Kamouri Yousefabad, Sepideh Aghajani, Mohammad Ali Avestam, Ali Behnam, Arash Malekmohammadi (These individuals are expert employees from the three targeted companies where this study was conducted, and they participated as interviewers and data collectors).

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Abstract

In contemporary knowledge intensive industries, the efficient management and sharing of knowledge within maintenance departments are crucial for maintaining a competitive edge. This case study delves into the complex landscape of knowledge management (KM) and knowledge sharing (KS) in the context of a maintenance departments within three prominent knowledge intensive organizations. The study synthesizes insights from both the end-users of knowledge, represented by the maintenance employees, and the experts in KM embedded within the organizations. Through a comprehensive series of in-depth interviews, this research provides a multifaceted exploration of the barriers and enablers of KM and KS.

The findings of this study unearth an array of barriers that impede the effective management and sharing of knowledge within maintenance departments. These barriers encompass not only technological and structural issues but also cultural aspects, including resistance to change and information silos. Additionally, the study identifies enablers that can promote effective KM and KS. Leadership support, comprehensive training programs, and a robust technological infrastructure emerge as pivotal facilitators in enhancing these critical processes.

The significance of this research lies not only in its comprehensive examination of the multifaceted challenges surrounding KM and KS but also in its ability to bridge the gap between knowledge users and experts. By incorporating the perspectives of maintenance employees and KM specialists, this study provides a holistic view of the intricacies within the maintenance departments.

Furthermore, this paper extends beyond identifying issues and solutions to offer practical recommendations for the improvement of KM and KS practices. The collective wisdom of

knowledge users and experts converges to present a roadmap for organizations in the knowledge intensive sector seeking to enhance their maintenance department's KM and KS capabilities.

In conclusion, this research contributes significantly to the field of KM, shedding light on the unique challenges faced by maintenance departments in knowledge intensive industries. It offers a comprehensive understanding of the barriers and enablers of KM and KS and, most importantly, provides actionable insights for organizations striving to optimize their KM and KS practices in the dynamic landscape of knowledge intensive maintenance.

Keywords

Knowledge management, knowledge sharing, industrial maintenance, physical asset management, knowledge sharing barriers.

3.1. Introduction

The dynamics of competition within various industries and the origins of competitive advantages have transitioned towards resources rooted in knowledge (Watson & Hewett, 2006) and have created competitive environments based on consolidation of existing knowledge assets as pathways to creating value (Iheukwumere-Esotu & Yunusa Kaltungo, 2020; Refaiy & Labib, 2009). This is especially evident in knowledge intensive sectors, where a company's competitive edge is intricately linked to its capacity to create and utilize novel knowledge-based solutions (Watson & Hewett, 2006). Knowledge has been classified and characterized from several points of view to individual, social, causal, conditional, general, specific, relational, tacit, explicit (Alavi & Leidner, 2001) embodied, encoded, and procedural (Venzin et al., 1998). An important classification of knowledge views it as tacit or explicit (Polanyi & Sen, 2009). Explicit knowledge is knowledge that has been expressed into words and can be shared formally and systematically in the form of data, specifications, manuals, drawings, audio and video, computer programs, patents, and so on (Becerra-Fernandez & Sabherwal, 2014). In contrast, tacit knowledge covers impressions, intuitions, and hunches, and is difficult to express and formalize, and therefore difficult to share (Khoshsima et al., 2004). Tacit knowledge is more personal and based on personal experiences and activities. Tacit knowledge may also include expertise that is so specific that it may be too expensive to make explicit; therefore, the organization chooses to let it reside with the expert.

The knowledge-based economy is emerging, and KM is being rapidly disseminated in academic circles, as well as in the business world (Chen & Chen, 2006). KM is viewed as an increasingly important discipline that promotes the creation, sharing, and leveraging of the

corporation's knowledge (Becerra-Fernandez & Sabherwal, 2014). KM success contributes to, or can even drive, an organization's success (Holsapple et al., 2016), thus learning how to manage organizational knowledge has many benefits such as leveraging core business competencies, accelerating innovation and time-to-market, empowering employees, innovating and delivering high-quality products, improving cycle times and decision-making, strengthening organizational commitment, and building sustainable competitive advantage (Davenport & Prusak, 1998).

A few KM processes have been introduced by researchers in the past decades. These processes involve various activities that relate with tacit and explicit knowledge such as: acquisition and retrieval, internalization, creation and generation, application and utilization, codification, storing, transferring and sharing (Wong et al., 2015). Among processes of KM, KS has been identified as the most vital one (Asrar-ul-Haq & Anwar, 2016). KS has been identified as the most important process for facilitating organizational learning and innovation and is critical to organizations that wish to use their knowledge as an asset to achieve competitive advantage. The major focus of KS is on the individual who can explicate, encode, and communicate knowledge to other individuals, groups, and organizations (King, 2011). Effective KS practices foster collaboration, build trust, and create a culture of continuous learning, promoting innovation and enabling organizations to remain competitive in the rapidly changing business environment. While other KM processes, such as knowledge creation and acquisition, are also essential, KS is the linchpin that connects all KM processes, allowing organizations to realize the full potential of their knowledge assets.

The importance of KM is not equal at all industries and departments and at knowledge intensive companies and departments, KM plays a vital role. "Knowledge-intensive companies and

departments" refer to organizations that rely heavily on knowledge and expertise to operate, innovate, and compete in their respective markets. These organizations are characterized by a significant focus on knowledge creation, acquisition, transfer, and application to support their business objectives and gain a competitive advantage. The phrase 'knowledge-intensive' can be used in at least three contexts: knowledge intensive work, knowledge workers and knowledge-intensive firms (Wiig, 2012). Knowledge intensity of work is a function of several factors. Increased knowledge intensity is a function of how much knowledge and understanding a person must possess and apply when required to perform competent work and to be prepared to deal with uncertainties and surprises (Wiig, 2012). Managing knowledge in knowledge intensive companies and departments is critical for success. This involves creating a supportive culture that encourages KS and collaboration, implementing KM systems and processes, and developing strategies to ensure that knowledge is effectively leveraged across the organization. Some of the challenges facing knowledge intensive companies and departments include managing the volume of knowledge generated, ensuring that knowledge is effectively shared and applied, and retaining critical knowledge when employees leave the organization. However, with the right KM strategies and tools in place, organizations can effectively harness their knowledge resources to drive innovation, growth, and competitive advantage.

3.2. Literature review

While KM is relevant to all organizational units, its importance varies. In production, KM is relatively straightforward due to the adherence to pre-approved instructions and repetitive tasks. In contrast, maintenance, R&D and engineering departments consider KM highly critical. Maintenance is defined as "the combination of all of technical, administrative and

managerial actions performed during life cycle of an item intended to retain it in, or restore it to, a state in which it can perform the required function (Márquez, 2007). Industrial maintenance is a complex and knowledge intensive field (Aromaa et al., 2015). KM is difficult in maintenance due to many factors, such as the way in which their technicians are used to working based on their experience and not upon sharing and explaining their knowledge of operating (Cárcel-Carrasco et al., 2020).

Maintenance knowledge representation can capitalize on both conventional knowledge and maintenance data (Pistofidis et al., 2016). Typical maintenance work encounters a highly diverse and non-routine tasks associated with electronic, hydraulic, software, hardware and electromechanical systems, requiring different sets of skills and competencies to diagnose and solve a problem (Chirumalla et al., 2015). Maintenance departments within companies operate with technicians with high knowledge based on their professional experiences, with a high component of tacit knowledge and, traditionally, with null KM policies (Cárcel-Carrasco et al., 2020). It is important to interact with and to share experiences among individuals within an organization, in order to formulate new knowledge (Shehab et al., 2018). Maintenance effectiveness depends in part on the quality, timeliness, accuracy and completeness of information related to machine degradation state, based on which decisions are made (Bjorling et al., 2013). Maintenance effectiveness, to a large extent, also depends on the quality of the knowledge of the managers and maintenance operators and the effectiveness of the internal and external collaborative environments (Bjorling et al., 2013). The following four categories of maintenance data are needed in data management (Raouf et al., 2006): failures/replacement data (failure mode/suspension, date and time of failure), inspection data (covariates, data and time of inspection), maintenance action data (maintenance action, start and finish date and time of maintenance action), and installation data (date and time of installation).

It has been acknowledged that the main way of developing competence of maintenance workforce is using the accumulated knowledge and experience available in the company (Alsyof, 2007). Maintenance workforce, such as service engineers, maintenance technicians, and repairmen, acquire firm-specific knowledge from their experience of working with the equipment over the years (Refaiy & Labib, 2009). Moreover, many large companies have been using some kind of computerized maintenance management system (CMMS) to accumulate, store and visualize maintenance-related data and learning from experiences (Márquez, 2007). Production and maintenance workforce are feeding in different types of formal information as well as individual insights and experiences after each maintenance intervention (e.g., type of failure, cause, actions performed). While the formal data acquired is often only used for traceability purpose (Ruiz et al., 2014) reusing experiences reported by maintenance workers' are still limited in practice. In the problem-solving phase of the maintenance work, the organizations often rely on maintenance workers' and production operators' descriptions and reports (Mannonen & Hölttä, 2013). Thus, it is important to capture and store experiences in such a way that those can be reused in the future for performing the right maintenance action at the right time.

Maintenance managers must strongly consider how to transfer expertise and knowledge from experts who have it to novices who need to know (Hinds et al., 2001). Sharing knowledge is not a common activity in most organizations, especially in maintenance. It has been shown that individuals are rewarded mostly for what they know, and not for what they share. The competitive environment that encourages individual instead of collective productivity has stimulated employees to consider their knowledge as their own property, and that to deepen and defend their knowledge is the main way to keep their jobs. An important effect of maintenance KS is that it will transfer maintenance expertise between experts and novices. This

will lead to much faster handling of machine failures, training of new staff and to reduce the dependence on external maintenance companies. Even more importantly, it will reduce the number of accidents related to maintenance activities. Industrial maintenance is a crucial function for ensuring the smooth and efficient operation of manufacturing facilities and other industrial settings. KM and KS are increasingly recognized as critical components of industrial maintenance as they help ensure the continuous improvement of maintenance practices, which can result in improved equipment reliability, reduced downtime, and increased profitability.

There are numerous examples where KS practices have not accomplished their objectives to manage companies' knowledge assets and skills, which is mainly due to the large diversity of potential sharing barriers (Riege, 2005). Some factors affect the KS and identified ones have been classified in five categories: "individual", "technological", "organizational", "cultural" and "geographical" (Anwar et al., 2019).

3.2.1. General barriers:

Organizations often face a multitude of barriers when it comes to KM and KS. Some of the most prominent individual barriers include a general lack of time for KS, fear of job insecurity, low awareness of knowledge's value, and dominance of explicit knowledge over tacit knowledge (Riege, 2005). Team-level barriers encompass issues like a lack of team cohesiveness, limited communication, resistance to change, lack of trust, inadequate leadership, and a lack of team diversity. At the organizational level, barriers can arise from the absence of integrated KM strategies, leadership direction, spaces for sharing and reflecting, transparent rewards systems, supportive corporate culture, knowledge retention strategies, and infrastructure for sharing (Riege, 2005). Technological barriers include challenges related to

IT systems integration, technical support, maintenance, KS tools, central knowledge repositories, technological knowledge gaps, compatibility issues, reluctance to use IT systems, and a lack of training. Cultural barriers revolve around trust, resistance to change, hierarchy and power distance, competitive cultures, and a lack of recognition for KS efforts. Overcoming these barriers requires a shift in organizational values and practices, emphasizing trust, collaboration, recognition, and a culture of continuous learning and improvement.

3.2.2. Specific barriers:

In the realm of maintenance activities, organizations encounter not only the general KM and KS barriers mentioned earlier but also a set of specific challenges that are unique to this domain and given the cultural resistance to change, KM might not be an easy concept to implement. The biggest challenge for many organizations today is how to encourage their staff to share knowledge (Al-Hawamdeh, 2003). Exploring the researches shows that beside above-mentioned general KM and KS barriers in maintenance, the following specific barriers (Table 6) have been identified at maintenance activities:

Table 6 : Specific KS barriers in maintenance domain.

Source: (Chirumalla et al., 2015).

KS barriers	
1	The absence of standard language to report the breakdowns.
2	Difficulty to search the similar problem history from different times.
3	The lack of contextual information in after action reports or descriptions.
4	Difficulty in codifying experiences or tacit knowledge.
5	The lack of motivation to spread experiences through documentation.
6	Difficulty in educating and training novices.
7	Different work styles and mindsets.

The existing literature on KM and KS is generally very broad and does not address the specificities posed by departments and units. This means that extant KM and KS theories and models might have a limited application to specific situations and contexts.

This study is underpinned by the recognition that effective KM and KS are pivotal for the success of maintenance departments in knowledge intensive industries. As illustrated by the comprehensive list of potential barriers and specific challenges within the maintenance domain, the complexities and nuances of managing and sharing knowledge are particularly pronounced in this context. While many organizations struggle to foster a culture of KS, maintenance activities add a layer of intricacy due to their specialized nature. Addressing these unique barriers, enablers, and recommendations is imperative, as they hold the key to enhancing KM and KS within the maintenance domain. The potential benefits are substantial, including improved performance, minimized downtime, and more efficient problem-solving processes. By shedding light on these specific challenges and offering practical recommendations, this study not only contributes to the KM field but also provides valuable insights for organizations in high-tech industries, ultimately facilitating their quest to optimize KM and sharing practices in maintenance departments.

Indeed, it is worth noting that research in this specific area is relatively limited, and there exists a scarcity of comprehensive studies that delve deep into the specific barriers and enablers of KM and KS within maintenance domains. Despite the pivotal role maintenance plays in high-tech industries, the literature falls short in offering a holistic understanding of the intricacies involved. This study bridges that gap by providing a detailed examination of the challenges and opportunities unique to this context. Therefore, the findings and recommendations

presented in this research offer a significant contribution to a field that is in need of more in-depth exploration. By doing so, this study sets the stage for further investigations and encourages future research endeavors to build upon this foundation, ultimately advancing our comprehension of KM and KS in maintenance departments.

3.3. Methods

This research adopts a qualitative multi case study design, concentrating on the maintenance departments of three knowledge intensive industries. The case study approach was chosen for its suitability in examining the multifaceted issues surrounding KM and KS within maintenance departments. The primary objective of this research is to comprehensively explore the barriers and enablers of KM and KS within the maintenance departments of a knowledge intensive organization, as well as to gather valuable suggestions for improving these crucial processes. Specifically, the research aims to achieve the following goals: to pinpoint the primary barriers perceived by maintenance knowledge users (MKUs) in effective KM and KS within maintenance departments and qualitatively assess the perspectives of KMEs regarding identified barriers and enablers for KM and KS. Additionally, the study explores practical suggestions and recommendations for enhancing KM and KS as offered by both MKUs and knowledge management experts (KMEs). This research is designed to align with the broader context of knowledge-intensive industries and address the unique challenges faced by maintenance departments in these organizations.

The study is guided by the following research questions:

- a. What are the primary barriers to effective KM and KS within the maintenance departments, as perceived by MKUs?

- b. How do KMEs within the organization view these barriers and the enablers for KM and KS?
- c. What practical suggestions and recommendations for enhancing KM and KS are offered by both knowledge MKUs and KMEs?

The study involved a total of 33 participants, including 25 MKU and 8 KME from three knowledge intensive companies. The diverse participant pool ensures a comprehensive perspective on KM and KS within maintenance departments. Data was primarily collected through semi-structured, in-deep interviews with participants. These interviews were designed to uncover the specific barriers and enablers of KM and KS as experienced and perceived by both MKUs and KMEs. Interviews were conducted one-on-one in a familiar setting at the participants' workplace. They were encouraged to share their experiences, insights, and suggestions regarding KM and KS. The interviews were recorded with participants' consent and transcribed for analysis. Ethical considerations were diligently observed. Informed consent was obtained from all participants, and their identities were protected through the use of pseudonyms. Data confidentiality and security were maintained throughout the research process. Thematic analysis was employed to examine the interview data, focusing on identifying barriers and enablers of KM and KS. Suggestions and recommendations from MKUs and KMEs were also systematically coded for further analysis. To ensure the validity and reliability of the findings, a second researcher independently reviewed and coded a subset of the data. Member checking was conducted by sharing preliminary findings with participants, allowing them to validate and provide feedback on the interpretations. Triangulation was utilized by combining insights from both MKU and KME to validate and strengthen the findings related to KM and KS barriers, enablers, and improvement suggestions.

In conclusion, this research methodology was designed to thoroughly investigate the complex landscape of KM and KS within the maintenance departments of knowledge intensive organizations. The study gathers insights from MKUs and KMEs, addressing barriers, enablers, and practical suggestions for improvement. The methodology ensures rigor and trustworthiness in the findings and aims to contribute significantly to the field of KM and KS, offering actionable insights for organizations seeking to optimize their maintenance department's KM and KS practices.

3.4. Results and discussion

This section presents the key findings derived from an in-depth exploration of KM and KS practices within the maintenance departments of three knowledge intensive manufacturing companies. The insights collected through interviews with MKU and KME offer a comprehensive understanding of the barriers, enablers, and recommendations that shape the landscape of KM in this context.

The findings are categorized into several dimensions, each shedding light on the intricacies of KM and KS. From individual-level barriers and enablers to interpersonal, organizational, cultural, and infrastructure-related factors, this study unveils the intricate dynamics at play in maintenance departments. These insights stem from the perspectives of both those actively engaged in the day-to-day operations of maintenance and those with expertise in KM within the organization.

The key findings encompass a range of challenges, facilitators, and strategic recommendations. Notable among these are the challenges posed by the absence of a common standard language for recording experiences, the fear of sharing unsuccessful experiences, and the reluctance

among technical personnel to document reports. On the flip side, the benefits of reducing the time gap between experience acquisition and recording, promoting face-to-face KS, and fostering informal communication among individuals are clear enablers to effective KM and KS.

Furthermore, this section discusses the organizational and cultural aspects that influence KM within the knowledge intensive maintenance context. The role of management support, environmental pressure, and the power dynamics of knowledge ownership within the organization are explored. Recommendations are offered to address these challenges, such as the incorporation of KM into organizational strategies and the allocation of adequate time for recording events. In addition, the study highlights the need for creating a culture of knowledge exchange, supported by the sharing of failure experiences by organizational leaders. The infrastructure-related challenges, including the lack of a suitable environment for knowledge recording and the limitations of knowledge recording systems, are also addressed with recommendations that seek to enhance the recording and utilization of knowledge. The following section present a comprehensive analysis of these findings, providing valuable insights for organizations looking to improve their KM and KS practices in knowledge-intensive maintenance departments. The tables below summarize the barriers, enablers, and recommendations presented by both MKU and KME in each of these dimensions, offering a deeper understanding of the intricate landscape of KM and KS within maintenance environments. This study's investigation is organized into five tables, each presenting unique perspectives. Table 7 examines individual viewpoints, Table 8 delves into interpersonal insights, and Table 9 explores the organizational perspective. Table 10 offers insights from a cultural standpoint, while Table 11 underscores the influence of infrastructure on our understanding of these critical elements. In tables, the "*" denotes that the idea has been

emphasized by MKUs, KMEs, or both. Its presence indicates agreement or relevance as highlighted by these perspectives in barriers, enablers, and recommendations.

Table 7: Insight from individual perspective.

Individual perspective		Insight of MKU	Insight of KME
Barriers	Lack of a common standard language for recording and reporting experiences and acquired knowledge.	*	*
	Fear of reporting unsuccessful experiences and failures.		*
	Technical personnel do not have a strong inclination towards writing and documenting reports.	*	*
	Inadequate detail in reports, making them ineffective.	*	*
Enablers	Reducing the time gap between gaining experience and its recording (utilizing Ebbinghaus's Forgetting Curve).		*
	Face-to-face KS can be more effective.		*
	Informal communication among individuals facilitates KS.	*	*
	Building mutual trust among individuals facilitates KS.	*	*
	KS should be a two-way process where all participants engage.		*
Recommendations	Events should be recorded and reported immediately after their completion.		*
	Encourage individuals to refer to documented materials.		*

Table 8: Insight from interpersonal (team) perspective.

Interpersonal perspective		Insight of MKU	Insight of KME
Barriers	Generation gap among employees hinders KS.	*	
	Neglecting the use of previously recorded reports.	*	*
	Possessing knowledge leads to increased workload and additional tasks.	*	*
	If KS is mandatory and against individuals' will, they won't transfer all their knowledge.		*
	Monopolized knowledge gives power to individuals.	*	*
	Individuals do not refer to documented records.	*	*
	Lack of competition for learning among individuals.	*	
	Individuals do not consider knowledge transfer as their responsibility.		*
Enablers	Informal communication among individuals outside the organization.	*	
	Motivation for KS should exist.	*	*
	Individuals of similar age find it easier to share their knowledge.		
	Keeping and not sharing knowledge creates a sense of job security.	*	*
Recommendations	New employees should have mentors.		*

Table 9: Insight from organizational perspective.

Organizational perspective		Insight of MKU	Insight of KME
Barriers	Insufficient support from management.	*	*
	Insufficient environmental pressure for KS.		*
	Poor quality of recorded reports due to insufficient rigor and oversight.	*	*
	Knowledge is power within the organization.	*	*
	Power lies in possessing knowledge, not in sharing it.	*	*
	Lack of standardized data recording.	*	*
Enablers	Having a robust organizational KM structure.		*
	Referring to previously recorded information should be part of the process.		*
	Experienced individuals who share their knowledge should be identified, introduced, and tagged in the organization.		*
	Reports are concise, rendering them unusable	*	
	Job rotation can lead to increased knowledge among individuals.		*
	Non-monetary incentives should be provided for KS.		*
Recommendations	KS and discussion sessions should be held alongside equipment breakdowns.		*
	KM should be incorporated into organizational strategies.		*
	Adequate time should be allocated for recording events for individuals.	*	*
	Career advancement should be linked to participation in KS.	*	*
	The extent of KS should be measured and evaluated.		*

Table 10: Insight from cultural perspective.

Cultural perspective		Insight of MKU	Insight of KME
Barriers	Lack of a culture of knowledge exchange.	*	*
Enablers	Support and approval from superiors have a significant impact on fostering a culture of KS.	*	
	The organization should be a pioneer in recording and reporting its failures and its managers should share their failure experiences.		*
Recommendations	Establish a culture of KS within the organization.	*	*

Table 11: Insight from infrastructural perspective.

Infrastructure point of view		Insight of MKU	Insight of KME
Barriers	Lack of a suitable and tranquil environment for recording and reporting experiences.	*	*
	Insufficient hardware infrastructure for knowledge recording, such as computers.	*	
	Knowledge on the Maintenance is inherently complex.	*	*
	The knowledge recording system is not user-friendly.	*	
	Registering information in the enterprise resource planning (ERP) system is difficult.	*	
	Inadequate tagging and search capabilities for reports.	*	*
Enablers	Adequate and sufficient hardware and software infrastructure for recording and reporting event.	*	*
Recommendations	Recorded knowledge should be validated.		*
	Utilizing augmented reality (AR) and virtual reality (VR) for recording experiences.		*

The tables in this section reveal key findings from an in-depth exploration of KM and KS practices within maintenance departments of knowledge-intensive manufacturing companies. Insights from MKUs and KMEs provide a nuanced understanding of barriers, enablers, and recommendations shaping the KM landscape in this context. Categorized across individual, interpersonal, organizational, cultural, and infrastructural dimensions, the results highlight

challenges like the absence of a common standard language and technical personnel's reluctance to document reports, alongside enablers such as reducing the time gap for recording experiences and fostering face-to-face KS.

3.5. Conclusion

Effective KM and KS are pivotal components of any knowledge intensive maintenance department's success. In this study, we delved into the practical challenges faced by knowledge users within three knowledge intensive manufacturing companies, as well as their insights into the enablers and barriers surrounding KM and KS. The results revealed a comprehensive landscape of factors that influence the efficient management and sharing of knowledge within this dynamic and technologically advanced environment.

3.5.1. Barriers:

The list of barriers uncovered through interviews offers valuable insights into the unique challenges faced by knowledge users in the maintenance department. These barriers include the absence of a standard language for knowledge recording, the fear of sharing unsuccessful experiences, a lack of enthusiasm for documenting reports among technical personnel, and issues related to generational gaps and job rotation. In particular, the fear of recording unsuccessful experiences is a notable psychological barrier that affects individuals' willingness to contribute to the knowledge pool. Additionally, the lack of enthusiasm for documenting reports, especially among technical personnel, highlights a disconnection between the daily routines of employees and the documentation processes required for effective KM and KS.

Furthermore, the absence of a common language for recording knowledge suggests a critical need for standardization in documenting and sharing experiences within the maintenance department. This barrier aligns with the need for a comprehensive, user-friendly knowledge recording system that would encourage employees to actively contribute their insights and experiences. The generation gap among employees, coupled with job rotation, exemplifies the unique dynamics of the high-tech industry. These structural and cultural barriers pose significant challenges to KM and KS within the department.

3.5.2. Enablers:

Conversely, the enablers identified in the study shed light on strategies and initiatives that can enhance KM and KS in high-tech maintenance departments. Notably, the recommendation that KS should be a two-way process emphasizes the importance of active participation from all individuals involved. Face-to-face interactions are encouraged, emphasizing the interpersonal dimension of KS. Trust among colleagues, facilitated by informal communication, emerges as a key enabler. The study highlights the significance of fostering a culture of knowledge exchange within the organization, a culture where both failures and successes are openly shared.

The insights reveal the potential for utilizing AR and VR technologies in KS, presenting an exciting opportunity to incorporate emerging technology into KM and KS practices. Similarly, the prospect of incorporating non-monetary incentives to encourage KS offers a practical way to motivate employees. Furthermore, measuring and evaluating the extent of KS and linking career advancement to participation in KM and KS provide valuable strategies for organizations seeking to strengthen their KM efforts.

3.5.3. Limitations:

This study is not without limitations. The research focused on three knowledge intensive manufacturing companies, and the findings may not be fully transferable to other organizational contexts. Additionally, the study primarily relied on self-reported data from knowledge users and experts, which can introduce potential biases. Future research should aim to encompass a broader range of knowledge intensive industries and utilize mixed methods to enhance the robustness of the findings.

3.5.4. Future research directions:

The insights gained from this study open avenues for future research in the realm of KM and KS. To address the limitations of this study, further investigations should aim to explore KM practices across various knowledge intensive industries, considering the nuances and specific challenges within each sector. Additionally, future research could delve deeper into the role of emerging technologies, such as AR and VR, in facilitating KM and KS. Furthermore, the dynamics of knowledge transfer between different generations within the workforce merit additional attention. Investigating the impact of generational gaps on KS, as well as strategies to bridge these gaps, could provide valuable insights for organizations aiming to harness the collective wisdom of their workforce. In conclusion, this research not only contributes to the body of knowledge in the field of KM but also offers actionable recommendations for enhancing KS practices within knowledge intensive maintenance departments. The insights from knowledge users are instrumental in addressing the unique challenges posed by the knowledge intensive industries, and the strategies and recommendations provided can be

adapted by organizations to facilitate efficient KM and KS for sustained success. This study can act as a catalyst for further research and innovation in the realm of KM within knowledge intensive industries.

In summary, this study sheds light on the intricate landscape of KM and KS within knowledge intensive maintenance departments. The identified barriers underscore the need for a standardized knowledge recording system, bridging generational gaps, and fostering a culture that encourages active participation. On the flip side, the enablers offer actionable strategies, from promoting face-to-face interactions to leveraging AR and VR technologies, to enhance KS.

The key takeaway is the urgent requirement for organizations to implement user-friendly knowledge recording systems, foster a culture of open communication, and leverage emerging technologies to overcome the identified barriers. This study not only contributes to the academic understanding of KM and KS but also offers practical recommendations for immediate implementation in knowledge-intensive maintenance departments.

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CHAPTER 4 (Study 2): Bringing Novices from the Passive Role in Knowledge Sharing to the Active Role

Hamid Roham, Jorge F.S. Gomes

This study was accepted and presented at the 24th European Conference on Knowledge Management, held in Lisbon, Portugal, on September 7-8, 2023, and published in the conference proceedings (ISSN: 2048-8963)

Additionally, this study won second place in the 9th Knowledge Management and Intellectual Capital Excellence Awards at the ECKM competition and has been featured in the award book titled "9th Knowledge Management and Intellectual Capital Excellence Awards 2023: An Anthology of Cases"; (ISBN: 978-1-914587-75-7).

Abstract:

Purpose: The nature of firm competition between firms and the source of competitive advantage in many industries has shifted toward a knowledge-based economy. This is particularly the case in knowledge intensive industries, wherein a firm's competitive advantage is highly dependent on its ability to generate and deploy new knowledge solutions. Although knowledge management (KM) is relevant to all organizations, it is likely that its importance is higher at some functional units like maintenance. The field of industrial maintenance is complex and knowledge-intensive. Typically, industrial maintenance knowledge is inaccessible due to industry policies and practices; furthermore, motivation to share knowledge is low or inexistent, due to its tacit and complex nature.

Despite these difficulties, sharing knowledge between experienced workers and managers, on one hand, and novices and new comers, on the other hand, is a fundamental problem in industrial maintenance settings, and about which there is still much to be known. The current research reports an investigation aimed at increasing knowledge sharing (KS) between novices and other workers in industrial maintenance.

Design/Methodology/Approach: A quantitative field longitudinal research was carried out at a maintenance department of a high-tech company. The research included three steps: the first one assessed the current situation of KM and KS in the department; the second one implemented a number of training programs aimed to increase KS between novices and the rest of the department; and the third one collected information about KM and KS, to assess changes between the two observation moments.

Findings: Novices can take an active role in KM and KS in maintenance departments of high-tech industries, rather than a passive role, which can significantly facilitate and improve their own and other employees' knowledge while moderately enhancing the culture of KS.

Practical Implications: sharing knowledge is a very challenging issue to maintenance managers, faced with risks and problems that need to be acquired by novices. The current research helps knowledge-intensive companies by highlighting solutions that can be designed and adapted to improve employees' knowledge and also KS.

Originality/Value: Empowering novices to transition from a passive role in KS to an active one, while simultaneously improving their knowledge and also KS practices in industrial maintenance through their involvement.

Keywords: Knowledge management, Knowledge sharing, industrial maintenance, novices, physical asset management, knowledge sharing barriers.

4.1. Introduction

In today's fast-paced and competitive industrial environment, the importance of KM and KS cannot be overstated (Iheukwumere-Esotu & Yunusa Kaltungo, 2020). Effective KM and KS can help organizations to reduce costs, increase efficiency, improve performance, and achieve a competitive advantage. KM is viewed as an increasingly important discipline that promotes the creation, sharing, and leveraging of the corporation's knowledge (Becerra-Fernandez & Sabherwal, 2014). KM was initially defined as the process of applying a systematic approach to the capture, structuring, management, and dissemination of knowledge throughout an organization to work faster, reuse best practices, and reduce costly rework from project to project (Nonaka & Takeuchi, 1995). Knowledge has been classified and characterized from several points of view to individual, social, causal, conditional, relational, tacit, explicit, pragmatic (Alavi & Leidner, 2001) embodied, encoded, and procedural (Venzin et al., 1998). An important classification of knowledge views it as tacit or explicit (Polanyi & Sen, 2009). Explicit knowledge is knowledge that has been expressed into words and can be shared formally and systematically in the form of data, specifications, manuals, drawings, audio and video, computer programs, patents, and so on (Becerra-Fernandez & Sabherwal, 2014). Among processes of KM, KS has been identified as the most vital one (Asrar-ul-Haq & Anwar, 2016). KS has been identified as the most important process for facilitating organizational learning and innovation and is critical to organizations that wish to use their knowledge as an asset to achieve competitive advantage. The major focus of KS is on the individual who can explicate, encode, and communicate knowledge to other individuals, groups, and organizations (King, 2011).

In the context of industrial maintenance, KM and KS are critical for ensuring optimal performance, safety, and reliability of equipment and systems (Cárcel-Carrasco & Cárcel-Carrasco, 2021). Maintenance is defined as "the combination of all of technical, administrative and managerial actions performed during life cycle of an item intended to retain it in, or restore it to, a state in which it can perform the required function" (Márquez, 2007). The field of industrial maintenance is complex and knowledge-intensive (Aromaa et al., 2015). However, despite the recognized importance of KM and KS, many organizations struggle to implement effective KS practices, particularly when it comes to new or inexperienced employees. Maintenance managers must strongly consider how to transfer expertise and knowledge from experts who have it to novices who need to know (Hinds et al., 2001). An important effect of maintenance KS is that it will transfer maintenance expertise between experts and novices. Novices and newcomers often have valuable insights and fresh perspectives that can contribute to the organization's overall knowledge base, but they may not have the same level of expertise and experience as their more experienced colleagues.

Difficulty in educating and training novices has been identified as one of the most important barriers of KS at maintenance (Chirumalla et al., 2015). To address this challenge, this paper explores a novel approach to KM and KS in an industrial maintenance setting. Specifically, this study has involved novices and newcomers in the KS process by assigning them tasks and using them as lecturers in the presence of experienced colleagues. By doing so, this study aims to facilitate KS between novice employees and their more experienced colleagues.

The paper describes the methodology used to implement this approach, as well as the results and outcomes achieved. It also discusses the implications of this approach for KM and KS in industrial maintenance settings, and provide recommendations for organizations seeking to

improve their KS practices. Overall, this paper highlights the importance of involving novices and newcomers in the KS process, and demonstrates a practical and effective approach for facilitating KS in industrial maintenance settings.

4.2. Method

For this study, a quantitative approach was utilized, and a questionnaire was administered. The questionnaire used in this study is a combination of four previously developed and utilized questionnaires by researchers. A quantitative approach was employed, utilizing a questionnaire with closed-ended questions. The study was conducted at a high-tech industry's maintenance department, which employs 103 personnel among the company's 1250 employees. To collect data, a questionnaire with 66 closed-ended questions that measure KM and KS related variables was distributed among the maintenance personnel. Next, 14 novices and new comers were selected, and new and challenging tasks were assigned to them, which they were not experts in. They were given two months to prepare training content and materials in whatever format they wanted, such as Word documents, PDFs, PowerPoint presentations, and videos. During this period, four follow-up meetings were held with the novices to facilitate document preparation and remove any obstacles, and the novices presented their progress.

After two months, experts on the selected topics and employees who needed to know about the topics were selected by the sub-department managers. Then semi-formal training sessions were conducted, in which the novices taught the topics and experts were present to correct any misinformation in this semi-formal atmosphere. The teachers who taught in the program were novices and lacked expertise in the topic they taught. Similarly, the learners who participated in the program were not experts in the topic they learned. On the other hand, the experts who

participated in the program were specialists in the topic they were assigned. It is important to note that some participants had multiple roles. For instance, a teacher who taught one topic also participated as a learner in another topic. To have a control group, 21.3% of employees were excluded from the program.

After the program was completed (which lasted for five months), the same questionnaire was distributed to measure the current level of knowledge, as well as the KM and KS variables. Furthermore, additional questions were added to the questionnaire for the second round of data collection. Finally, the data was analyzed using descriptive statistics to assess the impact of the training program on KS and knowledge of participants.

4.3. Findings and discussion

The study categorized participants based on their job level, education level, and responsibilities. It investigated the extent to which participants' knowledge improved during the program and the effectiveness of the program in the opinion of various participant categories. The study also examined whether participants across different categories agreed to extend the program. Additionally, the study explored the desired roles of participants in the program, including that of teacher, learner, expert, or a combination of roles.

4.3.1. Improvement in knowledge

According to the questionnaire, 67% of learners who attended the program reported an improvement in their knowledge. In addition, 77% of experts and 90% of teachers reported an improvement in their knowledge. Overall, 71% of all participants reported an improvement in

their knowledge, and the level of knowledge among participants in the program improved by 43.9%. All participants, regardless of their role (learner, expert, teacher (novice or newcomer)), reported an improvement in their knowledge as a result of their participation in the program. This is particularly noteworthy considering the short duration of the program and the fact that the training was provided by novices. Table 12 presents the percentage of participants who reported an improvement in their knowledge, categorized by the role they played in the program.

Table12: Knowledge improvement base on the role in the program.

Role in the program	Learners	Experts	Teachers (novices and new comers)	Overall
Percentage of participants reporting improvement in knowledge	67%	77%	90%	71%

Table 13 displays the knowledge levels of participants in the taught topic before and after the training by novices. The table is categorized by education level and also presents the percentage of change in knowledge and table 14 shows improvement in knowledge based on position level.

Table13: Improvement in knowledge based on education level.

Education level	Diploma	Associate	Bachelor	Master	PhD	Overall
Average knowledge level prior to Program (scored out of 7)	3.53	3.39	3.52	2.5	6	3.46
Average knowledge level after program completion (scored out of 7)	5.3	5.09	4.86	4.82	7	4.98
Percentage of change	+50%	+50%	+75.5%	+92.5%	+16.6%	43.9%

Table14: Improvement in Knowledge Based on Position Level.

Job level (position)	Technician	Foreman	Expert	Boss	Manager	Director
Average knowledge level prior to program (scored out of 7)	3.34	4.4	3.09	4.37	3.5	2
Average knowledge level after program completion (scored out of 7)	5	5.8	4.27	5	6	6
Percentage of change	+49.7%	+31.8%	+38.1%	+14.4%	+71.4%	+200%

4.3.2. Effectiveness of the program (training by novices)

Participants were asked to provide feedback on the effectiveness of the program. Table 15 displays the effectiveness of the program based on the job level of the participants, while Table 16 presents the effectiveness of the program based on their education level.

Table15: Effectiveness of program based on job level (position)

Job level (position)	Technician	Foreman	Expert	Boss	Manager	Director	overall
Percentage of participants who found the program effective	55.1%	80 %	57.1%	62.5%	100%	100%	58.5%

Table16: Effectiveness of program based on education

Education level	Diploma	Associate	Bachelor	Master	PhD
Percentage of participants who found the program effective	63.6%	56.3%	56.4%	60%	100%

4.3.3. Agree to extend (continuation of) the program

Participants were asked another question regarding their agreement with extending the program. Table 17 shows the percentage of participants who agreed with extending the program based on their job level (position), while Table 18 presents the percentage of those who agreed based on their education levels.

Table17: Agree to extend the program based on position

Job level (Position)	Technician	Forman	Expert	Boss	Manager	Director	Overall
Agree to extend the program	56.5%	60%	57.1%	62.5%	100%	100%	58%

Table 18: Agree to continue the program based on education

Education level	Diploma	Associate	Bachelor	Master	PhD
Agree to continue the program	77.3%	59.4%	48.7%	40%	100%

4.3.4. Desired roles

Participants were also asked to indicate their preferred role in the program, which included being a teacher, a learner, an expert, or a combination of these roles. Table 19 shows the results for each role.

Table19: Desired role of participants

Desired role in KM and KS program	Teacher	Leaner	Expert	Teacher and Learner	Teacher and Expert	Learner and Expert	Teacher and (Learner or Expert)	Not answered
percentage	9.7%	50.5%	12.6%	6.8%	1.9%	1.9%	7.8%	8.7%

4.3.5. Other findings

The findings of this study indicate that the program has resulted in a modest increase of 3.9% in KS among participants. Additionally, the participants' perception of the culture of KS has increased by 4.6%, but statistically, the difference is not significant. According to the results from the additional questions in the second round of data collection, participants have stated that the main problem with the program has been a lack of motivation. They suggested that the program should be connected and related to their career promotion as an improvement. Interestingly, the control group, who did not participate but were aware of the program, reported an increase in barriers to KS by 12.3%. These results suggest that while the program may have had some positive impact on KS, it may also have inadvertently created new barriers for non-participants.

4.4. Conclusion

There have been numerous studies on KM in various industrial and service sectors, but typically the focus is on general management, accounting, R&D, development activities,

information technology (IT), and similar areas, with less attention given to maintenance units (Cárcel-Carrasco et al., 2020). Within maintenance departments of companies, KM can be challenging due to the tendency of technicians to rely on their own experience rather than sharing and explaining their knowledge of operations (Cárcel-Carrasco et al., 2020).

In this study, the high levels of reported knowledge improvement among learners, experts, and teachers (67%, 77%, and 90%, respectively) suggest that this approach has been effective for a wide range of participants, regardless of their level of experience. This approach has the potential to foster a culture of continuous learning and development, where all employees are empowered to share their knowledge and expertise. Utilizing novices and newcomers as trainers in an industrial maintenance setting has proven to be an effective means of enhancing KM and KS among colleagues. Despite being conducted by novices and newcomers, the trainings have resulted in a significant increase in knowledge for experts, learners, and novices alike, specifically in the area being taught. Moreover, the increase in knowledge is substantial, even though the training was conducted over a short period of time. The findings of this study demonstrate that this approach has resulted in noteworthy improvements in the participants' knowledge, with an overall increase of 43.9% in knowledge improvement. The findings of this study also indicate that the use of novices as trainers has been particularly effective for novices and new comers, with a knowledge improvement rate of 56.52%. This suggests that this approach may be particularly beneficial for organizations that are looking to support the onboarding and development of their new employees. It is also important that most participants preferred to have the role of learner, indicating a need for further investigation to change their attitudes and make them more willing to take on other roles.

One of the most effective ways to learn is by adopting a mindset that allows the learner to teach the material to others. This approach not only helps learners to deepen their understanding of the subject matter, but it also helps them to retain the information more effectively. When learners attempt to teach a concept to someone else, they must organize the material in a way that is easy to understand and follow. This process forces them to break down complex ideas into simple, digestible parts, and helps them to identify any gaps in their knowledge or areas where they need more practice. Moreover, teaching others also requires learners to think critically about the material and consider different perspectives and approaches to the subject matter. By doing so, they gain a more comprehensive understanding of the material and are better equipped to apply their knowledge in practical settings.

In conclusion, the findings of this study suggest that the implemented program has had a meaningful positive impact on the participants' knowledge. Although the increase in KS and culture of KS was not statistically significant, participants reported finding the program effective and agreed to continue it. AS KS is a cultural and multidimensional subject, longer-term implementation of the program may be needed for more significant improvement in KS and its culture. Overall, this study has demonstrated the potential benefits of using novices and new comers as trainers in an industrial maintenance setting. By embracing this approach, organizations can enhance their KM and KS practices, promote a culture of continuous learning, and support the development of their employees.

Implications of the research to the theory and to the practice: This research makes a significant contribution to the theory of KM by emphasizing the importance of KS in knowledge-intensive departments like industrial maintenance, specifically highlighting the involvement of novices in the KM process. By empowering novices to actively participate in KS, the research enhances

the culture of KS, improves employees' knowledge, and offers practical solutions for maintenance managers in knowledge-intensive industries. This contribution expands upon existing knowledge by highlighting the active role that novices can play in KS practices.

Limitation: The findings of this study are limited by the fact that data were collected from only one company, thus limiting the generalizability of the results. Future research should aim to replicate these findings in other companies to enhance the external validity of the study.

Managerial Implication: Managers can utilize this approach to empower novices by shifting them from the passive side of KM and KS to the active side, while also increasing the knowledge of their employees and enhancing KS.

Future works: While the results of this study are promising, there are still areas for future research. One key area for future research is to investigate how to scale this approach across other departments and larger organizations and explore the potential barriers to implementing this approach on a larger scale. Additionally, more research is needed to explore the long-term impact of this approach on employee development and organizational performance. Also in order to further advance this research, future studies could focus on identifying the issues or limitations of the program. This could be achieved through conducting interviews or questionnaires with participants to gather feedback and suggestions for improvement. Additionally, exploring the long-term effectiveness and sustainability of the program could also be a valuable area for future research.

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CHAPTER 5 (Study 3): Knowledge Management and Knowledge Sharing In Maintenance Department Of High-Tech Industries

Hamid Roham, Jorge F.S. Gomes

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Abstract

Purpose – The competition and competitive advantage among firms in various industries have shifted towards a knowledge-based economy. This is particularly evident in knowledge-intensive industries where a company's competitive edge relies heavily on its ability to generate and utilize new knowledge solutions. Knowledge management (KM) is essential for all organizations, but it holds greater significance in specific functional units, such as maintenance. Industrial maintenance is a knowledge-intensive field and knowledge sharing (KS) motivation is low due to the tacit and intricate nature of knowledge. Despite these challenges, sharing knowledge between experienced and novice employees is fundamental to industrial maintenance, and much remains to be examined in this area. This study explores how novices' knowledge and KS with other workers can be improved in industrial maintenance.

Design/methodology/approach – This study adopted an action-research approach within a high-tech company's maintenance department, involving 103 maintenance employees. The research unfolded in three pivotal phases: first, an initial evaluation of KM and KS was carried out; second, training programs by novices aimed at strengthening KS between novices and department members were implemented; and third, data was collected to assess changes and facilitate improvement in knowledge exchange and collaboration within the department.

Findings – The study demonstrates that involving novices in training programs as trainers within high-tech industries' maintenance departments enhances KM and KS among all employees. The training programs led to substantial increases in knowledge for novices and experienced workers and fostered a culture of continuous learning. Despite the short training duration, participants' overall knowledge increased, and they found the program effective and

expressed willingness to continue, indicating potential for long-term improvements in KS practices.

Theoretical Implications –This research challenges conventional wisdom regarding KS in industrial maintenance. Showcasing the effectiveness of novices as trainers offers a fresh perspective on enhancing KS practices within knowledge-intensive industries.

Practical implications – This study provides actionable insights for maintenance managers grappling with KS challenges. Organizations can boost employees' knowledge and KS practices by advocating for structured training programs led by novices, fostering a more collaborative workplace culture. **Originality/value** – This study introduces a novel approach by empowering novices to engage actively in KS within industrial maintenance settings. By utilizing novices as trainers, the research demonstrates a practical means of enhancing both their own knowledge and that of their peers. This innovative strategy not only addresses common challenges in KM within maintenance units but also promotes a culture of continuous learning and development. This research offers valuable insights into improving KS practices and fostering a more collaborative organizational culture.

Keywords: Knowledge management, Knowledge sharing, industrial maintenance, novices, physical asset management, knowledge sharing barriers.

5.1. Introduction

The competitive landscape of many industries has evolved to prioritize knowledge-based resources as a source of competitive advantage (Watson and Hewett (2006). This shift has led to consolidating existing knowledge assets as a pathway to creating value (Iheukwumere-Esotu & Yunusa Kaltungo, 2020; Refaiy & Labib, 2009). This trend is particularly prominent in knowledge-intensive industries where a firm's competitive advantage depends on its ability to generate and deploy new knowledge solutions (Watson & Hewett, 2006). The success of KM can contribute to, or even drive, the success of an organization (Holsapple et al., 2016). Therefore, understanding how to manage organizational knowledge can provide many benefits, including leveraging core business competencies, accelerating innovation, empowering employees, , and building sustainable competitive advantage (Davenport & Prusak, 1998). As such, KM is seen as an increasingly important discipline that fosters creating, sharing, and utilizing an organization's knowledge (Becerra-Fernandez & Sabherwal, 2014).

While KM is relevant across all organizational facets, its significance is notably pronounced in specific functional units. For instance, KM holds importance in production but is streamlined due to standardized instructions and routine tasks, posing fewer challenges. Conversely, in maintenance and engineering departments, KM is likely to be highly critical. Maintenance is "the combination of all of technical, administrative and managerial actions performed during the life cycle of an item intended to retain it in, or restore it to, a state in which it can perform the required function" (Márquez, 2007). The field of industrial maintenance is complex and knowledge-intensive (Aromaa et al., 2015), so much so that one can argue that different or novel knowledge is produced every day. Maintenance is a knowledge-intensive process

involving organizations, groups, and/or individuals creating, reusing, and sharing specialized professional knowledge (Kovacs et al., 2019b).

Amidst the abundance of studies on KM in diverse sectors, the emphasis frequently centers on broad management, R&D, IT, and related domains. However, there is comparatively limited research on KM within maintenance units (Cárcel-Carrasco et al., 2020). Companies' maintenance departments face challenges in implementing KM due to the technicians' tendency to work based on their experience rather than actively sharing and explaining their knowledge of operations. This can make capturing and codifying their expertise difficult, which is often tacit and not easily shared (Cárcel-Carrasco et al., 2020). In many cases, industrial maintenance knowledge is not easily accessible due to industry policies and practices that provide little or no motivation to share it with others. As a result, in a factory setting, each failure is typically only discovered at its first occurrence and requires a lengthy and costly corrective operation. The maintenance process involves diagnostics to identify the reasons for a failure, assess its impact, and define and apply the correct repair procedures.

Maintenance managers must consider transferring expertise and knowledge from experts who have it to novices who need (Hinds et al., 2001). However, the mechanisms for transmitting and managing this knowledge are often created through tacit knowledge acquired by maintenance staff, which can be challenging to capture and study (Cárcel-Carrasco et al., 2020). Sharing knowledge is not an everyday activity in most organizations, especially maintenance. It has been shown that individuals are rewarded chiefly for what they know and not for what they share. The competitive environment that encourages individual instead of collective productivity has stimulated employees to consider their knowledge as their property, and deepening and defending their knowledge is the primary way to keep their jobs. An

essential effect of maintenance KS is that it will transfer maintenance expertise between experts and novices. This will lead to much faster handling of machine failures, training new staff and reducing the dependence on external maintenance companies. Even more importantly, it will reduce the number of accidents related to maintenance activities.

Identifying and addressing the education and training of novices has been recognized as one of the key barriers to KS within maintenance (Chirumalla et al., 2015). The introduction delves into a critical gap in theory and practice, aiming to bridge traditional approaches with innovative methodologies in KM and KS within industrial maintenance. This study focuses explicitly on involving novices in the KS process, presenting a unique strategy to enhance learning and collaboration. Recognizing the education and training of novices as a critical barrier to KS, the paper explores this novel approach by assigning tasks and utilizing novices as instructors in the presence of experienced colleagues. This study investigates whether novices can effectively play a more active role in KM and how such involvement can be implemented. By providing comprehensive training and fostering a culture of KS, novices can enhance their understanding and retention of material. The "training by novices" program aims to transition novices from passive to active KS roles, addressing barriers and improving knowledge. The research questions guiding this inquiry are:

1. Can novices play a more active learning role in KM in maintenance environments?
2. How can such a role be designed and implemented?

The paper concludes with a discussion on methodology, results, and implications, emphasizing the significance of involving novices in KS and providing practical insights for industrial maintenance settings.

5.2. Literature review

5.2.1. KM Definition and types of knowledge

The shift toward a knowledge-based economy has led to the widespread adoption of KM in both academic and business circles (Chen & Chen, 2006). KM is recognized as an essential discipline that facilitates creating, sharing, and leveraging an organization's knowledge assets (Becerra-Fernandez & Sabherwal, 2014). KM was first described as a methodical process that involves capturing, organizing, managing, and sharing knowledge across an organization to achieve quicker results, reduce redundant efforts, and leverage best practices (Nonaka & Takeuchi, 1995). KM can also be defined as a set of activities that include identifying, capturing, sharing, and applying knowledge to effectively enhance the impact of knowledge on an organization's goals in a cost-effectively.

Knowledge has been classified and characterized from several points of view to: individual, social, causal, conditional, relational, tacit, explicit (Alavi & Leidner, 2001) embodied, encoded, and procedural (Venzin et al., 1998). An important classification of knowledge views it as tacit or explicit (Polanyi & Sen, 2009). Explicit knowledge refers to knowledge that has been articulated into language and can be shared through formal and systematic means such as data, manuals, and other forms of documentation (Becerra-Fernandez & Sabherwal, 2014). In contrast, tacit knowledge includes intuitions, impressions, and hunches that are difficult to express and formalize, making sharing challenging (Khoshsima et al., 2004). Tacit knowledge is highly personal and rooted in an individual's experiences and activities. It can also encompass specialized expertise that may be too costly to document explicitly, prompting organizations to leave it with the expert.

5.2.2. KM processes

Over the past few decades, researchers have outlined several KM processes: acquisition and retrieval, internalization, creation and generation, application and utilization, codification, storing, transferring, and sharing knowledge (Wong et al., 2015). The process of acquiring, retrieving, and accumulating knowledge refers to how knowledge workers obtain valuable information necessary to carry out their job responsibilities. This can involve attending seminars and retrieving information from repositories (Wong et al., 2015). Creating and generating knowledge involves developing intellectual property, such as new ideas, best practices, or patents (Morey, 2001). Codification and storage of knowledge involves documenting and storing information in an organization's repositories, such as archives or databases (Shannak, 2009). KS is the process of communicating explicit or tacit knowledge to others. Transfer and dissemination of knowledge involve sharing tacit and explicit knowledge throughout an organization, often driven by activities such as attending seminars and workshops, assigning mentors to new recruits, and other methods (Wong et al., 2015).

5.2.3. Importance of KS and its tools and techniques

Among the processes of KM, KS is one of the most critical (Asrar-ul-Haq & Anwar, 2016). KS primarily focuses on individuals who can articulate, encode, and communicate knowledge to others, groups, and organizations (King, 2011). In some instances, using specific KM systems (KMSs) may require individuals to upload their knowledge to a system instead of keeping it to themselves or only sharing it through personal exchanges (King, 2011). When implemented effectively, KS practices encourage collaboration, build trust, and foster a culture of continuous learning, promoting innovation and enabling organizations to maintain a

competitive edge in an ever-changing business environment. Although other KM processes are also important, KS is the critical component that links all KM processes, allowing organizations to unlock the full potential of their knowledge assets.

Organizations can utilize a range of KS tools and techniques to promote exchanging of knowledge and expertise among their employees. KS can take various forms, such as written correspondence or face-to-face communication through networking with other experts. The most commonly used KS tools can be found in Table 20.

Table 20: Most commonly used KS tools. Source: (Hammouri & Altaher, 2020).

Author(s)	Construct
(Razak et al., 2016)	Formal Training
(Lee et al., 2016)	Written Report
(Al Saifi et al., 2016)	Periodic Meeting and Workshop
(Samarra et al., 2017)	Mentoring and Coaching Program
(Tan, 2016)	Face to Face Interaction
(Alavi & Leidner, 2001)	KM System
(Islam & Afroze, 2020)	KS Systems
(Stoddart, 2020)	Email
(Hartmann et al., 2017)	Cloud Computing
(Sole & Wilson, 2002)	Storytelling
(Ahmed et al., 2019)	Social Media
(Jeon et al., 2011)	Communities of Practice (CoPs)
(Christensen, 2007)	Best Practice Sharing

In organizational networks, firms must balance KS and protection, using practices such as excluding crucial topics and sharing selective details based on psychological contracts to contrast benefits and risks (Thalman et al., 2024).

5.2.4. Knowledge hiding and knowledge hoarding

The transfer of knowledge from one individual to another is a critical aspect of KM, and KS plays a vital role in this process. However, research has identified knowledge hiding and knowledge hoarding as significant barriers to effective KS (Oliveira et al., 2021). Knowledge hiding refers to the intentional withholding or concealment of knowledge that would benefit others (Connelly et al., 2019), while hoarding is the deliberate concealment of knowledge that is relevant to another but not requested (Evans et al., 2015). Knowledge hiding refers to intentionally withholding or concealing knowledge that would benefit others, while knowledge hoarding refers to monopolizing knowledge for personal gain.. Both behaviors can have adverse effects on KS and KM, leading to reduced collaboration and lower organizational performance. Furthermore, individual factors such as fear of job loss, lack of trust in colleagues, and personal gain are often the drivers behind these behaviors. According to Tang et al. (2024), employees typically reciprocate KS through peer respect, mirroring the initial act of sharing knowledge. However, the respect generated is amplified only when the knowledge contributor demonstrates competence. Therefore, organizations must address these individual factors to overcome these barriers and facilitate effective KS.

5.2.5. Knowledge intensive companies and departments

While the importance of KM varies across industries and departments, it is particularly crucial in knowledge-intensive companies and departments that heavily rely on knowledge and expertise to operate, innovate, and remain competitive in their respective markets. Knowledge-intensive companies and departments face various challenges, such as managing the volume of knowledge generated, effectively sharing and applying knowledge, and retaining critical

knowledge when employees leave the organization. The term "knowledge-intensive" can be used in different contexts, such as knowledge-intensive work, knowledge workers, and knowledge-intensive firms (Wiig, 2012). Knowledge intensity of work is determined by several factors, including the of knowledge and understanding a person must possess and apply when required to perform competent work and deal with uncertainties and surprises (Wiig, 2012). It involves at least four factors: a. Level and complexity of knowledge and understanding required to perform regular work; b. Level of expertise required for competent handling of work-related variability's; c. Severity of consequences of potential work errors; and d. the swiftness of action.

5.2.6. Maintenance and nature of knowledge at maintenance

In recent years, maintenance has become increasingly important within industrial settings due to its role in production (López-Ramos et al., 2019). This is due to the need to achieve specific goals such as increased availability, reduced maintenance costs, and higher quality products, all of which have become more complex and accelerated over time. The primary objective of maintenance is to ensure that equipment functions optimally which can be achieved by addressing losses that impede equipment efficiency. These losses include breakdowns, set-up and adjustment issues, cutting tool problems, start-up issues, minor stoppage and idling issues, and scrap and rework problems (Mansor et al., 2012).

Industrial maintenance, a knowledge-intensive field, can benefit from both conventional knowledge and maintenance data representation (Pistofidis et al., 2016). Maintenance work typically involves diverse and non-routine tasks associated with various systems requiring different skills and competencies to diagnose and solve problems (Chirumalla et al., 2015).

Maintenance knowledge is complex due to several factors. Firstly, maintenance involves multiple disciplines, such as mechanical, electrical, and instrumentation, and requires a comprehensive understanding of the interactions between different systems and components. Secondly, maintenance knowledge is often tacit. Thirdly, maintenance knowledge is constantly evolving due to technological advancements. Thus, a systematic and integrated approach to KM and KS is necessary to capture, codify, and transfer maintenance knowledge across organizational boundaries and ensure continuous improvement in maintenance practices.

In many industries, maintenance data is stored in a computerized maintenance management system (CMMS), a collection of software programs designed to aid in managing maintenance activities. CMMS programs help with tasks such as planning, scheduling, monitoring, controlling, reporting, and other administrative functions, making maintenance management more effective and efficient (Ben-Daya et al., 2016). The effectiveness of maintenance is partially dependent on the quality, timeliness, accuracy, and comprehensiveness of information related to the degradation state of machinery. Decisions regarding maintenance activities are made based on this information (Bjorling et al., 2013).

5.2.7. Necessity of KM and KS at maintenance

Maintenance departments in industries and service organizations increasingly rely on KS to enhance service quality and productivity (Aromaa et al., 2015). López-Ramos et al. (2019) found that traditional maintenance approaches do not have a specific mechanism to preserve knowledge, leading to experts reinventing past solutions instead of reusing their experiences to solve new problems. Although the maintenance process is often perceived as a routine activity that aims to reduce costs by mitigating the probability and risks of potential failures, it is, in

fact, a creative process that continuously generates new knowledge (López-Ramos et al., 2019). Due to the complexity of industrial maintenance systems and processes, a high level of expertise is required to ensure smooth operations. KS among maintenance personnel can help to ensure that this expertise is effectively utilized and disseminated across the organization and to prevent knowledge loss due to employee turnover or retirement. Research has found that KS can improve employee job satisfaction, motivation, and engagement (Kanawattanachai & Yoo, 2007).

Cárcel-Carrasco et al. (2020) noted that maintenance activities generate tacit knowledge based on experience at much higher levels than explicit knowledge and that this knowledge is often recorded in a fragmented manner. The valuable knowledge and experience related to maintenance activities held by employees is lost when they retire or leave the company, as it is not explicitly documented or transferred to the organization (Isworowati et al., 2019). The absence of a learning process in maintenance leads to knowledge loss and an increased reliance on a few experts and hinders the evolution of the maintenance process (López-Ramos et al., 2019). KM for maintenance activities suggests a shift from traditional maintenance to knowledge-based maintenance, also known as "K-Maintenance" (Mansor et al., 2012). The transfer of tacit knowledge within a maintenance organization can be facilitated through three essential KM steps, including capturing it, processing the collected information to make it appropriate for sharing, and communicating it effectively (Aromaa et al., 2015).

It has been recognized that one of the main ways to develop the competence of the maintenance workforce is by utilizing the accumulated knowledge and experience available within the company (Alsyouf, 2007). The maintenance workforces tend to accumulate valuable firm-specific knowledge from their years of experience working with equipment (Refaiy & Labib,

2009). In addition, many large companies have adopted CMMS to collect, store, and display maintenance-related data, and learn from experiences (Márquez, 2007). Despite the accumulation of formal data through CMMS, the practical use of reusing experiences reported by maintenance workers remains limited (Ruiz et al., 2014). During the problem-solving phase, organizations often rely on maintenance workers' descriptions and reports (Mannonen & Hölttä, 2013). Therefore, capturing and storing experiences in a manner that enables their reuse in the future for performing the appropriate maintenance actions at the appropriate time is crucial.

5.2.8. General and specific KM and KS barriers at maintenance

5.2.8.1. Potential general barriers

Despite the widespread adoption of KS practices, many companies have failed to manage their knowledge assets and skills effectively. One of the main reasons for this is the existence of numerous barriers to sharing, which can be highly diverse (Riege, 2005). Factors affecting KS have been classified into four categories: “individual”, “technological”, “organizational”, and “cultural” (Anwar et al., 2019). Some of the most significant general barriers to KM and KS are listed in Table 21.

Table 21: Potential general barriers to KM and KS. Source: (Riege, 2005).

Categories	Barriers
Individual barriers	Limited time to share knowledge. Fear of job security impact from KS. Communication gaps between knowledge holders and seekers. Weak oral, written, and interpersonal skills. Intellectual property ownership concerns. Trust issues lead to reluctance to share. Motivation lacking due to recognition or interest.
Organizational barriers	Lack of KM strategy. Missing motivating rewards system. Insufficient support in existing corporate culture. Low priority on retaining skilled staff knowledge. Lack of infrastructure for KS.
Technology barriers	Underutilized KS tools. Missing central knowledge repository.
Cultural barriers	Lack of trust hindering KS. Resistance to change impeding new KM tools. Inadequate recognition discouraging KS.

5.2.8.2. Specific KM and KS barriers at maintenance domain

Implementing KM can be difficult due to cultural resistance to change, and encouraging staff to share knowledge can be a significant challenge for organizations (Al-Hawamdeh, 2003). This is particularly the case in maintenance, where Chirumalla et al. (2015) have identified several specific barriers to KM and KS (Table 22).

Table 22: Specific barriers of KM and KS at maintenance. Source: (Chirumalla et al., 2015).

Item	Description
1	Reporting breakdowns without a standard language
2	Difficulty in searching for similar problems from different times
3	Lack of contextual information in after-action reports or descriptions
4	Challenges in codifying experiences or tacit knowledge
5	Low motivation to share experiences through documentation
6	Difficulty in educating and training novices
7	Different work styles and mindsets among employees

5.2.9. Knowledge hiding and hoarding at maintenance management

Despite the efforts to enhance knowledge transfer in maintenance, success has been elusive. It is becoming clear that in many instances, employees are unwilling to share their knowledge even when organizational practices are designed to facilitate transfer (Connelly et al., 2019). Knowledge withholding includes different types of counterproductive behaviors, such as hiding and hoarding. Clearly, interpersonal dynamics affect individuals' decisions to hide their knowledge. It is interesting to consider whether such decisions reflect an ongoing pattern of behavior. Given the need for KS within maintenance, knowledge hiding and hoarding are two types of counterproductive behavior that should be avoided (Evans et al., 2015). As knowledge means power, more job security and consequently more salary, at maintenance domain, knowledge hiding and hoarding are common problems which should be resolved.

5.2.10. Novices and new comers at maintenance

Maintenance professionals possess high qualifications and are skilled at resolving technical issues even in high-pressure situations (Cárcel-Carrasco et al., 2020). Losing these professionals means losing a valuable asset of the company (Cárcel-Carrasco et al., 2020). In order for organizations to gain a competitive advantage, it is not enough to simply depend on staffing and training systems that concentrate on selecting or developing employees with particular knowledge, skills, abilities, or competencies. While such systems are necessary, they alone do not suffice (Brown & Duguid, 1991). Maintenance technicians are required to be skilled workers since tasks are often technically challenging and safety-critical, with time pressure being a common occurrence, hence novice workers work with experienced coworkers in the beginning (Aromaa et al., 2016). Instead of relying solely on experts to produce quality content, it is better to combine content creation with community discussions involving both experts and novices (Hansen, 2006).

Hansen's (2006) comment is interesting, as it implies that novices can play some kind of more active role in KS. What role this might be, and how it can be developed and implemented, has not been addressed in previous research. Hence the current research has two research questions:

1. Can novices play a more active learning role in KM in maintenance environments?
2. How can such role be designed and implemented?

The existing literature offers some generic insights to respond the two questions above. For example, providing comprehensive training and support to novices, including hands-on experience with the equipment and systems they will be working with, is an interesting technique that triggers learning. Additionally, it is important to establish a culture of KS and mentorship within the maintenance team, so that experienced workers are encouraged to pass

on their knowledge and expertise to novices. Other specific strategies include the use of structured training programs, the development of knowledge repositories, the establishment of mentorship and coaching programs, and the use of technology to support KS.

Amongst these strategies and techniques, one of particular interest has been pinpointed by Cortese (2005), who suggests that one of the most effective ways to learn is by teaching the material to others. In the current case, this means that when novices take on the role of educators, then they are forced to organize and explain complex ideas, which deepens their understanding and retention of the material. This is the fundamental assumption of the current study, which furthermore was part of an action-research program called "Training by Novices." This is described in the next section.

5.3. Methodology

To embark on this transformative journey of enhancing KM and KS within the maintenance department, an action-research approach was crafted. Action research is a systematic approach to investigation that enables people to find effective solutions to problems they confront in their everyday lives (Stringer, 2007). Through action research, the researcher conducts experiments, implements changes, and observes the resulting outcomes (Saunders & Lewis, 2017).

The process had three phases. In the first one, a questionnaire was prepared to collect pre-change data. This survey was based on previous studies, and it comprised 66 closed-ended questions that were adapted from the following authors: Karamitri et al. (2020), Welschen (2014), Oyemomi (2017), and Fullwood (2014). . 103 valid answers were collected from a maintenance department in a high-tech company which had 1250 employees.

The second phase was the action one. Fourteen individuals, representing the novice segment, were entrusted with a unique challenge: to construct comprehensive training materials over an intensive two-month span. The scope of these materials was deliberately expansive, encompassing a range of formats spanning from Word documents, PDFs, PowerPoint presentations, and instructional videos. Novices were thoughtfully aided through meetings and coaches.

The meetings served as collaborative forums, designed to troubleshoot challenges, provide guidance, and harness the novices' untapped potential. The coaching required the direct involvement of sub-department managers, who were stimulating novices to create the teaching materials. In other words, the whole experiment phase of the action-research was based on the idea of triggering in novices the mindset and the responsibilities of educators, and not just learners. Accompanying the novices were subject matter experts, adept at their designated domains, imparting precision and depth to the knowledge dissemination process. During training sessions, experienced employees shared their expertise and provided feedback to novices in a semi-formal setting.

21.3% of employees who were aware of the program, were deliberately kept out of it to serve as a control group. This strategic exclusion facilitated a comparative analysis, enabling a robust assessment of the program's true impact on knowledge enhancement and sharing dynamics.

The final phase was the evaluation one. The aim of an evaluation is to appraise the outcomes and efficiency of a particular entity, often denoting an innovation, intervention, or practice (Robson & McCartan, 2016). This phase was similar to the first one, as it used the same survey to collect data on the same KM and KS variables. A few open questions were added to the survey, to allow exploration of participants' experiences. Through their narratives, participants

were invited to voice opinions on program intricacies, proffer suggestions for further refinement, and candidly reflect on barriers impeding effective KS.

In the quest for comprehensive insights, the evaluation phase further encompassed a nuanced examination of perceived knowledge improvement. Participants were encouraged to quantify the extent of their progress and illuminate the transformative journey they had undertaken. Crucially, the participants' inclinations toward future program involvement served as a litmus test of the program's resonance and efficacy. On top of this qualitative information, the quantitative data collected in phases 1 and 3 was the subject of descriptive statistics as well as of paired statistical comparison. This what can be called an holistic perspective in action-research as it provides not only quantifiable insights but also qualitative nuances (Robson & McCartan, 2016), offering a panoramic view of a program's impact as well as its evolving landscape.

5.4. Findings and discussion

The study classified participants based on their job level, educational background, and responsibilities. Its objective was to investigate the extent to which participants' knowledge improved during the program, as well as to determine the effectiveness of the program according to various participant categories. The study also examined whether participants from different categories agreed to extend the program. Additionally, the study explored the desired roles of participants in the program, such as teacher, learner, expert, or a combination of roles. Furthermore, the study investigated the problems that participants encountered with the program, their suggestions for improving it, and their opinions on the KS barriers they faced.

5.4.1. Improvement in knowledge

The findings show that 67% of learners who attended the program reported an improvement in their knowledge. In addition, 77% of experts and 90% of teachers reported an improvement in their knowledge. Overall, 71% of all participants reported an improvement in their knowledge, and the level of knowledge among participants in the program improved by 44.7%. All participants, regardless of their role (learner, expert, teacher (novice or newcomer)), reported an improvement in their knowledge as a result of their participation in the program. This is particularly noteworthy considering the short duration of the program and the fact that the training was provided by novices. Table 23 presents the percentage of participants who reported an improvement in their knowledge, categorized by the role they played in the program.

Table 23: Knowledge improvement base on the role in the program.

Role in the program	Learners	Experts	Teachers (novices and new comers)	Overall
Percentage of participants reporting improvement in knowledge	67%	77%	90%	71%

Table 24 displays the knowledge levels of participants in the taught topic before and after the training by novices. The table is categorized by education level and also presents the percentage of change in knowledge.

Table 24: Improvement in knowledge based on education level.

Education level	Diploma	Associate	Bachelor	Master	PhD	Overall statistics			
						Average	min	max	Std. Deviation
knowledge level prior to Program	3.53	3.39	3.52	2.5	6	3.44	1	7	1.48
knowledge level after program completion	5.3	5.09	4.86	4.82	7	4.98	2	7	1.23
Percentage of change	+50%	+50%	+38%	+92.8%	+16.6%	+44.75%			

Participants can be divided into two groups based on their managerial positions or responsibilities. Foremen, bosses, managers, and director hold managerial positions and can be considered in-charge, with an organizational attitude as they are responsible for others. Technicians and experts, on the other hand, do not hold positions of authority or responsibility for others, and may have their individual perspectives on the program. Table 25 illustrates the differences in knowledge between these two groups before and after the program.

Table 25: Improvement in knowledge based on responsibility.

Responsibility	Not-in-charges (technicians and experts) - individual view	In-charges (foremen, bosses, managers and director) - organizational view
Knowledge level prior to program (scored out of 7)	3.30	4.12
Knowledge level after program completion (scored out of 7)	4.87	5.43
Percentage of change	+47.5%	+31.7%

The results of the study suggest that employees who are not in-charge but have a personal interest in the topic, experienced a greater increase in knowledge compared to those in managerial positions who have both individual and organizational interests.

5.4.2. Effectiveness of the program (training by novices)

Participants were asked to provide feedback on the effectiveness of the program. Table 26 displays the effectiveness of the program based on the job level of the participants, while Table 27 presents the effectiveness of the program based on their education level.

Table 26: Effectiveness of program based on job level (position).

Job level (position)	Technician	Foreman	Expert	Boss	Manager	Director	overall
Percentage of participants who found the program effective	55.1%	80 %	57.1%	62.5%	100%	100%	58.5%

Table27: Effectiveness of program based on education.

Education level	Diploma	Associate	Bachelor	Master	PhD
Percentage of participants who found the program effective	63.6%	56.3%	56.4%	60%	100%

5.4.3. Agree to extend (continuation of) the program

Participants were asked another question regarding their agreement with extending the program. Table 28 shows the percentage of participants who agreed with extending the program based on their job level (position), while Table 29 presents the percentage of those who agreed based on their education levels.

Table 28: Agree to extend the program based on position.

Job level (Position)	Technician	Forman	Expert	Boss	Manager	Director	Overall
Agree to extend the program	56.5%	60%	57.1%	62.5%	100%	100%	58%

Table 29: Agree to continue the program based on education

Education level	Diploma	Associate	Bachelor	Master	PhD
Agree to continue the program	77.3%	59.4%	48.7%	40%	100%

5.4.4. Problems of the program

The study also identified several problems with the program as reported by participants. The most frequently reported problems (table 30) were related to the lack of experience and expertise of trainers, insufficient time allocated for preparation and presentation of materials, and a lack of motivation among participants. In the table "number of comments" reflects the frequency of specific suggestions or ideas voiced by participants in response to open-ended questions. Recurring themes were identified by analyzing participants' responses thematically and counting similar comments.

Table 30: Ranking of problems of program.

Item	Comment	Number of comments
1	Not allocating enough time to prepare training materials	13
2	Lack of sufficient expertise among trainers in presenting course materials and conducting classes	9
3	Conducting a large number of training sessions in a short period of time	8
4	Incomplete mastery of the subject matter by the trainer	7
5	Allocating insufficient and compressed time for presenting the materials	7
6	Time conflict between KS program and other work-related duties and responsibilities of personnel	6
7	Insufficient time to prepare the materials by trainers	6
8	Lack of sufficient information in internet regarding maintenance	5
9	Failure to allocate rewards or incentives for the trainer	4

Alongside the highly-voted comments, there are a few specific comments that are novel and worth considering, which have been presented in Table 31.

Table 31: Specific mentioned problems.

Item	Comment	Number of comments
1	Not recording the conducted classes	1
2	Lack of competition for learning in training courses	1
3	Lack of a responsible person for planning, monitoring, and conducting training courses	1

5.4.5. Recommendations for improvement: insights from study participants

The study has identified specific suggestions for improving the program. These suggestions are presented in Table 32.

Table 32: Recommendations of study participants for improving the program.

Item	Suggestion	Number of comments
1	Training is better off being conducted by experienced individuals	23
2	It is better to have a system in place that creates motivation for participation in this program	18
3	The content of educational courses should be more practical than theoretical	17
4	Using external experts for training	10
5	The 'training by novices' program should continue	10
6	Allocating sufficient time for participation in the program by the supervisor	8
7	Establishing a connection between job promotion and participation in KS	6

Similar to the problems identified in the program, maintenance employees have provided some suggestions with a relatively low number of votes, yet they are considered valuable and worth exploring. These suggestions are presented in Table 33.

Table33 : Specific suggestions.

Item	Description	Number of comments
1	The training course should be held by an inexperienced individual with the participation of an experienced person	4
2	To improve the effectiveness of the courses, participants should be tested	3
3	Validation of experienced individuals on the educational materials prepared before conducting the training	3
4	Creating a wiki file of the educational materials prepared and editing and completing it by other colleagues	2
5	Confirmation of the content outline by experienced individuals before the preparation of the materials by less experienced individuals	1
6	Two inexperienced instructors conducting the training together	1

5.4.6. Identifying barriers to KS in maintenance: insights from participant feedback

The study also found several barriers to KS among employees (table 34).

Table 34: KS barriers in maintenance: insights from participant feedback.

Item	Description	Number of comments
1	Lack of sufficient time for KS due to a high workload	30
2	Lack of sufficient motivation to participate in KS	16
3	Shortage of knowledge resources in the field of maintenance	9
4	Lack of support from management	5
5	Wide variety of topics in the field of maintenance and the inability to focus on limited areas	5
6	Lack of interest among personnel in teaching and learning	4
7	Lack of suitable and sufficient hardware infrastructure	4
8	Fear of losing job position in case of sharing and transferring knowledge to others	4
9	Insufficient allocation of time for KS	4
10	Lack of immediate impact of KS on personnel's job promotion	5
11	Lack of a formal KM plan	3
12	Lack of KM software	3
13	Lack of connection between personnel's salary and their knowledge	3
14	Lack of immediate rewards for KS	2
15	Fear of sharing knowledge due to lack of confidence in the accuracy of information	2
16	Lack of trust and sincere communication among colleagues	1
17	False confidence of low-skilled individuals and overestimating their current knowledge	1
18	Knowledge is power	1
19	Unhealthy competition among employees	1
20	monopolizing knowledge and not sharing it with others	1
21	Social loafing	1
22	Fear of revealing one's specialties and abilities, and as a result, assigning more work to skilled and capable personnel.	1

5.4.7. Other findings

Based on the reported statistical test, the findings of this study indicate that the program has resulted in a modest increase of 3.9% in KS among participants. Additionally, the participants'

perception of the culture of KS has increased by 4.6%, but statistically, the difference is not significant. Interestingly, the control group, who did not participate but were aware of the program, reported an increase in barriers to KS by 12.3%. These results suggest that while the program may have had some positive impact on KS, it may also have inadvertently created new barriers for non-participants. Additionally, this implies that the control group, who did not partake in the program, is anticipated to become engaged in the program and perceive it as a facilitator of KS among their colleagues despite their non-participation. Furthermore, they may also perceive that barriers to KS have increased for them.

5.5. Discussion and conclusion

KM is an essential aspect of organizational growth and development. Various studies have examined the topic of KM in different industrial and service sectors. But the importance of KM within maintenance units of companies is often overlooked. Implementing effective KM strategies in maintenance departments can be challenging (Cárcel-Carrasco et al., 2020) due to the technicians' reliance on their experience rather than sharing and explaining their knowledge.

One of the most effective ways to learn is by adopting a mindset that allows the learner to teach the material to others. This approach not only helps learners to deepen their understanding of the subject matter, but also helps them to retain the information more effectively. When learners attempt to teach a concept to someone else, they must organize the material in a way that is easy to understand and follow. This process forces them to break down complex ideas into simple, digestible parts and helps them identify gaps in their knowledge or areas where they need more practice. Moreover, teaching others also requires learners to think critically about the material and consider different perspectives and approaches to the subject matter. By doing

so, they gain a more comprehensive understanding of the material and are better equipped to apply their knowledge in practical settings (Cortese, 2005).

Utilizing novices and newcomers as trainers in an industrial maintenance setting has proven to effectively enhance KM and KS among colleagues. Despite being conducted by novices, the training has resulted in a significant increase in knowledge for experts, learners, and novices alike, specifically in the area being taught. The high levels of reported knowledge improvement among learners, experts, and teachers (67%, 77%, and 90%, respectively) suggest that this approach has been practical for a wide range of participants, regardless of their experience level. This approach can foster a culture of continuous learning and development, where all employees are empowered to share their knowledge and expertise.

Moreover, the increase in knowledge is substantial, even though the training was conducted over a short period. The findings of this study demonstrate that this approach has resulted in noteworthy improvements in the participants' knowledge, with an overall increase of 44.7% in KS. This suggests that this approach may be particularly beneficial for organizations that are looking to support the onboarding and development of their new employees. It is also important that most participants preferred to have the role of learner, indicating a need for further investigation to change their attitudes and make them more willing to take on other roles.

Although the increase in KS and culture of KS was not statistically significant, participants reported finding the program effective and agreed to continue it. As KS is a cultural and multidimensional subject, longer-term implementation of the program may be needed for more significant improvement in KS and its culture. Overall, this study has demonstrated the potential benefits of using novices and newcomers as trainers in an industrial maintenance

setting. By embracing this approach, organizations can enhance their KM and KS practices, promote a culture of continuous learning, and support the development of their employees.

The findings of this study show that there are several factors that influence KS in an industrial maintenance setting, including lack of time, lack of motivation, shortage of knowledge resources, and lack of support from management. These barriers can be overcome through various strategies, such as creating a formal KM plan, providing adequate hardware and software infrastructure, allocating sufficient time for KS, and establishing a connection between salary and KS.

This study aimed to answer two primary research questions: Can novices play a more active learning role in KM in maintenance environments? Moreover, how can such a role be designed and implemented? The findings suggest that novices can take a more active role in KM by serving as trainers, enhancing their understanding and retention of material while motivating experienced employees to share their knowledge. The "training by novices" program demonstrated that structured involvement of novices in KS activities not only improves their skills but also fosters a culture of continuous learning and collaboration.

In conclusion, the findings of this study indicate that "training by novices" programs can enhance the knowledge and skills of maintenance employees. Furthermore, the fact that novices were the target group of this study and that they have shown significant improvement in their knowledge and skills through the program is a positive sign. This suggests that the program has been effective in bridging the knowledge gap between experienced and less experienced personnel.

By implementing effective KS practices and strategies, organizations can create a culture of continuous learning and improvement, which can lead to better performance and efficiency. It

is recommended that organizations continue to invest in KS programs and make efforts to address the barriers to KS identified in this study. By doing so, they can create a competitive advantage for themselves and achieve long-term success.

The limitations of the study are several. Firstly, selection bias due to the research being conducted within a single high-tech company's maintenance department, which may not represent other industries or companies. To mitigate this, future research should include other companies and industries. Response bias is another concern, as participants might provide socially desirable answers or overstate the effectiveness of knowledge-sharing initiatives. Researcher bias was also an issue in the current investigation, due to the close interactions between researchers and participants. This was tackled by involving multiple researchers and incorporating peer reviews to maintain objectivity. Finally, sample size and diversity bias might occur if the sample is too small or homogenous, failing to capture a full range of perspectives and experiences. To reduce this limitation, participants from various roles and experience levels were included. Regarding managerial implications, the approach used in the paper is useful to empower novices by shifting them from the passive side of KM and KS to the active side, while also increasing the knowledge of their employees and enhancing KS.

While the results of this study are promising, there are still areas for future research. One key area for future research is to investigate how to extend this approach to other departments and larger organizations and explore the potential barriers to implementing this approach on a larger scale. Additionally, more research is needed to explore the long-term impact of this approach on employee development and organizational performance. Also in order to advance this research further, future studies could focus on identifying the issues or limitations of the program. This could be achieved through conducting interviews or questionnaires with

participants to gather feedback and suggestions for improvement. Additionally, exploring the long-term effectiveness and sustainability of the program could also be a valuable area for future research.

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CHAPTER 6 (Study 4): Innovative Approaches to Knowledge Management: The Role of Novices in Knowledge-Intensive Maintenance Environments

Hamid Roham, Jorge F.S. Gomes

This study was accepted and presented at the 7th European Conference on Industrial Engineering and Operations Management, which took place in Augsburg, Germany, from July 16-18, 2024, and was published in the conference proceedings.

Furthermore, the paper earned first place in the doctoral dissertation competition at the conference.

Abstract

In knowledge-intensive industries, effective management and sharing of knowledge within maintenance departments are critical for operational success. This paper presents an innovative approach to knowledge management (KM) and knowledge sharing (KS) by harnessing the untapped potential of novices within maintenance departments. In this study, novices were empowered to transition from passive participants to active facilitators of KS by undertaking the task of training experienced colleagues, aiming to bridge the gap between passive knowledge absorption and active participation. The study also investigates the impact of individual factors and organizational factors on KS within maintenance departments of a knowledge-intensive industry, considering the moderating effect of "training by novices."

The study used a questionnaire to assess various dimensions of KM and KS, administered to maintenance department personnel. Concurrently, novices played a pivotal role in developing extensive training materials over a one-year period, supported by collaborative sessions with seasoned experts. The program's impact was evaluated through a combination of closed-ended and open-ended questions, exploring participants' experiences and perceptions.

Findings revealed a transformation in KM and KS dynamics, highlighting the effectiveness of engaging novices as facilitators in driving KS within the maintenance department. This study provides empirical insights into the role of novices in enhancing KM and KS practices and offers recommendations for organizations seeking to harness the untapped potential of their workforce in driving innovation and efficiency.

Furthermore, the study proposes a conceptual model that illustrates how training by novices moderates the impact of influencing factors on KS within maintenance departments of knowledge-intensive industries. The study contributes to the evolving discourse on knowledge

dynamics within industries, advocating for inclusive strategies that harness the diverse expertise of all personnel in driving organizational innovation and efficiency.

Keywords: Knowledge management, knowledge sharing, industrial maintenance, knowledge-intensive companies, novices.

6.1. Introduction

In the ever-evolving landscape of knowledge-intensive industries, where knowledge and expertise are central to organizational competitiveness, to effectively manage and share knowledge within maintenance departments is widely acknowledged. KM is a process that involves creating, generating, capturing, storing, sharing, and using knowledge to support and improve individual performance (Ismail & Yusof, 2010). KS stands out as the most vital process among all KM initiatives. KS occurs when members of an organization exchange information, ideas, suggestions, and expertise among themselves (Bartol & Srivastava, 2002). The literature underscores the pivotal role of KM and KS in fostering innovation, improving operational efficiency, and ensuring adaptability in the face of industry dynamism. Organizations are increasingly acknowledging the necessity to transcend conventional paradigms, adopting more inclusive strategies to leverage the diverse knowledge resources within their workforce.

Maintenance stands as one of the pivotal departments within knowledge-intensive industries. Maintenance is defined as "the combination of all of technical, administrative and managerial actions performed during life cycle of an item intended to retain it in, or restore it to, a state in which it can perform the required function" (Márquez, 2007).

Traditional models of KM and KS have historically favored top-down approaches, often neglecting the potential contributions of personnel at various levels, particularly novices. While novices have traditionally been seen as passive knowledge consumers, recent studies advocate for a fundamental reassessment of their potential contributions (Gomes & Roham, 2023). The idea behind such proposal suggests that novices, with their fresh perspectives and unbridled curiosity, can actively participate and even facilitate the intricate processes of KM and KS. In

fact, although the existing literature emphasizes the challenges faced by novices, such as the limited access to tacit knowledge, the fact is that such challenges also underscore the need for innovative strategies that empower novices not only to absorb knowledge but also to actively engage in its creation and dissemination.

This paper contributes to the existing literature by presenting a program focused on engaging novices as facilitators in KM and KS initiatives within maintenance departments. By recognizing and harnessing the unique qualities of novices, the study aims to bridge theoretical concepts with practical implementation, exploring the tangible implications of such an approach in real organizational settings. Furthermore, this study introduces a conceptual model that elucidates how training by novices moderates the relationship between individual factors and organizational factors with KS within maintenance departments of knowledge-intensive industries.

In summary, this study lays the groundwork for a comprehensive exploration of the transformative potential inherent in engaging novices as active contributors to KM and KS. As organizations navigate the complexities of knowledge-intensive industries, understanding and leveraging the diverse expertise within their workforce emerges as a strategic imperative for sustained innovation and operational excellence.

6.2. Literature review

6.2.1. Introduction

An organization's performance is intricately tied to the utilization of its resources and the contextual characteristics of its environment Liebowitz and Frank (2016), and these resources encompass four fundamental types: human, material, financial, and knowledge. Bennet and

Bennet (2004) define knowledge as the capacity, whether in its potential or actual form to undertake effective actions in diverse and uncertain situations. The relevance and importance of knowledge is becoming increasingly critical in business as we transit from an industrial era into an information and knowledge era (Schwartz, 2005). KM is an attempt to spread useful knowledge in the organization (McInerney & Koenig, 2011) and could simply be defined as "doing what is needed to get the most out of knowledge resources" (Becerra-Fernandez & Sabherwal, 2014).

Knowledge-intensive industries are characterized by sectors in which the generation, application, and management of specialized knowledge play a central role in organizational activities and competitiveness. The contemporary landscape of knowledge-intensive industries underscores the pivotal role played by KM and KS in sustaining operational success. As organizations grapple with the complexities of managing and disseminating knowledge, the importance of effective KM and KS has become increasingly evident. A significant challenge faced by knowledge-intensive firms arises when employees possessing substantial knowledge depart from the organization (Rybo Molin & DAHLBERG, 2018).

Researchers in the past decades have introduced several KM processes, encompassing activities associated with both tacit and explicit knowledge. These processes include discovering, capturing, sharing, and applying knowledge to enhance organizational effectiveness in a cost-effective manner (Wong et al., 2015). The dissemination of knowledge involves the communication of explicit or tacit knowledge to other individuals. Knowledge transfer and sharing within the entire organization occur through activities such as attending seminars, workshops, and assigning mentors to new recruits, as outlined by Wong et al. (2015).

The success of KM initiatives is intricately tied to and is contingent upon KS (Wang and Noe (2010). It can be posited that KS constitutes a critical component of KM. The increasing focus on KS in both research and practice is attributed to its potential benefits for individuals and organizations, as highlighted by Yi (2009). When individuals provide any part of their knowledge to others, they are involved in KS (Bartol & Srivastava, 2002). KS represents a social activity that occurs within a system where knowledge represents a resource that has a value (Rolfsen, 2013).

Attaining a competitive advantage necessitates more than relying on staffing and training systems that emphasize the selection or acquisition of specific knowledge, skills, abilities, or competencies among employees (Brown & Duguid, 1991). Organizations must also address the crucial aspect of transferring expertise and knowledge from experienced experts to novices who require this knowledge (Hinds et al. (2001).

Organizations must prioritize and enhance the utilization of knowledge-based resources already present within the organization (Damodaran & Olphert, 2000). Among knowledge-centered activities, KS stands out as a fundamental means through which employees can actively contribute to knowledge application, foster innovation, and ultimately contribute to the organization's competitive advantage (Jackson et al., 2006). Effective KS among employees, both within and across teams, enables organizations to exploit and capitalize on their knowledge-based resources (Cabrera & Cabrera, 2005). Extensive research has showed a positive correlation between KS and various beneficial outcomes, including reductions in production costs, accelerated completion of new product development projects, improved team performance, enhanced firm innovation capabilities, and overall firm performance metrics such

as sales growth and revenue from new products and services (Mesmer-Magnus & DeChurch, 2009).

6.2.2. KS tools and techniques

According to Zheng (2017), the fundamental characteristics of KS encompass several key elements: 1) KS is regarded as a primary individual behavior; 2) it is characterized by voluntary and proactive behavioral engagement; 3) KS is influenced by environmental systems or procedures, such as legal and ethical standards, codes of conduct, and habitual practices; and 4) the outcome of KS results in shared possession by two or more parties. KS can occur through written correspondence or face-to-face communications, facilitated by networking with other experts, or through documenting, organizing, and capturing knowledge for others (Cummings, 2004). Some common KS tools include:

- **Formal Training:** Involves standardized training content for all team members and is used to share explicit knowledge verbally or visually.
- **Written Reports:** Used to document explicit knowledge in either hardcopy or softcopy format.
- **Periodic Meetings and Workshops:** Serve as traditional forums where individuals or team members convene in a designated space to engage in face-to-face discussions, facilitating the exchange of knowledge.
- **Mentoring and Coaching Programs:** Serve as effective management tools that support interpersonal processes and direct interactions among team members to reinforce KS.

- Face-to-Face Interaction: Involves personal communication through verbal and body language discussions.
- KS Systems: Refer to Information Technology that supports KM activities, such as video conferencing, groupware, and online communities.
- Email: One of the most widely used techniques for KS within organizations, both internally and externally.
- Cloud Computing: A modern technology providing large data centers that enable users to access data from anywhere.

6.2.3. Factors affecting KS

Previous research has identified over 40 factors that potentially influence KS. The most significant ones are outlined below.

Organizational culture

A frequently emphasized essential component of KS is culture. Goodman (2007) recognizes culture as a factor that promotes KS within an organization. This knowledge culture should be integrated into the routine operations of the organization, permeating every aspect of the business. The shared values, beliefs, and standards that constitute organizational culture play a crucial role in knowledge exchange (Lee & Ahn, 2007). A culture that promotes KS contributes to an efficient KM network, fostering an environment where KS is viewed as a constructive part of the organizational ethos (Al-Alawi et al., 2007). Organizational cultural elements emerge as pivotal in facilitating the exchange of valuable knowledge, emphasizing the significance of a supportive cultural foundation for effective KS (Søndergaard et al., 2007).

Enhanced reputation

Enhanced reputation appears to be a significant extrinsic motivator for KS (Kankanhalli et al., 2005). A positive reputation serves as a crucial asset for employees, earning them respect and proving vital for job security and advancement (Kankanhalli et al., 2005). Studies indicate that KS can be driven by a desire for peer recognition, as employees perceive that sharing valuable knowledge enhances their workplace reputation (O'Dell et al., 1998). The notion that sharing knowledge can bolster one's reputation within the workplace serves as a motivating factor for individuals.

Extrinsic motivation

Extrinsic motivation for behavior is grounded in the prospect of obtaining an external outcome from engaging in the activity. The outcome serves as the primary driver for participating in the behavior (Ryan & Deci, 2000). Within the context of KS, an "external outcome" refers to the perceived external benefits individuals can gain from participating in KS. Thus, specifically, extrinsic motivation entails individuals being driven to share knowledge based on their perceptions of the external benefits they can obtain, such as tangible rewards (e.g., money, promotion, job security), reciprocal relationships (Bock et al., 2005), verbal rewards (e.g., feedback, praise; (Michailova & Husted, 2002), and enhanced reputation (Wasko & Faraj, 2005). Extrinsic motivation is considered important in motivating employees to perform in a coordinated and goal-oriented manner (Osterloh & Frey, 2000).

Anticipated reciprocal relationships

When individuals perceive that engaging in KS can enhance their interpersonal connections, they are more inclined to develop favorable attitudes toward sharing. Empirical evidence indicates a positive correlation between anticipated reciprocal relationships and attitudes

toward KS. A study using the "Theory of Reasoned Action" explored how social capital influences organizational KS (Chow & Chan, 2008), and found that social capital, particularly social and network relations, positively influences attitudes toward KS. This conclusion aligns with prior research by (Bock et al., 2005) and (Lin, 2007), which also identified the positive impact of anticipated reciprocal relationships on attitudes toward KS.

Intrinsic motivation

In the realm of research on KS behavior, intrinsic motivation has increasingly captured attention, with its significance firmly established in prior studies (Foss et al., 2009). While intrinsic motivation is not a new concept within the KS literature, several studies have delved into its impact on KS. For example, Gagné (2009) conducted a conceptual inquiry linking need satisfaction with employee attitudes and intentions regarding KS. Moreover, empirical investigations have incorporated intrinsic motivation into KS models, with some studies treating it as a unified construct. For instance, Foss et al. (2009) developed and validated a model to explore the influence of intrinsic and extrinsic motivation on employee KS behavior, revealing a significant effect of intrinsic motivation on both knowledge dissemination and reception.

Intention to share knowledge

Intention refers to an individual's subjective likelihood of engaging in specific behaviors (Alajmi, 2012). Ajzen and Fishbein (1975) suggest that intention reflects the motivational aspects shaping behaviors, indicating an individual's willingness and readiness to act. Therefore, an individual's intention to share knowledge significantly influences their actual behavior of sharing knowledge with others. Studies indicate that the most effective way to forecast whether an individual will engage in a particular behavior is by assessing their

intention to do so (Ajzen & Fishbein, 1975). However, the intention to share knowledge may not always translate into actual KS behavior unless appropriate external controls or stimuli are considered (Yang & Farn, 2009). They also found that trust based on affect can enhance employees' inclination to share tacit knowledge, particularly within an informal environment.

Expected reward and association

In accordance with economic exchange theory, individuals act based on rational self-interest. Consequently, KS is expected to take place when the perceived rewards align with expectations (Kuo, 2013). These rewards may encompass both monetary incentives, such as profit sharing and bonuses, as well as non-monetary rewards like paid time off. Numerous studies have shown that incentives play a significant role in influencing knowledge-sharing behaviors (Jahani et al., 2011). However, while certain researchers have posited that rewards linked to KS positively impact individual knowledge contributions within organizations (Bartol & Srivastava, 2002), others, like Osterloh and Frey (2000), have suggested that intrinsic motivations are more potent drivers of KS compared to extrinsic incentives such as monetary or administrative rewards. These viewpoints warrant further exploration into the influence of rewards on KS within organizations.

Attitude toward KS

Attitude is recognized as a fundamental factor shaping behavior. Defined as "a person's favorable or unfavorable evaluation of an object" (Ajzen & Fishbein, 1975), attitude represents a general predisposition that influences one's intention to engage in specific behaviors (Ajzen & Fishbein, 1988). According to Ajzen and Fishbein (1975), the strength of this intention hinges on an individual's subjective probability of performing the behavior. The relationship between attitude toward KS and the intention to share knowledge has been substantiated by the

Theory of Reasoned Action (Ajzen & Fishbein, 1975), as well as in various studies exploring KS dynamics (Welschen et al., 2012). For instance, Welschen et al. (2012) identified positive associations between favorable attitudes toward KS and intentions to share knowledge.

6.2.4. Challenges in achieving optimal KS

While the significance of KS is widely acknowledged, organizations encounter persistent challenges in fostering a culture of openness and collaboration. The unwillingness of employees to engage in KS poses a substantial hurdle. Employees might experience anxiety about relinquishing ownership of their personal knowledge (Paulin & Suneson, 2015). According to Riege (2005), a significant impediment to implementing effective KM and KS is individuals' reluctance to share, rooted in their inclination to guard what they know as a form of personal intellectual property.

Unraveling this challenge necessitates an exploration of why, despite the acknowledged significance of KS, individuals remain hesitant. According to Pilsmo (2010), for knowledge-intensive businesses, navigating this challenge is complicated by individuals' innate survival instinct. KS is perceived as contradictory to human nature, creating a paradox where withholding information is deemed more advantageous than sharing, leading to a power struggle (Dunford, 2000). Additionally, the potential for inducing conflicts of interest further complicates the landscape of KS (Matzler et al., 2011).

Bock et al. (2005) identify this as a fundamental challenge in the KM process, highlighting the difficulty in motivating people to share their knowledge, citing factors such as the perceived scarcity and financial value of knowledge. Numerous examples exist where KS practices have not accomplished their objectives to manage companies' knowledge assets and skills, mainly

due to the large diversity of potential sharing barriers (Riege, 2005). Moreover, factors at both the individual and organizational levels, such as the fear of job loss, lack of trust in colleagues, and pursuit of personal gain, often serve as drivers behind the reluctance to share knowledge. Therefore, organizations must address these challenges to overcome these barriers and facilitate effective KS.

According to Virtanen (2011), two crucial aspects of the KS process involve externalization of knowledge through organizational resources and its subsequent internalization by the recipient, both of which should be considered and facilitated for successful KS. From an economic standpoint, the value of knowledge is contingent upon its scarcity, with individuals holding critical knowledge reaping benefits. Riege (2005) contends that experts should freely share their knowledge for the overall advancement of the organization, emphasizing the potential benefits for both the organization and the individual expert. Azeem et al. (2021) underscore the necessity of giving more attention to the KS process, emphasizing that without sharing, organizations may encounter challenges, highlighting the imperative of sharing and disseminating knowledge for organizational prosperity.

6.2.5. KM and KS at maintenance

Within the dynamic landscape of knowledge-intensive industries, the efficacy of KM and KS is pivotal. Maintenance tasks often encompass a range of diverse and non-standardized activities across different systems, necessitating a variety of skills and competencies to diagnose and address issues effectively (Chirumalla et al., 2015). Within knowledge-intensive maintenance departments, the exigency of effective KM and KS is amplified. The intricate and dynamic nature of maintenance operations necessitates a robust framework for handling and

sharing knowledge. Within maintenance activities, organizations face not only the typical barriers to KM and KS but also a series of distinct challenges specific to this field. The complexity of maintenance processes encounters a notable obstacle: employee resistance to KS. As highlighted by Abdullah et al. (2009), this reluctance emerges as a significant barrier, acknowledged as one of the most challenging issues in KM. Encouraging staff to share knowledge stands as a paramount challenge for many organizations (Al-Hawamdeh, 2003). Nevertheless, despite the acknowledged significance of KM and KS, numerous organizations encounter challenges in implementing efficient KS practices, especially with regard to novice or inexperienced employees (Gomes & Roham, 2023). Effective KM and KS practices become paramount in ensuring the seamless functioning of maintenance activities, minimizing downtime, and optimizing resource allocation.

6.2.6. Role of novices in KM and KS

Research on KS underscores the importance of organizations comprehending the process of transferring expertise and knowledge from knowledgeable experts to novices who require such knowledge (Wang & Noe, 2010). A novice is defined as a learner with no prior experience, causing them to struggle with determining which tasks are most relevant to accomplish. The novice learns and develops skills by receiving instructions from someone more knowledgeable on how to perform specific actions (Benner, 1984). The expansive part of KM involves training novices to become competent members of the activity, as it is routinely carried out (Boer, 2005). Novices in maintenance are confronted with the demanding task of navigating dynamic and constantly evolving environments, posing obstacles to their acquisition of pertinent job-related knowledge. The ever-changing nature of their work exposes them to diverse situations

and challenges, further complicating their learning process. Additionally, novices in maintenance may encounter difficulties in KS, as seasoned workers may exhibit reluctance to impart their expertise. Consequently, novices may find themselves lacking the guidance or mentorship of experienced colleagues, necessitating them to navigate their learning journey independently. While traditional perspectives might view novices as passive recipients, contemporary literature highlights their potential as active contributors to the knowledge ecosystem (Gomes & Roham, 2023). Novices with their fresh perspectives and eagerness to learn, can influence organizational learning processes.

6.2.7. Rationale for leveraging novices as facilitators

Maintenance managers grapple with the task of transferring expertise and knowledge from seasoned professionals to novices (Hinds et al., 2001). Yet, the strategies for conveying and managing this knowledge often rely on tacit knowledge acquired by maintenance staff, which poses challenges for documentation and analysis (Cárcel-Carrasco et al., 2020). KS remains uncommon in many organizations, particularly within the context of maintenance operations. Recognizing and mitigating the educational and training gaps among novices is widely acknowledged as a critical challenge hindering KS within maintenance contexts (Chirumalla et al., 2015). To address the challenges posed by KS, there is a growing rationale for exploring innovative approaches. Leveraging novices as facilitators emerges as a compelling strategy. The unique perspectives, fresh insights, and enthusiasm of novices present an untapped resource that can potentially transform the dynamics of KS.

6.2.8. Addressing KM and KS gaps: leveraging novices

A critical analysis of the current literature on KM and KS has uncovered significant gaps and unexplored territories within this domain, emphasizing the pressing need for research to bridge these deficiencies. These identified gaps underscore the urgency of leveraging novices as facilitators in knowledge-intensive maintenance departments through the application of quantitative methodology. This approach seeks to introduce innovative insights and methodologies, ultimately aiming to revolutionize the landscape of KM and KS practices within organizations. Through quantitative research method, these gaps can be effectively addressed, fostering a culture of continuous learning and improvement.

6.2.9. Summary

In conclusion, the literature review establishes a solid foundation by encapsulating the rationale, theoretical foundations, and gaps in existing literature, setting the stage for the subsequent methodology section. This comprehensive understanding of KM, KS, and the potential role of novices as facilitators underscores the need for a focused quantitative research approach in knowledge-intensive maintenance departments. The exploration of theoretical frameworks, development of a conceptual model, and identification of gaps contribute to a nuanced perspective that underpins the proposed quantitative research.

6.3. Method

This section elucidates the research design and approach employed in this study to provide insight into the systematic process undertaken. It outlines the steps taken to address the research

questions, emphasizing a quantitative research methodology for a thorough examination. Specifically, this study aims to investigate the utilization of novices as facilitators in KM and KS within maintenance departments, and to explore how they moderate the relationship between influencing factors affecting KS in knowledge-intensive maintenance departments.

Research design

The research design of this paper involves investigating factors influencing KS in maintenance departments of knowledge-intensive companies. It utilizes quantitative approach to provide a comprehensive understanding by taking following steps:

6.3.1. Literature review and theoretical framework

A comprehensive literature review was conducted to identify existing theories and concepts related to KM, KS, and the role of novices in organizational learning. Theoretical frameworks from literature were synthesized to inform the development of the conceptual model, ensuring a robust foundation for the study.

6.3.2. Variables and questionnaire development

During the initial phase, an extensive literature review informed the selection of 14 scales. The construction of the questionnaire was guided by prominent references, including Fullwood (2014), Karamitri et al. (2020), Oyemomi (2017), and Welschen (2014). By leveraging the expertise and findings from these sources, the questionnaire was crafted to capture essential aspects relevant to the research objectives. The incorporation of insights from these reputable references ensures a robust and well-founded instrument for data collection in this study.

Following the research, those that were uncorrelated were omitted, leaving 8 independent, one moderator, and one dependent variable. These variables, which have been described in the literature review, are presented in Table 35.

Table 35: variables.

Variable	Number of items	Reference
Intrinsic motivation	4	(Karamitri et al., 2020)
Attitude towards KS	4	(Fullwood, 2014)
Intention to share knowledge	4	(Fullwood, 2014)
Culture	5	(Oyemomi, 2017)
Extrinsic motivation	4	(Karamitri et al., 2020)
Expected rewards and associations	5	(Fullwood, 2014)
Anticipated reciprocal relationships	3	(Welschen, 2014)
Reputation	3	(Welschen, 2014)
Training by novices	1	(Gomes & Roham, 2023)
KS	11	(Oyemomi, 2017)

6.3.4. Research questions

Before delving into the specific inquiries driving this study, it is paramount to establish the broader context in which KS operates within maintenance departments. As organizations increasingly recognize the pivotal role of KM in sustaining operational efficiency, it becomes imperative to dissect the multifaceted factors influencing KS practices. In this section, we embark on a journey through the research questions guiding our investigation, aiming to unravel the intricate interplay between individual attributes, organizational structures, and the transformative potential of novel training approaches led by novices.

Question 1: What are the key factors influencing KS within knowledge-intensive maintenance domains?

Question 2: How does the involvement of novices in training impact and facilitate KS within knowledge-intensive maintenance domains?

Question 3: What is the relationship between the effectiveness of "training by novices" and the influence of various factors on KS behaviors within knowledge-intensive maintenance contexts?

6.3.5. Hypothesis

In formulating the hypotheses for this study, a comprehensive examination of the research questions and the underlying theoretical framework has led to the articulation of the following hypotheses. These hypotheses serve as the structured propositions that guide the empirical investigation, providing a clear and testable framework for exploring the intricate dynamics of KS within knowledge-intensive maintenance departments.

Hypothesis related to factors which influence KS in maintenance context:

H1: There is a positive relationship between intrinsic motivation and KS within the knowledge-intensive industrial maintenance domain.

H2: There is a positive relationship between attitude towards KS and KS within the knowledge-intensive industrial maintenance domain.

H3: There is a positive relationship between intention to share knowledge and KS within the knowledge-intensive industrial maintenance domain.

H4: There is a positive relationship between Culture and KS within the knowledge-intensive industrial maintenance domain.

H5: There is a positive relationship between extrinsic motivation and KS within the knowledge-intensive industrial maintenance domain.

H6: There is a positive relationship between expected rewards and associations and KS within the knowledge-intensive industrial maintenance domain.

H7: There is a positive relationship between anticipated reciprocal relationships and KS within the knowledge-intensive industrial maintenance domain.

H8: There is a positive relationship between reputation and KS within the knowledge-intensive industrial maintenance domain.

H9: There is a positive relationship between training by novices and KS within the knowledge-intensive industrial maintenance domain.

Figure 3 provides a summary of Hypotheses 1 to 9.

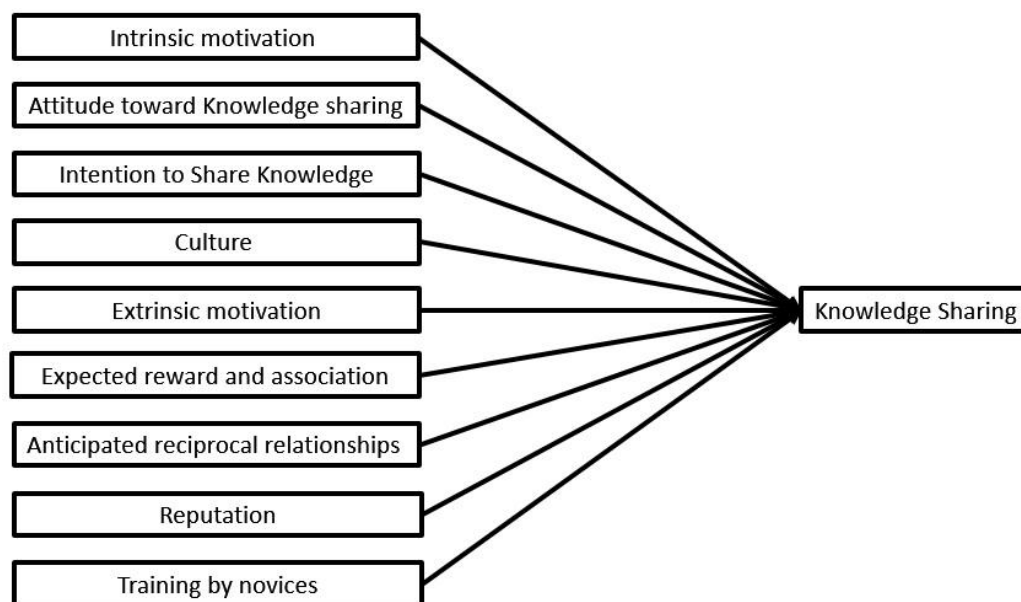


Figure 3: H1 to H9.

Hypothesis related to moderation effect:

H10: The impact of intrinsic motivation on KS within knowledge-intensive maintenance departments is moderated by "training by novices".

H11: The impact of attitude toward KS on KS within knowledge-intensive maintenance departments is moderated by "training by novices".

H12: The impact of intention to share knowledge on KS within knowledge-intensive maintenance departments is moderated by "training by novices".

H13: The impact of culture on KS within knowledge-intensive maintenance departments is moderated by "training by novices".

H14: The impact of extrinsic motivation on KS within knowledge-intensive maintenance departments is moderated by "training by novices".

H15: The impact of expected reward and association on KS within knowledge-intensive maintenance departments is moderated by "training by novices".

H16: The impact of anticipated reciprocal relationships on KS within knowledge-intensive maintenance departments is moderated by "training by novices".

H17: The impact of reputation on KS within knowledge-intensive maintenance departments is moderated by "training by novices".

These hypotheses collectively propose a nuanced understanding of how above mentioned factors contribute to KS within maintenance departments, and how the effectiveness of novices'

training programs can enhance these relationships. The study, through empirical analysis, can validate or refute these hypotheses, providing valuable insights for KM strategies in similar contexts.

6.3.6. Implementation

Before initiating the "training by novices" program, the initial phase involved collecting data. A questionnaire was meticulously crafted, consisting of 66 closed-ended questions derived from established scales, with the goal of comprehensively assessing the multifaceted dimensions of KM and KS variables. This questionnaire was administered to 103 personnel from the maintenance department of a knowledge-intensive industry, which boasted a workforce of 1250 employees. Tables 36 insights into the composition of the study population, facilitating a deeper understanding of the research context.

Table 36: Participants' distribution by position and percentage.

Participants' distribution							
Position	Technician	Foreman	Expert	Boss	Manager	Director	Total
Frequency	71	5	16	8	2	1	103
Percent	68.9	4.9	15.5	7.8	1.9	1.0	100.0

Concurrently, novices played a crucial role in the research endeavor. Fourteen individuals, representing the novice segment, were tasked with creating comprehensive training materials over an intensive two-month period. These materials encompassed various formats, including Word documents, PDFs, PowerPoint presentations, and engaging instructional videos. Throughout this immersive experience, the novices received ongoing support through a series

of follow-up meetings, serving as collaborative forums to troubleshoot challenges, provide guidance, and tap into the novices' untapped potential.

A significant aspect of this methodology involved pairing novices with seasoned experts, under the guidance of sub-department managers. These partnerships culminated in semi-formal training and coaching sessions, where novices assumed dual roles as both educators and learners. This approach aimed to bridge knowledge gaps and foster a reciprocal learning environment. Subject matter experts, proficient in their designated domains, complemented this process by imparting precision and depth to the knowledge dissemination.

Approximately 21.3% of employees were deliberately excluded from the program, forming a control group to facilitate a comparative analysis and enable a robust assessment of the program's impact on knowledge enhancement and sharing dynamics.

As the five-month program concluded, the methodology seamlessly transitioned from knowledge acquisition to evaluation. Participants were engaged once again through a revisited questionnaire to gauge the evolving landscape of KM and KS variables. This phase of data collection incorporated a blend of closed-ended and open-ended questions, enabling a qualitative exploration of participants' experiences. Participants were encouraged to share opinions, proffer suggestions for refinement, and reflect on barriers to effective KS.

The evaluation phase further delved into the complex realm of participant roles within the program, enriching program dynamics and underscoring the empirical focus of quantitative research. Additionally, a nuanced examination of perceived knowledge improvement was conducted, with participants quantifying their progress and reflecting on their transformative journey. Importantly, participants' inclinations toward future program involvement served as a litmus test of the program's resonance and efficacy.

The culmination of data collection facilitated a statistical analysis, to unravel the program's influence on participants' KS and knowledge augmentation. This analytical approach provided both quantifiable insights and qualitative nuances, offering a comprehensive view of the program's impact on knowledge enhancement within the maintenance department.

Furthermore, based on the results of the second round of data collection and thematic analysis of open-ended questions, four main improvement suggestions were identified and implemented. Subsequently, the program continued by assigning new training tasks to novices for an additional seven months. The same questionnaire was distributed to evaluate changes in KM and KS, with additional questions addressing improvements.

Finally, maintenance employees were surveyed to ascertain their perception of KS improvement within the department and to specify the percentage of contribution attributed to the aforementioned improvements. It is important to emphasize that this study focuses on reporting the data extracted from the third round of data collection.

Data analysis

Data analysis primarily involved quantitative methods, employing descriptive statistics to uncover the program's impact on KS and knowledge augmentation. This approach provided quantifiable insights into the observed phenomena. This holistic approach provided a comprehensive understanding of the program's impact and the evolving landscape of knowledge enhancement within the maintenance department.

Validity and reliability

Validity pertains to the accuracy of a measure. Hair et al. (2012) described it as the degree to which a construct accurately captures what it intends to measure. Ensuring the validity and

reliability of variables is essential for establishing the strength and credibility of research outcomes. The content validity of the variables was substantiated through an extensive examination of pertinent literature and expert opinions within the field. Rigorous alignment of each variable with the theoretical framework and existing knowledge base ensured content validity.

The study construction consisted of three phases. The first step involved discussions with senior pilots regarding the content of the questionnaire, aiming to check wording and identify which questions apply to the maintenance context. Based on feedback received, some adjustments were made to the wording and structure of certain questions to ensure clarity and relevance. The second step was the pre-test, which was administered to a small sample of respondents (6 maintenance employees) to verify validity and reliability. The focus was on how people answered, i.e., how they interpreted and responded to the questions in line with our research objectives. Lastly, the survey was distributed to all maintenance employees.

To assess internal consistency, Cronbach's alpha coefficient was calculated for scales and indices, indicating the degree of interrelatedness among the items within each variable. A high Cronbach's alpha suggests a strong internal consistency among the items. According to Hinton et al. (2004), the measures show moderate reliability when alpha is 0.50 or higher. The rigorous assessment of reliability using SPSS 25 instills confidence in the robustness of the variables employed in this study. Table 37 presents the Cronbach's alpha values for the variables included in the study.

Table 37: Cronbach's alpha of variable.

variables	Alpha
Intrinsic motivation	0.804
Intention to share knowledge	0.863
Attitude towards KS	0.892
Culture	0.769
Extrinsic motivation	0.869
Expected reward and association	0.789
Anticipated reciprocal relationships	0.876
Reputation	0.887
KS	0.892

Descriptive statistics

The analysis was initiated with descriptive statistics to provide a comprehensive overview of key variables, including means, standard deviations.

Correlation analysis

Correlation analyses has been undertaken to unveil initial relationships among factors affecting KS.

Regression analysis

Multiple regression analyses was executed to rigorously test the direct relationships outlined in the hypotheses.

Moderation analysis

The influence of X on a variable Y is moderated by W when the magnitude, direction, or intensity of its impact relies on or can be anticipated by W. In such instances, W is termed as a moderator of X's effect on Y, signifying an interaction between W and X in shaping their

influence on Y (Hayes, 2017). Moderation analysis, employing the Hayes' PROCESS macro version 4.2 in SPSS (written by Andrew F. Hayes), was applied to specifically explore these moderation effects. This involves examining interactions between influencing factors and "training by novices" to discern changes in the strength of their associations.

The macro process applies a bootstrapping test, i.e., a non-parametric method based on resampling with a replacement, which, in this case was done 5000 times. From each of these samples the indirect effect is computed, and a sampling distribution can be empirically generated. A confidence interval is computed, and it is checked to determine if zero is in the interval. If zero is not in the interval, then the researcher can be confident that the indirect effect is different from zero.

Model development

The methodology for this paper comprises the development and implementation of a conceptual model aimed at leveraging novices as facilitators in KS within maintenance departments of knowledge-intensive industries. The conceptual model serves as the foundational framework, delineating the key components and relationships that guide the intervention. The conceptual model was constructed based on the identified variables, emphasizing the transformation of novices from passive recipients to active facilitators in KM and KS processes. In the conceptual model of this study, the introduction of "training by novices" as a moderator adds a layer of complexity to the understanding of KS dynamics within maintenance departments. A moderator is a variable that influences the strength or direction of the relationship between independent and dependent variables. In this context, "training by novices" is poised to act as a moderator in the relationship between the influencing factors affecting KS (independent variables) and KS itself (dependent variable). This

conceptualization sets the stage for a comprehensive empirical investigation into the intricacies of these relationships, offering insights that can inform targeted interventions and improvements in KM practices.

6.4. Results and discussion

The following section presents the results of the empirical investigation.

The comparison between data collected at first and second round of data collection (before and after the implementation of the "training by novices" program) reveals a significant improvement in the knowledge of all participants, with an overall increase of 71%. However, the enhancement in KS saw a modest increase of 6.2%, which did not reach statistical significance.

Additionally, participants were invited to provide feedback through open-ended questions, yielding valuable recommendations for program improvement. Through thematic analysis, four following main suggestions emerged.

1. Allocating sufficient time for both training material preparation and program participation.
2. Linking job promotion to active participation in KS activities.
3. Providing financial incentives for employees actively involved in KS.
4. Continuing program "training by novices".

These recommendations were subsequently implemented to enhance the effectiveness of the program. The study continued by assigning new training tasks to novices for an additional seven months, followed by the distribution of the same questionnaire (third round of data

collection) to evaluate changes in KM and KS. Furthermore, new questions were incorporated into the questionnaire, prompting participants to evaluate the perceived enhancement in KS within the department. They were also tasked with allocating the percentage of this improvement attributed to the aforementioned enhancements. A summary of these results is presented in Table 38. Table 39 offers a comprehensive overview of the KS metrics collected across three rounds of data collection, providing valuable insights into the observed trends over time.

Table 38: Distribution of implemented enhancements impacting KS.

Improvement	Sufficient time	Linking job promotion	Financial incentives	Training by novices
Share of percentage in KS improvement	18.25%	29.7%	21.55%	30.05%

Table 39: Descriptive statistics of KS metrics across three data collection rounds.

KS	Improvement
KS at first round of data collection	---
KS at second round of data collection	6.1%
KS at third round of data collection	27.7%

Table 40 illustrates the participants' perceptions regarding the removal of KS barriers in the second and third rounds of data collection, indicating improvements over time.

Table 40: Perceived improvement in removal of KS barriers.

Data collection round	improvement
First round	---
Second round	1.8%
Third round	22.7%

Hypothesis testing

The correlation analysis conducted in this study aimed to explore the relationships between various factors and KS within the knowledge-intensive industrial maintenance domain. The results revealed significant positive correlations between several factors and KS (table 41).

Table 41: correlation between independent variables and dependent variable.

		Correlation matrix									
		Intrinsic motivation	Attitude towards KS	Intention to share	Culture	Extrinsic motivation	Expected rewards and	Anticipated reciprocal	Reputation	Training by novices	KS
KS	Pearson Correlation	.303**	.388**	.484**	.744**	.470**	.479**	.342**	.419**	.522**	
	Sig. (2-tailed)	.002	.000	.000	.000	.000	.000	.000	.000	.000	

Firstly, consistent with hypothesis H1, there was a positive relationship between intrinsic motivation and KS ($r = 0.303$, $p < 0.01$). This suggests that individuals who exhibit higher levels of intrinsic motivation are more likely to engage in KS activities within the maintenance domain.

Similarly, hypothesis H2 posited a positive relationship between attitude towards KS and KS itself. The correlation analysis supported this hypothesis, indicating a significant positive correlation between attitude towards KS and KS behavior ($r = 0.388$, $p < 0.01$).

Hypothesis H3 proposed a positive relationship between intention to share knowledge and KS. The results provided further support for this hypothesis, with a significant positive correlation observed between intention to share knowledge and actual KS behavior ($r = 0.484$, $p < 0.01$).

Moreover, hypothesis H4 suggested a positive relationship between organizational culture and KS. The correlation analysis confirmed this hypothesis, revealing a strong positive correlation between culture and KS ($r = 0.744, p < 0.01$).

Furthermore, hypotheses H5, H6, H7, H8, and H9, which respectively examined the relationships between extrinsic motivation, expected rewards and associations, anticipated reciprocal relationships, reputation, and training by novices with KS, were all supported by the correlation analysis. Significant positive correlations were found between each of these factors and KS behavior (all $p < 0.01$).

Overall, these findings provide empirical evidence supporting the notion that various above-mentioned factors, play crucial roles in influencing KS behavior within the knowledge-intensive industrial maintenance domain.

Multiple regression

The multiple regression analysis was conducted for all variables included in the study, and among them, "culture" and "intention to share knowledge" emerged as the most significant predictors of KS behavior within the knowledge-intensive industrial maintenance domain. These two variables collectively explain approximately 60.2% of the variance in KS behavior, indicating their substantial impact in shaping the dynamics of KS within the organizational context. Tables 42, 43 and 44 present the results of conducting multiple regression.

Table 42: Summary of model statistics for individual factors predicting KS.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.776 ^a	.602	.594	.38291
a. Predictors: (Constant), culture, intention to share knowledge				

Table 43: ANOVA results for predictors of KS.

ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	22.140	2	11.070	75.502	.000 ^b
	Residual	14.662	100	.147		
	Total	36.803	102			
a. Dependent Variable: KS						
b. Predictors: (Constant), culture, intention to share knowledge						

Table 44: Coefficients for predictors of KS.

Coefficients ^a						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.097	.346		6.057	.000
	Intention to share knowledge	.205	.059	.235	3.449	.001
	Culture	.441	.046	.655	9.598	.000
a. Dependent Variable: KS						

The model summary table provides information about the overall fit of the regression model. The coefficient of determination (R-squared) value indicates that approximately 60.2% of the variance in KS behavior can be explained by the predictors included in the model. The adjusted R-squared value, which adjusts for the number of predictors in the model, is slightly lower at 59.4%. Overall, the model shows a good fit to the data, suggesting that culture and intention to share knowledge are significant predictors of KS behavior.

The analysis of variance (ANOVA) table assesses the overall significance of the regression model. The F-statistic is highly significant ($F = 75.502$, $p < 0.001$), indicating that the

regression model as a whole is a good fit for the data. This suggests that the predictors (culture and intention to share knowledge) collectively contribute to the prediction of KS behavior.

Moving on to the coefficients table, both culture and intention to share knowledge have significant positive effects on KS behavior. The standardized coefficients (Beta) indicate the relative importance of each predictor. Culture has a higher standardized coefficient (Beta = 0.655) compared to intention to share knowledge (Beta = 0.235), suggesting that culture has a stronger influence on KS behavior in this context.

Overall, these results suggest that both organizational culture and individuals' intention to share knowledge significantly contribute to KS behavior within the studied context. A positive organizational culture and a strong intention to share knowledge are associated with higher levels of KS among employees. These findings highlight the importance of fostering a supportive organizational culture and promoting individuals' willingness to share knowledge in enhancing KS within the knowledge-intensive industrial maintenance domain.

Moderation effect

The Hayes process macro analysis was utilized to explore the moderating impact of "training by novices" on the association between all other independent variables with KS within the maintenance context. However, the analysis revealed a negative moderation effect for "training by novices" on the relationship between all independent variables and KS, except for hypothesis 12 (intention to share knowledge). Consequently, hypotheses 10 to 18, with the exception of hypothesis 12, were not supported by the findings (tables 45, 46 and 47 present the results).

Table 45: Summary of model statistics for training by novices predicting KS.

Model Summary: Model: 1 X: Intention to share knowledge, W: Training by Novices, Y: KS						
R	R-sq	MSE	F	df1	df2	p
.5968	.3561	.2393	18.2535	3.0000	99.0000	.0000
a. Predictors: (Constant), Training by novices, Intention to share knowledge						

Table 46: Hayes' regression coefficients and significance levels for model variables.

Model						
	coeff	se	t	p	LLCI	ULCI
constant	5.5312	.0516	107.2460	.0000	5.4289	5.6335
Intention to share knowledge	.3462	.1002	3.4548	.0008	.1473	.5450
Training by novices	.0322	.0080	4.0032	.0001	.0162	.0481
Int_1	.0139	.0057	2.4623	.0155	.0027	.0252
Product terms key: Int_1 : Intention to share knowledge * Training by novices						

Table 47: Test results for highest order unconditional interactions.

Test(s) of highest order unconditional interaction(s):					
	R2-chng	F	df1	df2	p
X*W	.0394	6.0628	1.0000	99.0000	.0155
Focal predict: Intention to share knowledge (X) Mod var: Training by novices (W)					

The results for intention to share knowledge indicate that the overall model is statistically significant ($p < .001$), with an R-squared value of .3561, suggesting that approximately 35.61% of the variance in KS behavior can be explained by the predictors included in the model.

Individually, both "intention to share knowledge" and "training by novices" were found to have a significant positive effect on KS behavior ($p < .001$ for both). Specifically, for every one-unit increase in "Intention to Share Knowledge," there is a corresponding increase of approximately .3462 units in KS behavior, holding all other variables constant. Similarly, for every one-unit increase in "training by novices," there is a corresponding increase of approximately .0322 units in KS behavior.

Furthermore, the interaction term "Int_1" (representing the interaction between "intention to share knowledge" and "training by novices") was found to be statistically significant ($p = .0155$), indicating that the moderating effect of "training by novices" on the relationship between "intention to share knowledge" and "KS" is significant.

In summary, these findings suggest that "intention to share knowledge" and "training by novices" play important roles in influencing KS behavior within the knowledge-intensive industrial maintenance domain. Moreover, the interaction between these factors further amplifies their impact on KS behavior, highlighting the complex interplay between individual intentions and organizational support in facilitating effective KS practices.

Conceptual models

Based on the results of this study, a conceptual model has been developed to illustrate the moderating role of "training by novices" on the relationship between "intention to share knowledge" and "KS within the knowledge-intensive maintenance domain (figure 4). This model highlights how the presence of novices at trainer roles influences the propensity of individuals to share knowledge, emphasizing the significance of intentionality in shaping KS behaviors.

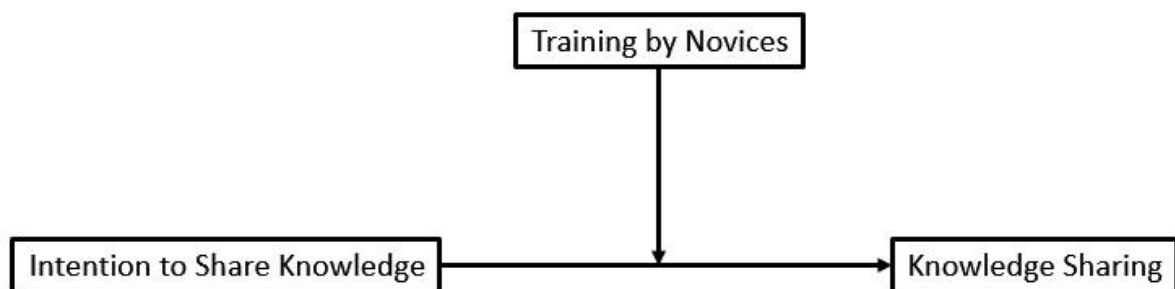


Figure 4: Conceptual model; influence of intention to share knowledge on KS, moderated by training by novices.

6.5. Conclusion

In this study, all hypotheses 1 to 9 were validated, revealing substantial positive correlations among influencing factors and KS within maintenance departments. Notably, the effectiveness of "training by novices" emerged as a moderator, highlighting its pivotal role. These results emphasize the significance of culture and intention to share knowledge as the most influential factors shaping KS dynamics within knowledge-intensive sectors.

However, it is essential to acknowledge certain limitations inherent in this study. Firstly, the research was conducted within a specific context, limiting the generalizability of the findings to other industries or organizational settings. Additionally, while efforts were made to control for various factors, there may still be unaccounted variables that could influence KS dynamics. Biases may have been introduced due to the self-report nature of the data, as participants may have provided socially desirable responses or inaccurately assessed their own KS behaviors.

Furthermore, the duration of the program and the relatively short timeframe of the study may have restricted the depth of insights gained. The program's effectiveness and the sustained impact of novices' involvement in KS initiatives could be better understood through longer-term observation and evaluation. Additionally, the reliance on quantitative measures may have overlooked qualitative aspects of KS experiences and perceptions, potentially missing nuances that qualitative research methods could capture. Biases may have been introduced due to the self-report nature of the data, as participants may have provided socially desirable responses or inaccurately assessed their own KS behaviors.

Certainly, the theoretical and practical implications of this study are substantial. The confirmation of the hypothesized positive relationships between influencing factors and KS

within maintenance departments contributes significantly to existing literature on KM and organizational behavior. The findings underscore the importance of considering the role of culture and intention to share knowledge in fostering KS, particularly in knowledge-intensive industries where effective knowledge transfer is crucial for organizational success.

Theoretically, this study advances our understanding of the complex interplay between training by novices and individual factors, organizational factors, and KS behaviors. By highlighting the moderating role of "training by novices," it sheds light on the potential of innovative training approaches to enhance KS dynamics within organizations.

Practically, the insights gleaned from this study have direct implications for organizational leaders and managers seeking to improve KS practices within their departments. By recognizing the importance of both individual competencies and organizational support structures, organizations can design more effective training programs, implement supportive organizational policies, and create a conducive environment for KS to thrive. Moreover, the findings emphasize the value of incorporating diverse perspectives, such as those of novice employees, in KS initiatives, thereby promoting inclusivity and fostering a culture of continuous learning and innovation.

Overall, the theoretical and practical implications of this study contribute to the ongoing discourse on KM and organizational behavior, offering valuable insights for scholars, practitioners, and organizational leaders alike. By addressing the multifaceted nature of KS and the factors that influence it, this research paves the way for future endeavors aimed at enhancing KM practices and driving organizational success.

Moving forward, future research endeavors could explore the longitudinal effects of novices' involvement in KS initiatives, tracking the sustainability of their contributions over time.

Furthermore, investigating the role of technology in facilitating KS processes, particularly in virtual or remote work environments, presents an avenue for further exploration. Additionally, qualitative studies delving into the nuanced experiences and perceptions of individuals involved in KS initiatives could provide valuable insights into the underlying mechanisms driving effective knowledge exchange.

In conclusion, this research highlights the pivotal role of both culture and intention to share knowledge in shaping KS dynamics within maintenance departments. While the findings offer valuable insights into enhancing KM practices, future research endeavors should continue to explore and expand upon these foundations to foster a deeper understanding of KS processes in diverse organizational contexts.

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CHAPTER 7: CONCLUSION

In this final chapter, the synthesis and conclusion of the findings from the thesis's four papers offer valuable insights into KM and KS within knowledge-intensive maintenance departments. Each paper provides unique perspectives on theoretical frameworks, practical applications, methodological considerations, and limitations, contributing to a comprehensive understanding of KM and KS.

This chapter is organized to present these contributions effectively. It begins with a brief review of relevant literature on KM and KS in maintenance settings, establishing the research context. This is followed by an overview and synthesis of the key findings, highlighting the emerging central themes and insights. A detailed analysis then examines the barriers, enablers, and innovative approaches identified in the research.

The discussion continues by exploring the practical implications for organizations, emphasizing how these findings can be applied in real-world settings. Theoretical implications are also considered, mainly regarding how this research contributes to existing KM and KS models and expands our understanding of these concepts. Methodological implications are then discussed, shedding light on the contributions and limitations of the research approach.

The chapter concludes by addressing the study's limitations and suggesting directions for future research, ensuring that this thesis's contributions extend beyond the immediate context of maintenance departments to inform the broader field of KM. Finally, reflections on the significance of these findings are provided, underscoring their relevance to scholars and practitioners.

7.1. Literature review: KM and KS in maintenance settings

In maintenance settings, KM and KS are increasingly recognized as vital to ensuring operational efficiency, safety, and continuous improvement (Aromaa et al., 2015). These environments, characterized by their complexity and the need for precision, rely heavily on the proper management and dissemination of knowledge to maintain high standards of performance (Chebel-Morello et al., 2017). This brief literature review explores the current understanding of KM and KS within maintenance settings, highlighting their importance, challenges, and innovative strategies for enhancing these practices.

7.1.1. The importance of KM in maintenance

Maintenance operations, particularly in KIFs, require the efficient management of vast amounts of technical information and expertise. KM is crucial in these settings as it helps capture, store, and disseminate explicit and tacit knowledge that maintenance personnel need to perform their tasks effectively (Cárcel-Carrasco & Cárcel-Carrasco, 2021). KM systems in maintenance settings typically involve databases of historical maintenance records, technical manuals, and troubleshooting guides, which provide workers with access to essential information (Chirumalla et al., 2015). KM facilitates the standardization of maintenance procedures, ensuring that best practices are consistently applied, thus reducing the likelihood of errors and enhancing operational reliability.

Moreover, KM plays a significant role in the preservation of institutional knowledge, particularly in environments where the workforce may be aging, and critical expertise is at risk of being lost. Studies have shown that by systematically capturing the experiences and insights of seasoned maintenance workers, organizations can mitigate the impact of workforce turnover and maintain a high level of operational capability (Dalkir, 2013). In this context, KM not only

supports day-to-day operations but also contributes to the long-term sustainability of the organization by ensuring that critical knowledge is retained and made accessible to future generations of workers.

7.1.2. KS as a Key component of KM

KS is an essential component of KM, particularly in the maintenance sector, where the exchange of information and expertise among workers can significantly influence the effectiveness of maintenance activities (Wang & Noe, 2010). KS involves the dissemination of both explicit knowledge, such as documented procedures and technical data, and tacit knowledge, which includes the practical know-how and problem-solving skills acquired through experience. Nonaka et al. (1995) emphasize the importance of tacit knowledge in maintenance settings, noting that much of the expertise required to troubleshoot complex machinery or systems is not easily codified but is instead shared through direct interaction and collaboration among workers.

The literature identifies several factors that influence KS in maintenance settings, including organizational culture, trust among employees, and the presence of formal and informal communication channels. Organizations with a strong culture of collaboration and trust are more likely to foster effective KS, as employees feel more comfortable sharing their knowledge without fear of losing their competitive advantage or job security. However, the challenges to KS in maintenance settings are also well-documented. (Ipe, 2003) highlights the reluctance of some workers to share knowledge due to concerns about job security, the fear of criticism, or the perception that sharing knowledge diminishes their value to the organization.

Another challenge in KS is the siloed nature of many maintenance departments, where knowledge is often compartmentalized within specific teams or departments, limiting its accessibility to the broader workforce (Chirumalla & Parida, 2016). This issue is particularly problematic in large and complex organizations, where the failure to share critical knowledge across departmental boundaries can lead to inefficiencies, increased downtime, and even safety incidents. To address these challenges, researchers have explored various strategies for promoting KS, including using cross-functional teams, developing KS incentives, and implementing digital platforms that facilitate the sharing of knowledge across organizational boundaries (Becerra-Fernandez & Sabherwal, 2014).

7.1.3. Innovative approaches to KM and KS in maintenance settings

Recent technological advancements have opened new avenues for enhancing KM and KS in maintenance settings. Digital tools such as AR, VR, and mobile applications are being increasingly adopted to facilitate the capture and dissemination of knowledge. AR and VR can be used to create immersive training environments where maintenance workers can practice complex procedures and troubleshooting techniques in a simulated setting. These technologies also enable real-time KS, allowing experienced workers to provide remote guidance and feedback to less experienced colleagues.

The literature indicates that more than technological solutions are needed to overcome the barriers to effective KM and KS in maintenance settings. Cultural and organizational factors, such as leadership support, the alignment of KM and KS practices with organizational goals, and the establishment of clear incentives for KS, are equally important (Leidner et al., 2006). For instance, although establishing a link between participation in KS and career advancement,

allocating more time by superiors for KS activities, and financial incentives are essential, more is needed on their own to improve KS outcomes significantly. These strategies must be complemented by efforts to foster a collaborative culture, build trust among employees, and break down organizational silos to realize the benefits of KM and KS fully.

7.2. Overview and synthesis

The culmination of this thesis marks a significant journey through the complex and multifaceted terrain of KM and KS within the highly specialized, knowledge-intensive environment of maintenance departments. This research aimed to unravel the intricate dynamics governing the management, transfer, and utilization of knowledge in such settings, where the expertise required to maintain operational efficiency is critical and difficult to codify. Through four interconnected studies, this thesis offers a nuanced understanding of how knowledge is cultivated and disseminated, with each study contributing a distinct yet interrelated perspective to the broader discourse on KM and KS.

The synthesis of these studies has not only illuminated the critical challenges that maintenance departments face but also provided practical solutions and theoretical advancements. These can be applied across similar knowledge-intensive sectors, offering a robust framework for organizations seeking to enhance their KM and KS practices. The core recognition of this thesis is that knowledge is not a static resource but a dynamic and evolving asset. Effective KM and KS, therefore, require not only careful management but also the deliberate cultivation of an environment where knowledge can be shared and utilized to its fullest potential.

This research underscores the importance of creating a conducive environment where knowledge flows freely through an exhaustive examination of barriers, enablers, and

innovative approaches—such as the "training by novices" concept. In such an environment, every member of the organization, regardless of their experience level, can contribute to and benefit from the collective knowledge pool. In other words, the key points of this thesis can be summarized as follows:

- Trust and face-to-face interactions are critical enablers of effective KS in maintenance departments.
- The innovative 'training by novices' approach can significantly enhance KM and KS practices.
- Emerging technologies like AR and VR have great potential in facilitating KS.
- Barriers to KM and KS are multifaceted, encompassing organizational, cultural, and individual dimensions.
- Structural changes alone are insufficient for improving KS; a holistic approach is necessary to address structural and cultural aspects.
- The effectiveness of KS improvements is not strongly correlated with traditional interventions like career incentives or time allocation alone.
- Organizational knowledge should be viewed as a dynamic and evolving asset rather than a static resource.

These key findings form the foundation for our detailed analysis and discussion in the following sections.

7.3. Detailed analysis of key findings

7.3.1. Barriers to KM and KS: A multifaceted challenge

One of the most persistent challenges identified in this research is the presence of barriers that impede effective KM and KS within maintenance departments. These barriers are multifaceted, encompassing organizational, cultural, and individual dimensions. Organizationally, the absence of standardized knowledge recording practices emerged as a significant obstacle. In many maintenance departments, knowledge remains tacit, residing within the minds of experienced technicians and engineers rather than being documented and shared. This reliance on personal experience rather than codified knowledge creates vulnerabilities, mainly when key personnel leave the organization. The lack of standardized practices also hinders the ability to systematically capture and disseminate knowledge, leading to inefficiencies and potential knowledge loss.

Culturally, the research identified a reluctance to share unsuccessful experiences or failures driven by a fear of judgment or repercussions. This reluctance not only stifles learning opportunities but also perpetuates a culture where only success is valued, thereby missing the rich learning that can come from understanding what went wrong. The cultural dimension also includes generational gaps, which significantly impact knowledge sharing. Differences in communication styles, values, and expectations between older and younger employees create friction and hinder effective KS. These generational gaps can result in misunderstandings, misalignment of goals, and a fragmented approach to KM, highlighting the need for strategies to bridge these gaps and improve communication.

Individually, the preference for relying on personal experience rather than sharing knowledge is a significant barrier. This attitude is particularly prevalent among senior technicians who

may view their knowledge as a source of power or job security. The reluctance to share can also stem from a lack of confidence or fear of being replaced, particularly in industries where rapid technological advancements can render specific skills obsolete. This creates a challenging environment where knowledge that could drive innovation and efficiency is held back, limiting the department's overall effectiveness.

7.3.2. Enablers of KM and KS: Harnessing potential

Despite the significant barriers, this research has identified several enablers to facilitate effective KM and KS within maintenance departments. These enablers provide a roadmap for organizations seeking to overcome the challenges and create a more knowledge-friendly environment.

Trust among colleagues is a fundamental enabler of KS. Trust fosters open communication and collaboration, making individuals more willing to share their knowledge and experiences. Trust is built through consistent, positive interactions, transparency, and a culture that values and rewards KS. In maintenance departments, where teamwork is often crucial to solving complex problems, trust becomes essential to effective KS.

Face-to-face interactions are a cornerstone of effective knowledge sharing. These interactions enable the immediate exchange of information, clarification of misunderstandings, and building rapport among team members. In maintenance departments, where the knowledge being shared is often practical and hands-on, face-to-face communication can be particularly effective. It allows for the demonstration of techniques, the immediate addressing of questions, and the building of a shared understanding.

Emerging technologies such as AR and VR hold immense potential in enhancing knowledge sharing. These technologies can create immersive learning environments where complex concepts can be visualized and experienced, rather than just explained. In maintenance departments, AR and VR can be used to simulate real-world scenarios, allowing technicians to practice and refine their skills in a safe and controlled environment. These technologies also allow for the capturing and sharing of knowledge in ways that are more engaging and interactive, potentially overcoming some of the barriers associated with traditional knowledge recording practices.

7.3.3. The role of "training by novices": A paradigm shift

One of this research's most innovative and impactful findings is the concept of "training by novices." This approach challenges traditional notions of training and KS by suggesting that less experienced individuals can play a significant role in learning. The findings indicate that when novices are empowered to teach, they not only enhance their understanding but also contribute to the knowledge of their peers, including more experienced colleagues.

This approach is rooted in teaching and is one of the most effective learning methods. When novices teach a concept, they are forced to organize their thoughts, simplify complex ideas, and identify gaps in their understanding. This process deepens their knowledge and makes the material more accessible to others. Teaching also boosts confidence and encourages a sense of ownership over the knowledge being shared.

The effectiveness of 'training by novices' as a moderator in KS dynamics is significant. It suggests that traditional hierarchical approaches to knowledge transfer—where knowledge flows from the top down—may not always be the most effective. Instead, a more collaborative

approach, where knowledge flows in multiple directions and where everyone has the opportunity to contribute, can lead to better outcomes. This collaborative nature of knowledge transfer ensures that everyone feels included and part of a team, fostering a sense of unity and shared responsibility.

However, the research also highlights a cultural barrier to this approach: the preference among participants to remain in the role of learners rather than transition into teaching roles. This finding indicates that while the potential benefits of 'training by novices' are substantial, organizations may need to address underlying cultural attitudes to fully realize these benefits. Encouraging employees to take on teaching roles may require building their confidence, providing support and resources, and changing perceptions about the value of teaching within the organization. This need for cultural change presents a challenge that, when met, can engage and invigorate the entire organization.

Before delving into the practical implications of our research, it is essential to situate our findings within the broader context of KM and KS literature. This research both supports and challenges existing scholarship in several key areas and emphasis on trust as a critical enabler of KS aligns with seminal works such as those of Nahapiet and Ghoshal (1998), who identified trust as a critical component of social capital facilitating knowledge exchange. Similarly, these findings on the importance of face-to-face interactions echo the research of Nonaka et al. (1995) on the socialization process in knowledge creation.

However, 'training by novices' concept challenges traditional models of knowledge transfer. While most literature, such as Davenport and Prusak (1998), emphasizes the role of experts in knowledge dissemination, this research suggests that novices can play a crucial role in KS.

This aligns more closely with theories of collaborative learning Dillenbourg (1999) and expands understanding of knowledge creation and dissemination in organizations.

The findings on the limited effectiveness of structural changes in improving KS present a nuanced view that supports and challenges existing literature. For instance, while Bartol and Srivastava (2002) emphasized the importance of reward systems in promoting KS, the research suggests that such necessary interventions are insufficient without addressing cultural and relational aspects. This aligns more closely with the work of McDermott and O'dell (2001), who emphasized the importance of aligning KM initiatives with existing organizational culture.

Recognizing organizational knowledge as a dynamic asset builds upon and extends the work of scholars like Tsoukas and Vladimirou (2001), who conceptualized it as constantly evolving through practice. These comparisons highlight how this research contributes to the evolving understanding of KM and KS in knowledge-intensive environments, challenging some existing assumptions while reinforcing and extending others. With this context in mind, the focus now shifts to the practical implications of these findings.

7.4. Practical implications

The findings from this research have several practical implications for organizations seeking to enhance their KM and KS practices, particularly within knowledge-intensive maintenance departments.

7.4.1. Enhancing trust and face-to-face interactions

One of the key practical insights from this research is the critical role of trust and face-to-face interactions in facilitating effective KS. The findings suggest that organizations should prioritize creating opportunities for employees to engage in direct, personal interactions, as these interactions are often where the most meaningful and effective KS occurs. This could involve regular meetings, workshops, or informal gatherings where employees can share their knowledge and experiences in a supportive environment.

Building trust among team members is also essential. Organizations should focus on fostering a culture of openness and mutual respect, where employees feel comfortable sharing their knowledge without fear of judgment or retribution. Leaders, as the key drivers of organizational culture, can play a crucial role in modeling these behaviors and setting the tone for a trusting organizational culture. Their actions and words can significantly influence the trust levels within the team.

7.4.2. Implementing the "training by novices" approach

Another significant practical implication is the innovative "training by novices" approach. This approach challenges traditional models of KM by suggesting that novices, rather than just experts, can play a crucial role in KS. Organizations can create a more dynamic and inclusive knowledge environment by involving novices in training and knowledge transfer activities. Organizations could create structured opportunities for novices to share their perspectives and learn from others through mentoring programs, peer-to-peer training sessions, or collaborative projects. This helps accelerate the development of novices and encourages more experienced employees to engage in reflective practice and continuous learning.

7.4.3. Leveraging technology: Balancing digital tools with human interaction

While the research highlights the importance of face-to-face interactions, it also recognizes the potential of emerging technologies, such as AR and VR, to enhance KS. These technologies can create immersive learning environments that complement traditional KS methods, allowing employees to gain hands-on experience and practice new skills in a virtual setting.

Underlining the importance of both digital tools and personal connections in effective knowledge sharing, the findings suggest that technology should not replace human interaction but rather be used to support and enhance it. Organizations should strive to strike a balance, using technology to facilitate remote knowledge sharing while ensuring that there are still opportunities for face-to-face interaction.

7.4.4. Addressing cultural barriers: Promoting a learning culture

Cultural barriers, such as the reluctance to share failures or the preference for relying on personal experience, can significantly hinder KS efforts. To overcome these barriers, organizations must promote a culture of learning where all experiences, including failures, are valued and seen as opportunities for growth. This involves changing the mindset within the organization, encouraging employees to share their knowledge, and reframing failures as learning opportunities rather than shortcomings. Leaders, as the guiding force, must play an active role in modeling these behaviors, sharing their own experiences and creating an environment where open communication is encouraged.

Recognizing and rewarding employees contributing to KS initiatives can reinforce the desired culture. By celebrating KS and learning, organizations can create a more positive and supportive environment where KS is seen as a core value.

7.4.5. Evaluating the impact of multiple KS improvements

In addition to the "training by novices" approach, the research also explored three other improvements to enhance KS:

- establishing a link between participation in KS and career advancement
- allocating more time by superiors for participating in KM
- financial incentives

Despite these efforts, the improvement in KS was not strongly correlated with these three interventions. This suggests that while these initiatives are necessary for creating an environment conducive to KS, more is needed to enhance KS significantly. The absence of a strong correlation implies that these factors, although necessary, do not directly drive KS improvements unless integrated with other key elements, such as trust-building and fostering personal interactions. This highlights the complex and multifaceted nature of KS, where interpersonal dynamics and active engagement from all levels of the organization must support structural and cultural changes.

Therefore, it is imperative that organizations do not rely solely on formal mechanisms, such as career incentives or time allocation, to boost KS. Instead, they should adopt a holistic approach that combines these structural improvements with efforts to build a culture of trust, encourage face-to-face interactions, and implement innovative approaches like 'training by novices.' By

addressing both the structural and relational aspects of KS, organizations can create a more effective and sustainable KM environment. This comprehensive approach is the key to enhancing KS in the workplace.

7.5. Theoretical implications

The findings from this research offer several significant theoretical contributions to the field of KM and KS, particularly within the context of knowledge-intensive maintenance departments.

7.5.1. Expanding traditional KM models: Integrating the role of novices

One of the most notable theoretical contributions is introducing the "training by novices" concept. Traditional KM models often emphasize the role of senior employees and experts in driving knowledge transfer, with knowledge flowing primarily from the top down. However, this research challenges that notion, suggesting that novices can also play a crucial role in KS. By incorporating novices into the KM process, organizations can create a more dynamic and inclusive knowledge environment where knowledge flows in multiple directions. This expands the traditional KM model, adding a new dimension that recognizes the value of contributions from all levels of the organization. The "training by novices" concept also highlights the importance of creating opportunities for less experienced employees to engage in KS, suggesting that organizations can benefit from a more collaborative and decentralized approach to knowledge transfer.

7.5.2. Rethinking organizational knowledge: Knowledge as a dynamic asset

This research also contributes to the theoretical understanding of organizational knowledge as a dynamic and evolving asset rather than a static resource. Traditional KM theories often view knowledge as something that can be captured, stored, and transferred. However, the findings from this research suggest that knowledge is more fluid and shaped by interactions, experiences, and the organizational context.

By emphasizing the dynamic nature of knowledge, this research calls for a more flexible and adaptive approach to KM. Organizations should focus on creating environments where knowledge can be continuously updated, shared, and applied rather than simply trying to capture and store it. This requires a shift in mindset from viewing KM as a static process to understanding it as an ongoing and evolving practice.

7.5.3. Cultural and structural factors: Their influence on KM and KS

Another significant theoretical contribution emphasizes cultural and structural factors as critical influences on KM and KS. While many KM theories focus on processes and technologies, this research highlights the importance of organizational culture, trust, and the social dynamics that influence KS. The findings suggest that effective KM and KS cannot be achieved through processes and technology alone. Organizations must also address the cultural and structural factors that shape how knowledge is created, shared, and applied. This includes fostering a culture of trust, promoting collaboration, and addressing the individual and organizational barriers that hinder KS.

The research also underscores the complexity of KS, illustrating that while structural changes—such as linking KS participation to career advancement or allocating time for KS—are essential, they are not sufficient on their own. These factors must be part of a broader strategy addressing KS's relational and cultural aspects. This emphasizes the urgency and importance of a holistic KM approach that integrates structural and interpersonal dynamics.

7.6. Methodological implications

The methodological approach used in this research—combining qualitative and quantitative methods—has proven effective in capturing the complexities and nuances of KM and KS within maintenance departments. This mixed-methods approach allowed for a comprehensive exploration of the research questions, providing depth and breadth of understanding.

7.6.1. The Value of mixed-methods research

The use of mixed-methods research is a significant methodological contribution. By combining qualitative interviews with quantitative surveys, the research explored the experiences and perspectives of participants in depth while providing empirical data to support the findings. This approach allowed for data triangulation, enhancing the findings' validity and reliability.

Future research in KM and KS can greatly benefit from adopting a mixed-methods approach. This is particularly true when exploring complex and multifaceted phenomena. By integrating qualitative and quantitative methods, researchers can gain a more comprehensive understanding of the factors that influence KM and KS. This approach not only provides a comprehensive view but also offers richer insights into the dynamics at play in these fields.

7.6.2. The importance of context-specific research

Another methodological implication is the importance of context-specific research. The findings from this research are deeply rooted in the specific context of knowledge-intensive maintenance departments. They focus on a specific context, allowing for a more detailed exploration of the unique challenges and opportunities associated with KM and KS in these settings.

Future research should continue exploring KM and KS within specific contexts, as this can provide valuable insights often overlooked in broader studies. By focusing on particular industries, organizational types, or cultural contexts, researchers can uncover the unique dynamics that shape KM and KS in those settings, contributing to a more nuanced understanding of these processes.

7.6.3. Longitudinal and experimental approaches: Potential avenues for future research

While this research provides valuable insights into KM and KS, it is primarily cross-sectional, capturing a snapshot of these processes at a particular time. Future research could build on these findings by incorporating longitudinal studies examining how KM and KS evolve. Such studies could provide insights into the long-term effectiveness of KM initiatives, the sustainability of "training by novices," and the impact of cultural changes on KS.

Additionally, experimental approaches could be used to explore the effectiveness of different KM and KS strategies. For example, researchers could design experiments to test the impact

of specific interventions, such as trust-building exercises, the introduction of new technologies, or changes in organizational culture, on KS outcomes. These experimental studies could provide valuable evidence-based insights into what works in enhancing KS, offering practical guidance for organizations.

7.7. Limitations of the research

While this research provides valuable insights into KM and KS within knowledge-intensive maintenance departments, it is not without its limitations. Recognizing these limitations is essential for interpreting the findings and identifying areas for future research.

7.7.1. Contextual specificity: Generalizability of findings

One of the main limitations of this research is its contextual specificity. The findings are based on a study of knowledge-intensive maintenance departments, which may have unique characteristics that do not generalize to other organizational settings. While the insights gained from this research are valuable, they may not directly apply to other industries or organizational contexts.

Future research could address this limitation by conducting similar studies in different contexts, such as other types of knowledge-intensive work, industries, or organizations in different cultural settings. By comparing the findings across different contexts, researchers could better understand the factors that influence KM and KS and how these processes vary across different environments.

7.7.2. Methodological constraints: The cross-sectional nature of the study

Another limitation is the study's cross-sectional nature. While the research provides a snapshot of KM and KS at a particular time, it does not capture how these processes evolve. Longitudinal research could address this limitation by examining how KM and KS develop over time, providing insights into the long-term impact of KM initiatives and the sustainability of "training by novices."

7.7.3. Limited exploration of certain factors

While the research explored various factors influencing KM and KS, some areas needed to be examined in depth, for example, the impact of specific technological tools on KS, the role of leadership styles in shaping KS behaviors, and the influence of external factors such as market dynamics or regulatory changes were not fully explored.

Future research could build on these findings by examining these factors in more detail, providing a more comprehensive understanding of the various influences on KM and KS. Additionally, researchers could explore the interactions between different factors, such as how organizational culture and technology intersect to shape KS outcomes.

7.8. Future research directions

Building on the findings and limitations of this research, several directions for future research can be identified. These areas offer opportunities to further explore the dynamics of KM and KS and to address some of the gaps identified in this study.

7.8.1. Longitudinal studies: Exploring the evolution of KM and KS

One promising avenue for future research is using longitudinal studies to explore how KM and KS evolve. This research has provided valuable insights into the current state of KM and KS within knowledge-intensive maintenance departments, but it is based on a cross-sectional analysis.

Longitudinal studies could examine how KM and KS develop over time, particularly in response to organizational culture, leadership, or technology changes. Such research could provide insights into the long-term effectiveness of KM initiatives, the sustainability of new approaches like "training by novices," and how organizations adapt their KM practices to changing environments.

7.8.2. Comparative studies: Examining KM and KS across different contexts

Comparative studies offer another valuable direction for future research. This research has highlighted the importance of context in shaping KM and KS, but the findings are specific to knowledge-intensive maintenance departments. Comparative studies that examine KM and KS across different industries, organizational types, or cultural settings could provide valuable insights into the diversity of KM practices and the factors that influence KS in different contexts.

For example, researchers could investigate how AR and VR create immersive learning environments, how AI captures and analyzes knowledge, and how digital collaboration platforms facilitate remote KS. Comparative studies could also examine the effectiveness of

different technologies in enhancing KS, providing insights into which tools are most effective in different contexts.

7.8.3. Cultural dimensions of KM and KS: Comparative studies across cultures

The cultural dimensions of KM and KS are another critical area for future research. This study highlighted the significant influence of organizational culture on KM and KS, but the findings are rooted in a specific cultural context. Comparative studies that examine KM and KS across different cultural settings could provide valuable insights into how cultural factors shape these processes and how organizations can adapt their KM strategies to different cultural environments.

For example, future research could explore how cultural differences in communication styles, power distance, and attitudes toward failure influence KS behaviors and how organizations in different cultural contexts address these challenges. These studies could also examine how multinational organizations manage KM and KS across different cultural settings, providing insights into the challenges and best practices for global KM.

7.8.4. Experimental research: Testing interventions to enhance KS

Finally, experimental research offers a valuable approach to testing interventions designed to enhance KS. Experimental studies could investigate the effectiveness of specific interventions, such as trust-building exercises, changes in organizational culture, or the introduction of new technologies, in improving KS outcomes.

For example, researchers could design experiments to test the impact of different trust-building strategies on KS, such as the use of team-building activities, transparency initiatives, or

changes in leadership practices. Other experiments could test the effectiveness of different technological tools in enhancing KS, providing evidence-based insights into which tools are most effective in different contexts.

7.9. Conclusion

In conclusion, this thesis has comprehensively explored KM and KS within knowledge-intensive maintenance departments, offering valuable insights into the barriers, enablers, and innovative approaches that shape these processes. A combination of qualitative and quantitative research has highlighted the critical role of trust, face-to-face interactions, and emerging technologies in facilitating KS while also introducing the innovative concept of "training by novices."

Furthermore, while the research explored additional improvements aimed at enhancing KS—such as linking participation in KS to career advancement, allocating more time by superiors for KM activities, and financial incentives—these initiatives, though necessary, were insufficient to improve KS significantly. This finding underscores the complexity of KS and suggests that structural changes must be accompanied by efforts to build trust, encourage personal interactions, and create a supportive organizational culture.

The findings from this research have significant implications for both theory and practice. They challenge traditional KM models, expand our understanding of organizational knowledge as a dynamic asset, and emphasize the importance of cultural and structural factors in shaping KS. Practically, the research offers actionable insights for organizations seeking to enhance their KM and KS practices, particularly in knowledge-intensive environments.

While the research has limitations, it also opens up several promising avenues for future research, including longitudinal studies, comparative cultural research, and experimental studies. By continuing to explore these areas, future research can build on this thesis's contributions, deepening our understanding of KM and KS and providing further insights into how organizations can effectively manage and share knowledge in an increasingly complex and dynamic world.

Ultimately, the journey of KM and KS is ongoing, and this thesis represents a significant step forward. It offers a robust foundation for scholars and practitioners to build upon as they continue exploring the rich and evolving landscape of knowledge within organizations.

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APENDIXES

APENDIX1

Questionnaire of second study

BIOGRAPHICAL INFORMATION

Gender	Male	Female

Age

Education level	Diploma	Associate of Science	Bachelor	Master	PhD

Job level	Technician	Foreman	Expert	Boss	Manager	Director

Years of Work Experience	Less than 3 (Novice)	Between 3 and 5 (Advanced Beginner)	Between 5 and 10 (Competent)	More than 10 (Proficient)	More than 20 (Expert)

Item	Questions	Strongly 1	Disagree 2	Somewhat 3	Either agree 4	Somewhat 5	Agree 6	Strongly 7
SELF-EFFICACY								
Q1	I am confident about my ability to share knowledge with other department's members.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q2	I have mastered the skills necessary to share knowledge with other department's members.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
MEANINGFULNESS								
Q ^r	My knowledge sharing with other department's members is personally meaningful to me.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q ^f	The knowledge sharing I do with other department's members is very important to me.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
IMPACT								
Q ^d	My knowledge sharing with other department's members has a large impact on what happens in my department.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q ^r	Through my knowledge sharing with other department's members, I have a great deal of control over what happens in my department.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q ^v	My knowledge sharing would get me well-acquainted with new members in the organization.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q ^h	My knowledge sharing would enable me to associate more with other members in the department.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Item	Questions	Strongly 1	Disagree 2	Somewhat 3	Either agree 4	Somewhat 5	Agree 6	Strongly 7
Q ⁹	My knowledge sharing would not result in colleagues sharing their knowledge with me.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q1 ⁰	My knowledge sharing activities would not improve my sense of self-worth.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
ANTICIPATED RECIPROCAL RELATIONSHIPS								
Q1 ¹	My knowledge sharing would expand the scope of my association with other members in the department.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q1 ²	My knowledge sharing would draw smooth cooperation from outstanding members in the department in the future.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q1 ³	My knowledge sharing would create strong relationships with members who have common interests in the department.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
REPUTATION								
Q1 ⁴	I feel that sharing my knowledge with other department's members improves my status in the organization.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q1 ⁵	Sharing my knowledge with other department's members enhances my reputation in the department.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q1 ⁶	Sharing my knowledge with other organizational members improves others' recognition of me in the department.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Item	Questions	Strongly 1	Disagree 2	Somewhat 3	Either agree 4	Somewhat 5	Agree 6	Strongly 7
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ATTITUDE TOWARDS KNOWLEDGE SHARING

Q17 My knowledge sharing with other department's members is an enjoyable experience.

Q18 My knowledge sharing with other department's members is beneficial.

Q19 My knowledge sharing with other department's members is a wise move.

Q20 I share my knowledge in an appropriate and effective way.

INTENTION TO SHARE KNOWLEDGE

Q21 I intend to share my knowledge with other department's members more frequently in the future.

Q22 I will always make an effort to share my knowledge with other department's members.

Q23 I will always share my knowledge at the request of other department's members.

Q24 I intend to share my knowledge with any colleague if it is helpful to the department.

EXPECTED REWARDS AND ASSOCIATIONS

Q25 I am less likely to be considered for interesting and prestigious projects if I engage in knowledge sharing.

Item	Questions	Strongly 1	Disagree 2	Somewhat 3	Either agree 4	Somewhat 5	Agree 6	Strongly 7
Q26	I am more likely to be considered for internal promotions if I engage in knowledge sharing.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q27	I am more likely to be considered for appointments in other organizations or departments if I engage in knowledge sharing.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q28	I am less likely to be given the opportunity to attend conferences and other events if I share my knowledge.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q29	My knowledge sharing would strengthen the ties between existing members and myself in the department.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

EXPECTED CONTRIBUTION

Q30	My knowledge sharing would not help other members in the department to solve problems.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q31	My knowledge sharing would improve work processes in the department.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q32	My knowledge sharing would reduce the productivity in the department.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q33	My knowledge sharing would help the department to achieve its performance objectives.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

INTRINSIC MOTIVATION

Q34	I feel content when I share my knowledge with others.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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Item	Questions	Strongly 1	Disagree 2	Somewhat 3	Either agree 4	Somewhat 5	Agree 6	Strongly 7
Q ³⁵	When I know something is useful for my colleagues, I inform them. It is a matter of principle.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q ³⁶	I could participate in a seminar because I like knowledge even if I would not receive credit or a certificate of participation.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q ³⁷	Knowledge acquisition gives me power.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

EXTRINSIC MOTIVATION

Q ³⁸	When I share my knowledge, my colleagues respect me more.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q ³⁹	When I share my knowledge, I bond with my colleagues.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q ⁴⁰	When I help my colleagues, they help me, respectively.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q ⁴¹	I have higher chances of promotion where I possess knowledge.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

COOPERATION

Q ⁴²	I often cooperate with my colleagues to face a new situation.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q ⁴³	When I come across difficulties, I ask my colleagues.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q ⁴⁴	When I know the work of the others, it improves my performance.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Item	Questions	Strongly 1	Disagree 2	Somewhat 3	Either agree 4	Somewhat 5	Agree 6	Strongly 7
Q45	Cooperation when creating new knowledge reduces the anxiety of responsibility in case of an error.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

SHARING

Q46	Knowledge is shared during group meetings.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q47	Knowledge is shared using electronic means (websites, wikis, forums, social networks ...).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q48	Employees are committed to continual develop their skills and are constantly generating new ideas within the context of my department.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q49	Formal networks exist to facilitate dissemination of knowledge in my department.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q50	Resources are committed for training and development of employees in my department.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q51	There are systems in place to facilitate effective communication across departments and units.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q52	My department hones its skills for generating, acquiring and applying knowledge by learning from other organization's learning processes.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q53	Team learning is an action strategy within my department for improving member's technical skills.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q54	In my department, When a team completes a task, it distils and documents what it has learned.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Item	Questions	Strongly 1	Disagree 2	Somewhat 3	Either agree 4	Somewhat 5	Agree 6	Strongly 7
Q ⁵⁵	I share knowledge with colleagues who are my friends.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q ⁵⁶	I share knowledge with colleagues from my department.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

CULTURE

Q ⁵⁷	In this department, there are commonly shared files to inform employees.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q ⁵⁸	Most colleagues share their knowledge freely.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q ⁵⁹	In my department, employees are encouraged to practice knowledge sharing rather than knowledge hoarding.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q ⁶⁰	My department has a friendly work environment for employees to interact.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q ⁶¹	In my department, employees' intellectual assets are recognized, valued and rewarded.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

PERCEPTIONS

Q ⁶²	Knowledge Management is essential for the performance of the department.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q ⁶³	Knowledge acquisition helps the individual's autonomy.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q ⁶⁴	Knowledge recording helps employees adapt when they are transferred to different departments of the company.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Item	Questions	Strongly 1	Disagree 2	Somewhat 3	Either agree 4	Somewhat 5	Agree 6	Strongly 7
BARRIERS								
Q ⁵	I have no access to useful information for my work.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q ⁶	I do not know very well where to find useful information for my work.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

APENDIX2

Additional questions of third study

1. Have you participated in a program called "Training by novices"?

Yes, as trainee <input type="checkbox"/>	Yes, as expert <input type="checkbox"/>	Yes, as trainer <input type="checkbox"/>	Yes, as trainer and trainee or expert <input type="checkbox"/>
If your answer is yes, please rate your knowledge level related to the specific training area both before and after completing this project on a scale of 1 to 7, where 1 represents the least and 7 represents the most.			
My knowledge before training: 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/> 6 <input type="checkbox"/> 7 <input type="checkbox"/>			
My knowledge after training: 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/> 6 <input type="checkbox"/> 7 <input type="checkbox"/>			
No, I have not participated in training <input type="checkbox"/>			

2. Which role would you prefer to have in a Knowledge Management project: Trainee, Trainer, or Expert?

Trainer <input type="checkbox"/>	Trainee <input type="checkbox"/>	Expert <input type="checkbox"/>
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3. Do you believe that the "Training by Novices" program has been effective in improving Knowledge Management and Knowledge Sharing within your department?

Yes <input type="checkbox"/>	No <input type="checkbox"/>
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4. In your opinion, should the knowledge sharing program continue to follow the "Training by Novices" approach?

Yes <input type="checkbox"/>	No <input type="checkbox"/>
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5. Do you think that the training that took place should be repeated to improve its effectiveness?

Yes <input type="checkbox"/>	No <input type="checkbox"/>
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6. In your opinion, what were the problems with this program?

1. -----
2. -----
3. -----
4. -----
5. -----

7. Do you have any suggestions for better implementation and improvement of this program?

1. -----
2. -----
3. -----
4. -----
5. -----

8. In your opinion, what are the biggest obstacles to knowledge sharing within your department?

1. -----
2. -----
3. -----
4. -----
5. -----

APENDIX3

Additional questions for third round of data collection

Regarding the share of knowledge in your department, please compare the before and the after of the implemented measures:

Item	Changes	
1	A lot less knowledge is shared now when compared to before the measures	<input type="checkbox"/>
2	Less knowledge is shared now when compared to before the measures	<input type="checkbox"/>
3	Same knowledge is shared now as before the measures	<input type="checkbox"/>
4	More knowledge is shared now when compared to before the measures	<input type="checkbox"/>
5	A lot more knowledge is shared now when compared to before the measures	<input type="checkbox"/>

If you responded 4 or 5, please specify the percentage of contribution from each of the following factors to this enhancement (Allocate 100% across the following factors).

Item	Factor	Percentage out of 100%
1	Financial incentives	
2	Establishing a link between participation in knowledge sharing and career advancement	
3	Allocation of more time by superiors for participating in knowledge management	
4	Training by novices	