Gaining Insights into the Use and Documentation of Lessons Learned in Tender Processes

Addressing the Gaps in Knowledge Sharing

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Master Thesis

Gaining Insights into the Use and Documentation of Lessons Learned in Tender Processes.

Addressing the Gaps in Knowledge Sharing.

By

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Preface

"*It's not that I'm so smart, it's just that I stay with problems longer.*" – Albert Einstein.
This quote resonates deeply with the journey I've undertaken while writing this thesis. It wasn't brilliance or instant success that brought me to this point, but persistence, tackling challenges one by one, even when the path forward wasn't always clear. This process of staying with the problems, digging deeper, and continuously refining my approach has defined much of my academic experience.

As I present this final piece of work in my academic career, I look back on a process that was both challenging and rewarding, especially in the past few months. The last seven months at Royal BAM Group have been particularly memorable. During my time there, I was not only supported in completing this research, but I was also immersed in the daily workings of the company. I had the privilege of speaking with everyone, and I found that colleagues were genuinely curious about my work. Their openness and willingness to engage with me played a significant role in shaping this thesis.

A special thanks goes to Robin Kuipers, Team Lead of Information Management, who, despite his busy schedule, always made time for me. His insights and feedback were essential to my progress, and I am deeply grateful for his dedication.

I would also like to extend my deepest gratitude to my supervisors at TU Delft. Sander, thank you for skillfully leading the committee and helping me shape my research topic into something both meaningful and impactful. Tong, I truly appreciate your direct approach and for always making time to answer my questions, no matter how busy your schedule. Your clear guidance helped me stay focused. Lastly, Hans, your unwavering positivity was a source of motivation, and for that, I am sincerely grateful.

I would also like to take a moment to thank my family, whose unwavering support has been a constant source of strength throughout my studies. To the friends I've made along this journey, your companionship and encouragement have been invaluable. It's a wonderful feeling to close this chapter of my life with all of you by my side, and as I look toward the future, I do so with excitement and anticipation for the many opportunities that lie ahead.

Job Rijpma,
November, 2024

Executive summary

The construction industry in the Netherlands, as in many sectors globally, is under increasing pressure to enhance efficiency, foster innovation, and improve project quality amidst tight budgets and growing competition (De Waal & Uil, 2023). Within this context, effective knowledge management, particularly the systematic capture and application of lessons learned, has become essential for continuous improvement and for achieving successful tender outcomes. However, despite advances in technology and data systems, construction companies often face significant internal barriers to capturing and reapplying lessons learned from past projects. Key challenges include fragmented knowledge-sharing practices and inconsistent data management systems, which create obstacles for leveraging valuable insights (Ellis et al., 2021; Eken et al., 2020). Existing research frequently explores inter-organizational data sharing but lacks in-depth studies on how knowledge is managed internally within firms, particularly in the construction industry (Zhu & Augenbroe, 2006; Bektas, 2013). Unique structural factors in construction firms, such as the project-based and divisional nature of their operations, can hinder efforts to convert tacit knowledge into reusable insights across departments. These divisions, compounded by technological limitations and organizational resistance to change, form barriers that prevent lessons learned from effectively informing future projects (Beer & Mulder, 2020; Kululanga et al., 2001; Alaloul et al., 2020).

This study, conducted within the Royal BAM Group, seeks to address these issues by investigating current practices in knowledge management and lessons learned processes. Specifically, it examines how organizational structures and internal communication networks impact the sharing of project insights within the tender process. Through analyzing key barriers and enabling factors, this research aims to bridge the gap between current knowledge capture practices and the potential for more integrated systems. Central to this investigation is the question:

How can the integration, capturing of lessons learned be enhanced within tender processes in construction organizations?

Literature review

The literature review examines the critical aspects of "lessons learned" and "data sharing" within the construction industry, highlighting the complexities of knowledge management and organizational learning in project-based environments. Following the framework by Verschuren et al. (2010), the review emphasizes two main areas:

1. **Lessons Learned**: This section addresses the importance of systematically capturing, analyzing, and applying insights from project experiences to support continuous improvement. It outlines the role of organizational culture, leadership, and structured documentation processes in enabling effective lessons learned. However, it identifies common barriers, including cultural resistance, time constraints, and lack of structured processes, which often limit organizations to basic maturity levels in knowledge management. Studies suggest that supportive cultures and leadership, alongside

validated and standardized documentation, are essential for a higher level of maturity in lessons learned processes (Milton, 2012; Carrillo et al., 2004).

2. **Data Sharing**: Intra-organizational data sharing is explored in the context of divisional construction organizations, where fragmented data practices often lead to knowledge silos. Barriers such as incompatible Data Management Systems (DMS), lack of a standardized approach, and resistance to new technologies limit effective data sharing across divisions. The review advocates for a Common Data Environment (CDE) to address these issues by facilitating data integration and accessibility across departments (Ayodele & Kajimo-Shakantu, 2021).

Together, these insights lay a foundation for understanding the organizational and technological requirements for improving knowledge sharing and the integration of lessons learned. The review sets the stage for identifying practical strategies to bridge the gap between current practices and effective knowledge management within construction tenders.

Methodology

The methodology of this research encompasses a mixed-method approach that combines Social Network Analysis (SNA) and Root Cause Analysis (RCA). These methodologies were strategically selected to investigate how data sharing and lessons learned are embedded within tender processes in a construction setting. The SNA was used to map and analyze the network of information flow within tender processes, identifying key nodes and pathways for knowledge sharing. By examining these interactions, the analysis highlighted central roles within the network, such as project leaders and tender managers, who facilitate the transfer of critical information. This network mapping provides insight into communication dynamics, highlighting where fragmentation or bottlenecks may hinder effective knowledge sharing across departments. Complementing the SNA, the RCA delves into the root causes behind challenges observed in knowledge-sharing practices, identifying factors that both support and limit the integration of lessons learned. In-depth interviews were conducted with key stakeholders, who shared insights on organizational practices that impact the capture and application of lessons. This analysis uncovered underlying organizational, technological, and cultural barriers and enablers, providing a detailed understanding of the factors that need to be addressed to foster a more robust knowledge-sharing environment within tender processes .

Together, the findings from SNA and RCA informed the development of the GIS application design, ensuring it aligns with the organization's specific knowledge-sharing needs. The GIS application leverages these insights by integrating lessons learned with project and geographic data, facilitating a more seamless knowledge transfer across a construction companies project phases and improving the accessibility of critical insights across departments.

Results and Findings

The analysis began with identifying various factors related to data sharing and lessons learned from the literature review. These factors were then grouped using a qualitative factor analysis, which allowed for a systematic categorization of relevant elements into key themes. The analysis

was structured along two axes: technology-people and individual-collective. This framework helped to organize and understand the different dimensions influencing the capture and application of lessons learned in the construction industry. By applying the qualitative factor analysis, the identified factors were grouped into nine key statements, which were subsequently used as the basis for the RCA. These nine statements reflect the core enabling and limiting factors that impact the use of lessons learned within construction tender processes. The RCA utilized these statements to delve deeper into the root causes affecting organizational learning and data-sharing practices. The findings from this analysis provided critical insights into both the technological and human aspects of knowledge management within BAM's tender process. These themes of the 9 statements are as followed:

Quantitative Social Network Analysis

In this study, three case studies were conducted to analyze the knowledge-sharing networks of three projects: N346, Alexi aviaduct, and N211. To gain insight into the connections within these networks, a survey was distributed among key participants involved in the tender processes. The survey aimed to map out how data sharing occurs within the network and to understand how lessons learned are embedded into this behavior. Through the analysis of the responses, it became evident that Tender Managers and Project Leaders emerged as the most well-connected nodes in the network, responsible for facilitating communication and ensuring knowledge flows efficiently across various departments and stakeholders. Underneath are the networks visualized.

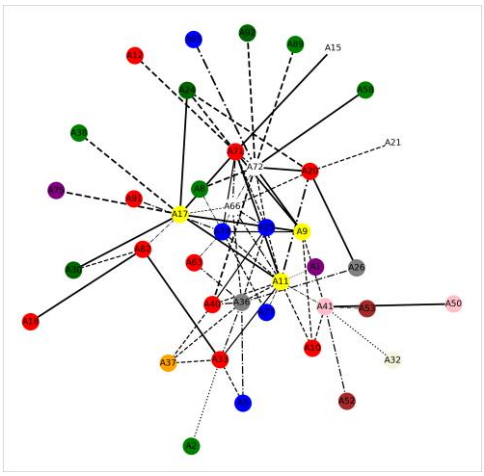

Figure 1: Network N346

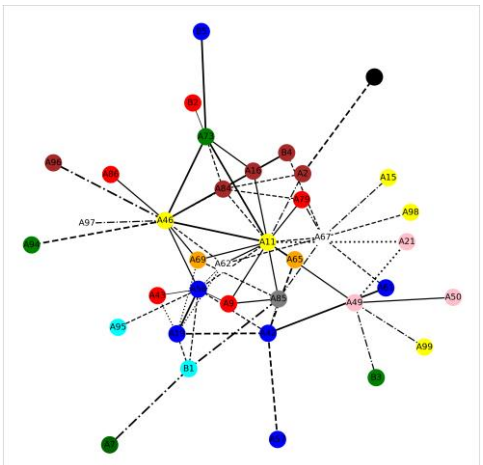

Figure 2: Network Alexia Viaduct

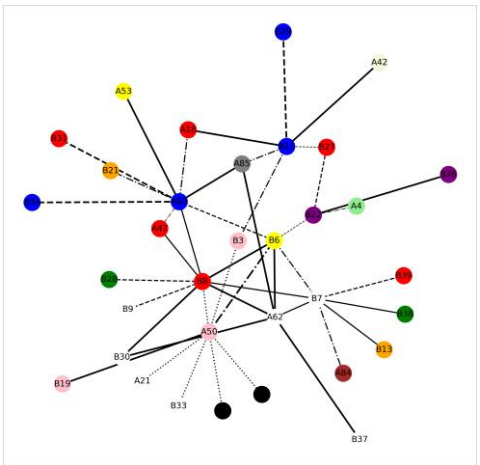

Figure 3: Network N211 Wippolderlaan

Across the three case studies, Tender Managers and Project Leaders consistently emerged as central nodes, playing key roles in communication and the integration of lessons learned. Email and face-to-face were commonly used tools for communication and document storage in all cases. However, network density varied significantly, with N211 displaying the lowest density (7.8%), leading to isolated departments and inefficient data sharing. Lessons learned were systematically applied in N346 and Alexia viaduct, while N211 showed inconsistent application, resulting in missed opportunities. The use of collaborative tools like SharePoint, Microsoft Teams and Relatics also differed, with N346 utilizing them more effectively for real-time collaboration compared to N211. Overall, improving network connectivity and adopting collaborative tools can enhance lessons learned processes in tender projects

Qualitative Root Cause Analysis

Through RCA, the research identified key barriers to effective knowledge sharing, such as insufficient training, informal communication practices, and inconsistent documentation of lessons learned (Vliet, 2010). Moreover, it was evident that the organizational culture and resistance to technological changes played a significant role in limiting the successful adoption of knowledge-sharing practices (Kululanga et al., 2001).

In-depth interviews were conducted to gain a deeper understanding of how lessons learned are used within the data-sharing behavior of employees involved in tender processes. These interviews provided valuable insights into the factors that either enable or limit the effective integration of lessons learned within the organization. The analysis of enabling and limiting factors related to lessons-learned processes revealed a near-equal balance between the two. This balance suggests that while robust mechanisms exist to support the use of lessons learned, significant challenges remain that limit their overall effectiveness.

One of the key findings was that management's role in driving the integration of lessons learned is widely recognized as a critical enabling factor. The presence of strong leadership support and structured management initiatives was seen as essential for promoting the effective use of lessons learned across tender processes. Additionally, the reliability of lessons learned documentation was another key enabler, as most employees expressed confidence in the accuracy and dependability of these documents, which serve as a trusted foundation for decision-making and strategic development.

However, several limiting factors were also identified. A prominent issue is the lack of standardization in the documentation of lessons learned, leading to inconsistencies in how knowledge is captured and shared across projects. Furthermore, there is a significant lack of clarity on where lessons learned documents are stored, making it difficult for employees to retrieve valuable insights. This issue highlights the absence of a centralized knowledge repository, which hinders the effective application of lessons learned. Moreover, informal communication practices, rather than formal channels, often dominate the transfer of knowledge, leading to gaps in the consistent application of key lessons.

Root causes Enabling factors

- Prioritization
- Open communication
- Consistent approach
- Trust

Root causes Limiting factors

- Fragmentation
- Informal communication
- No centralized system
- No initiative

Discussion and Conclusion

In this section, the factors identified through the case studies and interviews are compared with those found in the existing literature to determine how well they align. The practical findings from the tender processes confirm several established theories, while also providing new insights into the challenges and opportunities for improving lessons learned practices in the construction industry. This comparison reveals both enabling and limiting factors that influence the effective integration of lessons learned into tender processes.

Table 18 illustrates the alignment between the root causes identified in the practical case studies and the lessons learned factors from the literature. For example, "Top-Down Support for Prioritizing Lessons Learned Integration" appears as a critical enabler in both practice and theory, underscoring the role of strong managerial support in embedding lessons learned into daily workflows (Duffield & Whitty, 2015; Milton, 2012). Conversely, practical challenges like "Lack of Standardized Documentation" and "Fragmented Knowledge Sharing" also mirror theoretical insights into barriers that limit effective integration (Shokri-Ghasabeh & Chileshe, 2014). The comparison indicates that while formalized processes for lessons learned are valued theoretically, their real-world application is often hindered by time constraints and lack of standardized systems, which results in knowledge fragmentation across departments (Levy, 2018). Furthermore, while digital platforms are highlighted for their importance in knowledge sharing, practical use is limited by underdeveloped databases that impact their effectiveness (Martínez-Rojas et al., 2016). To support effective organizational learning, construction companies must adopt a revised approach to embedding lessons learned in tender processes. Tender managers should lead by emphasizing lessons learned from the outset, encouraging team members to document and apply insights actively. This top-down approach integrates lessons learned into routine workflows, fostering an organization-wide culture of knowledge sharing that drives better decision-making and addresses root causes.

Essential Factors for Strengthening Lessons Learned Integration:

- Top-down support for prioritizing lessons learned integration
- Integration of lessons learned into the tender lifecycle
- Effective documentation tools for capturing lessons learned
- Formalized processes for capturing and applying lessons learned
- Use of digital platforms for knowledge sharing

These factors serve as enablers, yet limitations like fragmented data, informal communication, and absence of centralized systems still impede consistency. Addressing these issues through stronger leadership support, standardized documentation, and open communication can enhance lessons learned integration, ultimately improving project outcomes and supporting a culture of continuous improvement

GIS-Application Design

To integrate the findings from the RCA and SNA analyses into a cohesive GIS application design, insights on communication patterns and organizational barriers identified in these analyses were foundational. The SNA clarified relational structures within the construction company, identifying roles such as Tender Managers and Project Leaders as critical information hubs. Recognizing these key roles informed the application design to prioritize accessibility and usability, ensuring that lessons learned are easily accessible to those who rely on them at strategic points. The RCA further informed the design by highlighting operational challenges, such as fragmented communication and inconsistencies in documentation processes. To address these, the application design incorporated features like metadata and categorization capabilities, allowing users to filter information by project type, geographic location, or project phase. These enhancements aim to provide structure and consistency, supporting improved knowledge-sharing practices. Additionally, the GIS application design drew on insights from discussions with industry experts, which underscored the need for seamless integration with existing platforms, like SharePoint and Relatics, as well as a user-friendly interface. These conversations clarified practical needs, guiding refinements in the GIS application design to ensure it would function as a centralized, visual tool that links project and knowledge documents effectively across phases. By presenting data with geographic context and linking lessons learned to specific locations, the design addresses both daily operational needs and long-term knowledge retention. In the discussion, the GIS application's intended role in breaking down silos between departments and its potential to streamline cross-functional collaboration are highlighted as central outcomes of the RCA and SNA findings. By improving data accessibility and organization, the application offers a sustainable solution to challenges such as fragmented data flow and inconsistent document management, thus directly addressing the barriers identified in construction project management. Integrating these findings into the GIS application design provides a strategic response to enhancing lessons learned documentation and retrieval, ultimately supporting continuous improvement across tender processes.

Recommendations

The recommendations focus on practical measures, which are stated in Table 19, to improve the lessons-learned process at both the tender and organizational levels, addressing the enabling and limiting factors identified in the research. Furthermore, it will outline concrete steps to improve the lessons-learned process within tendering and across the organization, focusing on immediate improvements, long-term strategies, and fostering a culture of organizational learning.

The Quick Wins section includes actions that can be swiftly implemented for immediate impact. One of these is establishing a centralized, well-structured platform for knowledge sharing. This platform ensures that valuable insights are easily accessible across departments, enhancing collaboration and preventing critical lessons from being overlooked. Additionally, securing top-down support is crucial; management must actively prioritize knowledge sharing by embedding lessons learned into the organization's strategic goals. This commitment from leadership will foster a culture that promotes knowledge transfer. The Long-Term Strategies aim to formally integrate lessons learned within organizational processes through structured documentation and standardized application of insights. Developing clear guidelines for documenting and reviewing lessons across projects ensures consistency and accountability. E-learning modules are recommended as part of this strategy to continuously train employees on how to apply organizational learning effectively in their roles, thus embedding knowledge sharing as an ongoing component of the project lifecycle. The Organizational Learning Mindset promotes a culture of learning by encouraging teams to pause and reflect on past lessons at critical project phases. By establishing regular checkpoints throughout project phases, teams are encouraged to proactively integrate past insights, ensuring knowledge transfer becomes a routine part of the tender process. This approach not only enhances knowledge accessibility but also cultivates an environment of continuous learning and improvement.

To further support the lessons-learned process, specific strategies are proposed for the implementation of a GIS-based knowledge-sharing application. This GIS application will serve as a visual, geographically organized interface for accessing project-related documents, including lessons learned. Integrating the application with existing platforms like SharePoint and Relatics will enable efficient linking of documents to specific project locations, making them easily accessible to users. The design prioritizes usability and intuitive navigation by allowing users to filter information by project phase, document type, and geographical location. By presenting knowledge documents in a map-based interface, the GIS application provides valuable geographic context, helping users understand the location-specific aspects of each project. This user-friendly setup, combined with systematic filtering, ensures that project knowledge is immediately accessible, thereby supporting day-to-day project navigation. The GIS application is envisioned as a long-term asset, designed to grow with the organization, allowing for future integrations with advanced analytical tools, and providing a scalable solution that will continue to support strategic and operational knowledge needs within the tender process.

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List of Abbreviations

DMS	Document Management System
MBSE	Model-Based System Engineering
GIS	Geographical Information System
RCA	Root Cause Analysis
PMI	Project Management Institute
PMBOK	Project Management Body of Knowledge
LL	Lessons Learned
SNA	Social Network Analysis
BIM	Building Information Modeling
CDE	Common Data Environment

I Exploration

1 Introduction

The construction industry in the Netherlands, like many globally, operates within a highly competitive and dynamic environment where efficiency, innovation, and quality are paramount (De Waal en Uil, 2023). This sector is instrumental in shaping infrastructure and economic landscapes, yet it grapples with complex challenges that hinder optimal performance. The demand for rapid project delivery alongside superior outcomes is increasing, driven by both economic pressures and evolving client expectations. Clients now often require advanced technological integration and continuous improvement methodologies embedded in contracts, pushing firms to innovate relentlessly (Tandale et al., 2023; De Waal en Uil, 2023).

1.1 Context and problem analysis

Despite the technological advancements and knowledge available, the Dutch construction industry faces persistent obstacles in adopting and integrating these resources effectively (Ellis et al., 2021). The sector is characterized by a project-based approach where each project could potentially add to a firm's collective knowledge and efficiency. However, the lack of a coherent organizational learning culture and effective knowledge management practices often leads to repeated mistakes and inefficiencies (Beer & Mulder, 2020; Kululanga et al., 2001).

This backdrop of high demands and internal inefficiencies creates a fertile ground for examining how lessons learned can be better captured, managed, and utilized to drive continuous improvement and maintain competitiveness in a tough market. The importance of this study lies in addressing these critical gaps, particularly focusing on the internal barriers within firms that stifle innovation and learning, thereby proposing actionable solutions to enhance overall industry performance (Eken et al., 2020; Gamil et al., 2019).

1.1.1 Problem analysis

The Dutch construction industry is currently facing a multifaceted challenge characterized by escalating demands from both public and private sectors for quicker project completions and high quality outcomes (Tandale et al., 2023; De Waal en Uil 2023). The construction industry is now at a point where adopting continuous improvement techniques and innovations is not merely an option, but a necessity. Clients are increasingly demanding these advancements and are explicitly incorporating them into contracts. This shift compels construction companies in the Netherlands to embrace new practices and technologies to stay competitive and meet the evolving requirements of their projects (De Waal en Uil 2023). Furthermore, in the construction industry ,which is largely driven by project-based work, identifying improvements and innovations often involves conducting lessons learned activities. Despite their potential to drive progress, successfully implementing these practices has proven challenging (Ellis et al., 2021). In the current economic environment, a major issue is that much of the knowledge from lessons learned remains tacit, existing primarily in the minds of individuals (Qusef et al., 2019; Bossink, 2002).

Furthermore, with reductions in the workforce, this valuable knowledge is at risk of dissipating and could be permanently lost to the organization unless it is effectively captured and shared (Mattisson & Thomasson, 2007; Malik et al ., 2021)

1.1.2 Lessons learned

Learning is described as the 'acquisition of knowledge' and encompasses the activities through which organizational members share, create, assess, and integrate knowledge (Argote et al., 2013). Kululanga et al. (2001) describe organizational learning as “the systematic promotion of a learning culture within an organization such that employees at all levels, individually and collectively, continually increase their capacity to improve their level of performance”. The importance of OL has been discussed inside multiple literature studies about literature management (Tandale et al, 2023; Ellis et al., 2021; Shokri-Ghasabeh & Chileshe, 2014). It has also been noted that the construction industry has yet to achieve the necessary level of organizational learning, primarily due to the absence of a learning culture and the lack of tools to facilitate this learning (Beer & Mulder, 2020; Kululanga et al., 2001; Eken et al., 2020). While existing literature acknowledges the significant role of lessons learned in enhancing organizational learning, there remains a substantial gap in understanding the specific barriers that impede effective data sharing within organizations. Research has identified general challenges, such as technological limitations, resistance to change, and lack of standardized processes. However, detailed studies on how these barriers specifically affect different sectors, including the construction industry, are sparse.

For it to be successfully implemented, OL principles must be effectively integrated into the business processes or value chain of the organization. OL is facilitated when individual insights and skills are incorporated into the organization's routines, practices, and beliefs (AlMaian & Qammaz, 2019; Eken et al., 2020). Lessons learned is an integral component of OL, enabling organizations to systematically apply past insights to future projects and strategic decisions, thereby enhancing overall effectiveness, reducing errors, and fostering a proactive culture of continuous improvement and adaptability (Debs & Hubbard, 2023). Incorporating lessons learned into organizational processes not only mitigates past mistakes but also amplifies the capability to innovate and adapt in rapidly changing markets. This systematic integration ensures that valuable knowledge is not lost but is instead utilized to optimize both current and future operations (Sumanarathna et al., 2023; Levy & Salem, 2020). To fully harness the potential of lessons learned, it is crucial to manage their lifecycle effectively. This involves not just capturing and documenting experiences but also processing these lessons, maintaining them in an independent database, and creating mechanisms to ensure their active use (Succar & Poirier, 2020).

An example from a project led by a project leader within BAM highlights the significance of capturing lessons learned. During a bridge project, there was a failure to account for wind load on an arch structure. This oversight revealed the critical need to consider wind forces during the initial planning and design phases. As a direct result, future projects will now integrate wind load calculations as standard practice in similar designs, preventing costly revisions and ensuring more accurate project planning from the outset. The lesson from this incident is twofold:

- **Technical Lesson:** Always include wind forces in the calculations for arch structures to avoid structural problems and design changes later.

- **Process Lesson:** Collaboration between team members, especially involving senior advisors, is vital to catch potential issues early. By working more closely and leveraging expertise, the team can prevent technical errors like the one encountered in this project.

Another example involves a project on Amsterdam Centraal, where lessons learned about the challenges of working on a busy site with many stakeholders led to changes in personnel scheduling. By incorporating these insights, the tender process was improved, and the team was better prepared for the demands of the project.

This insight was documented and shared with other teams to improve future projects, exemplifying how lessons learned can be captured and applied. The most important classification structure for knowledge management is the classification of tacit knowledge and explicit knowledge (Argote et al., 2003). Tacit knowledge is personal, context-specific, and often subconscious, built from personal experiences and specific contexts, making it highly internalized and intuitive. It is difficult to access and communicate as it includes insights and intuitions carried in individuals' minds. In contrast, explicit knowledge is formal, systematic, and easy to communicate. It can be readily articulated, codified, stored, and accessed, making it easy to transfer or teach to others. This type of knowledge includes documented data, facts, and information, which are organized for straightforward communication and dissemination (Hugo-Burrows, 2022; G. Chen et al. 2011; Davies, 2015). Implicit knowledge, on the other hand, exists between tacit and explicit knowledge. It is knowledge that is often not yet fully documented but can be made explicit through conscious effort and collaboration. Implicit knowledge is typically shared informally, through day-to-day interactions, mentoring, and teamwork, and plays a crucial role in how organizations operate (Nonaka, 1998). In the context of lessons learned, identifying and transferring implicit knowledge is essential for ensuring that valuable insights are not lost but instead transformed into explicit knowledge that can be systematically documented and shared across the organization (Argote & Ingram, 2000). By capturing implicit knowledge, organizations can bridge the gap between personal experience and formalized processes, thereby enhancing organizational learning and continuous improvement.

Lessons learned is categorized as tacit knowledge because it predominantly consists of personal insights and experiences that are not immediately visible or easily documented. This makes the capture and transfer of lessons learned a complex process, often requiring deliberate efforts to articulate and share these valuable insights (Goffin & Koners, 2011). However, despite the importance of these practices, there is a notable lack of research specifically addressing the lifecycle management of lessons learned. Existing literature extensively covers the lifecycle management of project and asset information, but it falls short in defining, managing, and integrating lessons learned within organizational processes.

1.1.3 Specific barriers

While the integration of lessons learned into organizational processes is critical for continuous improvement and innovation, underlying challenges can hinder this integration, particularly in the construction industry.

A key area of concern is the communication between departments and the individuals within those departments during tender processes. Exploring the technological, organizational, and cultural factors that impede effective communication can shed light on the obstacles

construction firms must address to fully benefit from lessons learned (Hossain & Wu, 2009). Research has identified several general challenges, such as technological limitations, resistance to change, and lack of standardized processes. However, detailed studies on how these barriers specifically affect different sectors, including the construction industry, are sparse. Poor communication has been shown to contribute significantly to cost and time overruns in construction projects (Gamil, Rahman, & Nagapan, 2019). This indicates that ineffective communication is a critical barrier that needs to be addressed to enhance the utilization of lessons learned. Moreover, communication network centrality plays a crucial role in organizational coordination, and better-managed communication networks can improve overall project outcomes (Hossain & Wu, 2009). Despite the recognized importance of communication networks, there is limited research on how these networks function within the specific context of construction firms and how they can be optimized to support lessons learned processes. Workplace communication hindrances, including contextual, structural, and behavioral factors, further worsen the challenges of integrating lessons learned into organizational processes. These barriers not only hinder the effective sharing of lessons learned but also impact the firm's ability to leverage past experiences to inform future projects (Varma et al., 2021). Current literature often lacks a detailed examination of these specific communication barriers within construction firms, highlighting a significant gap in knowledge.

Following the exploration of these barriers, this research will investigate how a GIS (Geographical Information system) application might support overcoming these challenges. Currently, GIS is primarily used for managing geographical information within the construction industry, but it holds potential for much more (Gamil et al., 2019). By linking knowledge documents, such as lessons learned, directly to geographical data, a GIS application could provide valuable context, making it easier for users to understand and apply the information relevant to specific locations and projects. This integration could enhance accessibility, streamline data sharing, and offer a more intuitive, user-friendly interface for those who need to access and contribute to lessons learned. However, for this GIS application, it is essential to define the requirements for effective data storage and accessibility, considering integration with systems such as a Document Management System (DMS) or a Model-Based System Engineering (MBSE) platform(Henderson & Salado, 2020; Hu et al., 2020). These integrations could enhance how lessons learned are organized and accessed, creating a more cohesive knowledge management framework. By linking geographical context with structured project data, this approach aims to ensure that valuable insights are easily retrievable and practically applicable across departments and future projects. The study will explore whether this approach not only improves communication across departments but also makes the knowledge-sharing process more effective and seamless during tender processes. La

1.1.4 Organizational structure

The organizational structure of construction firms significantly impacts the management, sharing, and utilization of data across different departments, particularly in the context of implementing lessons learned and improving project outcomes. In the Dutch construction industry, many companies operate with a divisional structure, where each division functions semi-autonomously with its own data management systems. While this structure facilitates specialization and concentrated expertise, it also presents considerable challenges in integrating data and effectively leveraging lessons learned across the entire organization.

In the divisional structure commonly found in Dutch construction firms, data streams are often isolated within individual divisions (Bühler et al., 2023). This segregation impedes the free flow of information across the organization, leading to isolated knowledge pools that are not easily accessible to other parts of the firm. Such compartmentalization results in inefficiencies and missed opportunities for optimization, as valuable insights and data from one division may not be utilized by others. According to Alaloul et al. (2020), the integration of new technologies in the construction industry is often hampered by the fragmented nature of organizational structures, which limits the effective sharing and use of data. Several barriers contribute to the challenges of data sharing within a divisional organizational structure. Technological limitations, such as incompatible data management systems and the absence of integrated platforms, are significant obstacles. Furthermore, organizational culture and resistance to change can impede efforts to improve data sharing practices. Employees may be hesitant to adopt new technologies or processes that facilitate data integration, preferring to stick with established methods (Abolbashari et al., 2018). Additionally, the lack of standardized processes for data management and sharing creates inconsistencies that further hinder efforts to streamline data flows. Without clear guidelines and protocols, divisions may develop their own practices, leading to a fragmented approach that undermines the overall efficiency of data use within the organization (You & Wu, 2019).

The effectiveness of lessons learned processes is heavily influenced by the organizational structure. In a divisional setup, the capture and dissemination of lessons learned can be uneven, with some divisions excelling while others lag behind. This inconsistency undermines the potential benefits of organizational learning, as valuable insights are not consistently shared and applied across the firm. Organizational learning (OL) relies on the systematic promotion of a learning culture where employees at all levels continually increase their capacity to improve performance (Kululanga et al., 2001). However, the absence of a unified approach to managing lessons learned means that insights gained in one project may not inform future projects, leading to repeated mistakes and lost opportunities for improvement (Shokri-Ghasabeh & Chileshe, 2014).

While existing literature acknowledges the significant role of organizational structure in influencing data streams and lessons learned, there remains a substantial gap in understanding the specific mechanisms through which these influences operate. Detailed studies on how different organizational structures impact data sharing and the effectiveness of lessons learned processes in the construction industry are sparse. Research is needed to explore how integrated data management systems can overcome the barriers posed by divisional structures. Additionally, there is a need for studies that examine the cultural and behavioral factors that influence data sharing practices within construction firms. Understanding these dynamics can inform the development of strategies to foster a culture of continuous improvement and effective organizational learning (Ayodele & Kajimo-Shakantu, 2021).

In conclusion, addressing the challenges posed by organizational structure is critical for enhancing data management and the utilization of lessons learned in the construction industry. By bridging the existing knowledge gaps through focused research, construction firms can develop more effective frameworks for data sharing and organizational learning, ultimately leading to improved project outcomes and competitive advantage.

1.2 Research design

In this research design chapter, the study's structure is outlined to explore the key issues around lessons learned in construction tender processes. The knowledge gap (1.2.1) highlights the lack of detailed research into how organizational structures and data sharing impact lessons learned. The scope (1.2.2) defines the research boundaries, focusing on the collaboration between TU Delft and the Royal BAM Group. The research questions (1.2.3) guide the study, examining the influence of organizational factors on the capture and utilization of lessons learned. Finally, the research structure (1.2.4) provides an overview of the phases and methods used to address these questions.

1.2.1 Knowledge gap

While the strategic importance of lessons learned is recognized in the construction sector for driving innovation and continuous improvement, the systematic capture and utilization of these lessons remain inadequately explored, especially within the organizational confines of individual firms. Previous research predominantly focuses on the technological and process-oriented aspects of lessons learned across different industries, with significant attention to inter-organizational data sharing and the external transfer of knowledge (Zhu & Augenbroe, 2006; Bektas, 2013). However, there is a conspicuous lack of detailed examination of intra-organizational lessons learned processes, particularly how these processes are affected by the structural divisions within firms (Beer & Mulder, 2020; Kululanga et al., 2001) Specifically, the construction industry, characterized by its complex projects and divisional organizational structures, faces unique challenges in effectively converting tacit knowledge from lessons learned into structured, actionable data that can be seamlessly integrated and utilized across different divisions (Alaloul et al., 2020; Abolbashari et al., 2018). While general barriers to this integration, such as technological limitations and resistance to change, are somewhat understood, the specific impacts of these barriers on the lifecycle management of lessons learned within construction firms are not well-documented (You & Wu, 2019; Gamil, Rahman, & Nagapan, 2019).

Moreover, there is minimal exploration into how advanced methodologies, such as network theory, could be leveraged to enhance the flow and application of lessons learned within these structured confines. During the interviews, a GIS specialist suggested the development of a GIS-based portal to better capture and share lessons learned, which emerged as a key recommendation from the analysis of the existing knowledge management processes. This GIS application would address the need for a centralized, accessible platform that integrates lessons learned across projects and divisions. The potential to systematically transform captured knowledge into data that informs strategic decision-making and operational adjustments within firms remains a significant gap.In addition, this study seeks to explore not only the theoretical foundation for a GIS-based knowledge-sharing platform but also the practical aspects of its implementation. Specifically, it will examine how such an application should be structured and integrated into existing systems to ensure usability and effectiveness. Understanding which systems the GIS application must connect with to create a seamless workflow is critical. The goal is to investigate how these integrations can support the ongoing capturing and application of lessons learned, while providing insights into the organizational and technical frameworks needed to make this solution work across construction firms. By addressing this gap, the study aims to provide a roadmap for improving organizational learning capabilities and enhancing project outcomes (Shokri-Ghasabeh & Chileshe, 2014; Ayodele & Kajimo-Shakantu, 2021).

This research will utilize Social Network Analysis (SNA) and Root Cause Analysis (RCA) to delve into the specific challenges construction firms face in capturing and leveraging lessons learned, particularly examining how organizational structures and network dynamics within these firms impede or facilitate knowledge transfer. The application of SNA, as described by Latora et al. (2017), will allow for the identification and analysis of key communicative roles within the network, measuring centrality metrics like betweenness, density, eccentricity, closeness, and degree to understand the flow of information and pinpoint critical nodes and gaps in communication. This analysis aims to quantify the structural barriers that prevent effective knowledge sharing within the organizational networks of construction companies, as highlighted by Hossain and Wu (2009). Root Cause Analysis will complement this approach by identifying the underlying causes that lead to these barriers, focusing on organizational and technological impediments as suggested by Vliet (2010). By integrating RCA, the research will move beyond merely describing patterns to understanding the root causes behind ineffective knowledge transfer, aiming to provide actionable insights that can lead to substantive improvements in how lessons learned are managed and utilized across projects within the construction sector. These methodologies will collectively offer a robust framework to not only map and understand the existing communication structures but also to propose targeted interventions that could enhance the overall efficiency and effectiveness of knowledge management practices within the construction industry.

1.2.2 Scope

The research is done for TU Delft and is done in collaboration with the Royal BAM Group where the data is gathered for this research provides a unique opportunity to explore these challenges and opportunities within a real-world context. BAM, being one of the leading construction firms in Europe, encounters diverse and complex project demands that necessitate robust data sharing mechanisms to streamline their tender processes effectively. TU Delft, renowned for its cutting-edge research in technology and construction management, brings academic rigor and innovative methodologies to the study.

This research is significant as it focuses on analyzing the mechanisms that influence the effective capture, sharing, and utilization of lessons learned during tender processes within the construction industry. The scope is visualized in Figure 4. By focusing on intra-organizational data sharing, the study aims to contribute to the broader field of construction management by providing empirical evidence and practical solutions that can enhance tender success rates and operational efficiency. For BAM, the findings and recommendations from this research will offer direct benefits in terms of reduced redundancies, enhanced coordination, and improved competitiveness in the market. For the academic community at TU Delft, this research enriches the scholarly discussions around construction management, particularly in the application of network theory and information systems in large-scale operational settings.

This research aligns with current industry trends towards digital transformation and emphasizes the need for an integrated approach to manage information flows, which are crucial for the strategic success of large construction projects.

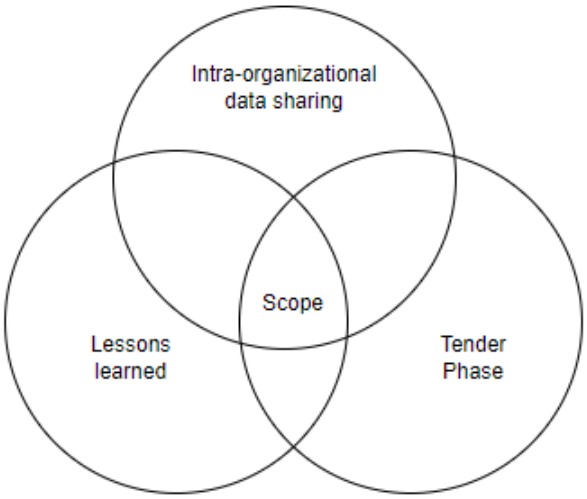


Figure 4: Scope research

1.2.3 Research questions

This research aims to explore how standardization, influenced by organizational structures and digital tools, impacts this communication. The primary question guiding this study is: How does standardization affect communication in construction industry tender processes? To address this, the research will identify specific communication barriers between departments, examine the influence of organizational structures on communication effectiveness, assess the digital tools in use, and evaluate the potential benefits of standardizing tender management processes. These questions are designed to provide a comprehensive understanding of the communication dynamics and offer insights for improving tender management in construction firms.

Main Question

RQ **How can the integration and capturing of lessons learned be enhanced within tender processes in construction organizations?**

The primary goal of this thesis is to address how the integration and capturing of lessons learned can be enhanced within tender processes in construction organizations. This question is important because the construction industry frequently faces challenges in effectively applying knowledge gained from past projects. Inefficiencies and repeated mistakes occur when these valuable insights are not shared or embedded in future tenders. By exploring the dynamics of knowledge-sharing practices and organizational learning, this research aims to emphasize the necessity of systematically capturing and using these lessons in a way that ensures they are accessible and relevant to all involved stakeholders. This study is essential for highlighting how lessons learned can improve the flow of information, ensuring that knowledge is applied consistently across departments.

Sub questions

To address the complexities of the main research question, this thesis is divided into four sub-questions. These sub-questions aim to cover different aspects of how lessons learned are

captured and integrated into the tender process. By focusing on these specific areas, the sub-questions provide a more detailed examination of the factors that influence knowledge-sharing within construction organizations. This structured approach ensures that various dimensions of the main question are considered, offering a clearer understanding of the challenges and opportunities involved in improving the use of lessons learned. The sub questions are:

Q1 **How do data sharing practices within a tender organization influence the movement of lessons learned during tender processes?**

This question examines how different organizational structures affect the effectiveness of capturing and applying lessons learned during tender processes. The focus is on how these structures either facilitate or hinder information flow and knowledge integration across departments, according to theory.

Q2 **What are the factors that influence the integration of lessons learned in tender processes, according to theory?**

This question examines how data sharing practices within an organization impact the effectiveness of capturing and utilizing lessons learned, according to theory. It considers the barriers that data sharing practices might create, such as information silos or fragmented communication, and the requirements necessary to overcome these barriers, like consistent data integration and accessible, centralized knowledge repositories.

Q3 **How does the intra-organizational data sharing network function within tender processes, in practice?**

This question investigates how data is actually shared and circulated within an organization during tender processes. It looks at how the internal data sharing network operates in practice, including the tools, channels, and methods used, and how effectively these facilitate the flow of information necessary for capturing and applying lessons learned.

Q4 **What are the enabling and limiting factors that influence the integration of lessons learned into organizational tender processes within the studied projects?**

This question examines how the specific organizational structures within the studied projects impact the practical capturing of lessons learned. It looks at how the way an organization is structured, such as how communication between teams and departments are arranged, affects the ability to effectively document and share lessons learned during tender processes.

These questions collectively aim to assess the impact of standardization, organizational structures, and digital tools on the management of lessons learned within the tender processes of construction firms. They focus on identifying key issues and opportunities for enhancing how lessons learned are captured, shared, and utilized effectively across the organization.

1.3 Research structure

The research structure and overview is shown in Figure 5. It summarizes the different work phases of this research and work methods. This structure will be used to answer the sub questions and eventually the main research question.

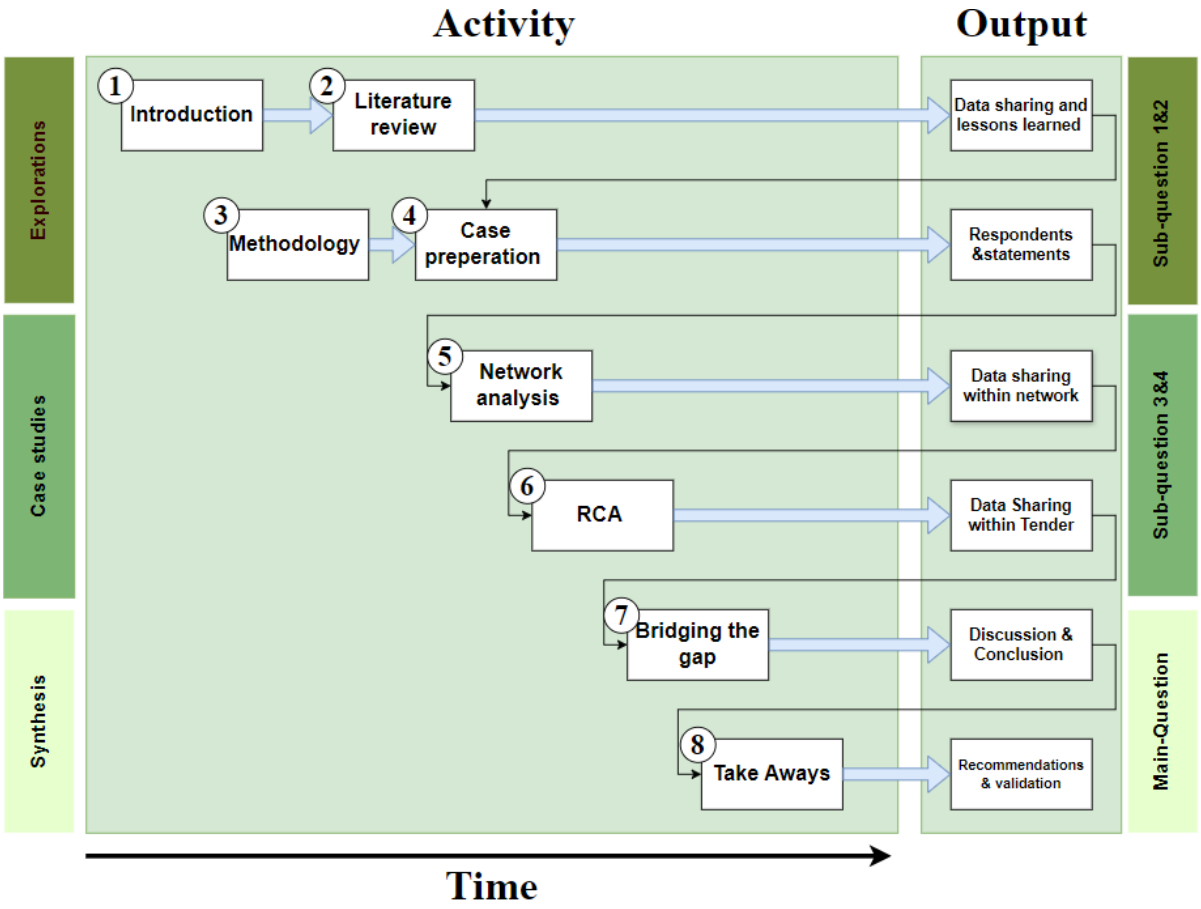


Figure 5: Research structure

2 Literature review

This literature review is an essential component of our study into the critical aspects of "lessons learned" and "data sharing" in the construction industry. Drawing upon the methodological framework proposed by Verschuren et al (2010), this review aims to systematically explore these multifaceted topics, uncovering underlying patterns, evaluating existing practices, and identifying gaps in current research. The design of our research project is deeply anchored in a combination of theoretical constructs and practical applications, offering a comprehensive analysis of how knowledge is managed, shared, and utilized in construction projects.

The first major area of focus is "lessons learned," which is pivotal for continuous improvement in the construction sector. This section delves into the management of lessons learned, exploring the processes and frameworks that support the capturing and codifying of insights within construction projects. It also examines the role of human behavior in the effectiveness of these lessons, including cognitive, social, and cultural dimensions. Further, the review assesses the impact of lessons learned on organizational learning and their broader implications for project success and strategic decision-making. Additionally, it considers the tools and technologies that facilitate the systematic management of lessons learned, alongside the standardization efforts that aim to enhance their effectiveness across projects.

The second area, "data sharing," addresses how information is exchanged within the construction industry, focusing on the influence of organizational structures on the flow of knowledge. This part of the review identifies the barriers to effective data sharing and explores strategies to enhance these practices, including the deployment of appropriate technological infrastructure. By investigating how data sharing and lessons learned interact within organizational settings, the review seeks to provide insights into improving overall project outcomes and the strategic success of construction firms. By integrating these discussions, the literature review will serve as the foundation for understanding the complexities of knowledge management in construction, paving the way for practical applications and strategic improvements in the field.

2.1 Lessons Learned

Lessons learned are fundamental processes within the realm of project management, aiming to refine future practices by reflecting on past experiences. These processes involve systematically capturing, documenting, analyzing, and utilizing insights from both successes and failures to foster continuous improvement. Key to this process is the collection of data that is both accurate and comprehensive, ensuring that future projects benefit from previous learnings (Duffield & Whitty, 2015). However, the effectiveness of lessons learned processes is profoundly influenced by the organizational environment in which they are implemented. The organizational culture and structure play pivotal roles in either facilitating or hindering the flow and utilization of knowledge. Studies highlight that supportive cultures, which encourage open communication and knowledge sharing, significantly enhance the success of lessons learned systems (Carrillo et al., 2004). Conversely, environments that do not cultivate these values may see diminished returns from their lessons learned initiatives. Additionally, the dynamic nature of project management, especially in industries like construction where tenders and project scopes can change rapidly, poses unique challenges. These environments require that lessons learned processes be highly

adaptive and responsive. Managers face the dual challenges of keeping up with the pace of change and ensuring that lessons are applied swiftly and effectively to benefit ongoing and future projects (Bohari et al., 2021; Debs & Hubbard, 2023). Building on this framework, Milton (2012) identifies three maturity levels of lessons learned initiatives that further illustrate the potential depth and impact of these processes within an organization:

- **Level 1 – Reactive Capture**: At this initial level, lessons are captured reactively and documented in a specified location. Individuals need to actively seek out these lessons or opt-in to receive notifications to gain knowledge.
- **Level 2 – Reactive Change**: This level advances by ensuring that captured lessons lead to actionable changes and are embedded into practice and processes. At this stage, individuals can access the embedded knowledge through updated procedures and processes without needing to read each lesson explicitly.
- **Level 3 – Proactive Change**: The most advanced level involves proactive 'lesson-hunting' across the organization. This involves prioritizing learning areas within a knowledge management plan and investigating themes and trends that may be obscured in operational lessons.

Milton finds that many organizations remain trapped at level 1 maturity, which offers minimal benefits. To truly harness the power of lessons learned as a method for organizational learning, Milton suggests aiming for at least level 2 maturity, where the integration of lessons into practices significantly enhances the learning culture and operational effectiveness.

2.1.1 Management of lessons learned

Lessons learned management involves the systematic approach to capturing, documenting, analyzing, and disseminating knowledge gained from the experiences of conducting projects. This management process ensures that valuable insights, both successes and failures, are actively integrated into the organization's practices, helping to improve future project performance and decision-making (Patton, 2001; Gowrishankar, 2012 Rhodes & Dawson, 2013; Taher, 2005). An effective lessons learned management process is composed of several key components, each of which plays a critical role in ensuring that knowledge is effectively utilized to benefit future projects. These components include (Duffield & Whitty, 2015; McClory et al., 2017; Levy & Salem, 2020) :

- **Identification**.
- **Documentation**
- **Analysis**.
- **Application**.
- **Dissemination**

The process of lessons learned is designed to systematically capture the outcomes and experiences from various aspects of project execution, including successes, failures, and near-misses (McClory et al., 2017). The primary goal is to absorb this valuable knowledge into the organizational structure, ensuring that it can be leveraged to enhance future performance and decision-making. Capturing comprehensive experiences is essential for the lessons-learned

process. By documenting what went well, organizations can replicate effective strategies and best practices in future projects. This creates a repository of successful methodologies that can be referred to and applied across different teams and projects (Nelson, 2021). Understanding what went wrong in a project is crucial for avoiding similar pitfalls in the future. Analyzing failures allows organizations to identify weaknesses in processes, technologies, or strategies, leading to the development of more robust systems (Hughes et al., 2016). Near-misses provide critical insights into potential risks that were narrowly avoided. Capturing these instances helps in improving risk management practices and implementing preventive measures before issues escalate into significant problems (Zhou et al., 2019).

2.1.2 Lessons learned barriers

Despite the structured approach to managing lessons learned, the success of these processes is not solely dependent on their systematic implementation. It is equally influenced by the organizational culture within which they operate. As we explore further, we will examine how cultural barriers can impact the effectiveness of lessons learned processes, shaping the ways in which knowledge is shared and utilized across projects. This is further supported by findings that the culture and structure of an organization appear to be critical success factors in the effective collection and dissemination of lessons (Williams, 2008; Koenig & Srikantaiah, 2004; Rhodes & Dawson, 2013). For lessons learned processes to be effective, organizational culture must support open sharing and learning from mistakes. A cultural change is needed to ensure these benefits are fully realized (Maya et al ., 2005). Building on this understanding, the most significant challenge to fully leveraging lessons learned is the organizational culture itself. For optimal results, a culture that promotes openness and continuous learning is essential (McCann & Buckner, 2004; Mason & Pauleen, 2003; De Long & Fahey, 2000; Carrillo et al. 2004). Duffield and Whitty (2015) highlight that both people and culture significantly impact the effectiveness of the Lessons Learned process. To investigate this issue further, Milton (2020) carried out a survey and identified the most common cultural barriers impacting the Lessons Learned process. These cultural barriers are:

1. Short-term thinking
2. Lack of openness to sharing
3. Lack of empowerment
4. Lack of challenge to the status quo
5. Lack of acceptance of new ideas
6. Secrecy
7. Internal competition
8. Preferring invention to re-use
9. Lack of performance drive
10. Lack of honesty in sharing.

These barriers are summarized in Table 1 Table 1to provide a clearer overview of how they manifest in organizations. Leadership plays a crucial role in the management of lessons learned within organizations, as it involves establishing, articulating, and upholding clear guidelines to enhance the process. While effective leadership is essential for creating systems to capture and share lessons, it can also pose significant barriers if not properly executed. Managers are expected

to provide consistent support and guidance, ensuring that guidelines are followed rigorously. A lack of clear direction can cause the lessons learned process to become fragmented and lose effectiveness (Davenport & Prusak, 1998; Weber et al 2001; Carrillo et al., 2004; Rhodes & Dawson, 2013). Studies focused on Australian construction contractors, for instance, have identified that unclear guidelines and insufficient management support are significant barriers to capturing lessons learned effectively (Shokri-Ghasabeh & Chileshe, 2014). Additionally, leaders must foster an environment where employees feel safe to share failures and learn from them. Psychological safety, as described by Edmondson (2004), is crucial for encouraging open reporting and active sharing of insights. Leaders who fail to create such an environment significantly hinder the lessons learned process by stifling the free exchange of information necessary for organizational learning and improvement. In the context of tenders, which often operate within rapidly changing environments due to the frequent introduction of new projects and requirements, leadership's ability to adapt and provide continuous learning opportunities becomes even more critical. According to Longenecker (2010), dynamic and rapidly changing organizations face unique challenges that can impede effective leadership, including intense time pressures and a lack of performance feedback. These conditions can severely restrict a manager's ability to absorb, implement, and disseminate lessons learned, which are crucial for navigating the complexities of tender processes.

Besides leadership and cultural barriers, time is another barrier that influences lessons learned processes (Le et al. ,2017; Rubin, 2013; Levy, 2018; Yang et al., 2019, Wiewiora & Murphy, 2015; Williams, 2008). Levy (2018) highlights that individuals often move on to the next task without pausing to reflect and learn from previous projects due to time constraints. Similarly, Wiewiora and Murphy (2015) and Williams (2008) emphasize that time pressure prevents thorough engagement in the Lessons Learned process, leading to incomplete learning. In the Australian construction industry, a study involving 450 organizations revealed that "lack of employee time" was one of the top barriers to effectively capturing lessons learned. Despite formal procedures, many organizations failed to retain LL documentation due to time constraints (Shokri-Ghasabeh & Chileshe, 2014). Similarly, in competitive tendering processes, time pressure often leaves little room for reflecting on lessons learned, impacting the effectiveness of future bids. A case study on SME contractors highlighted the adverse effects of time constraints on tendering, emphasizing the need for better time management to ensure lessons are captured and utilized (Ellis et al., 2021). Time constraints are a significant barrier to effective lessons learned management. To address this, organizations need to prioritize the Lessons learned process, allocate adequate time for reflection and learning, and integrate these activities into their regular workflows. By doing so, they can enhance their ability to learn from past experiences and improve future performance.

The survey's Williams (2008) and Wiewiora & Murphy (2015) stated that lack in motivation and incentives can also be seen as barriers. Reduced motivation to participate in the lessons learned process is a significant barrier to effective knowledge management. When employees do not see a direct benefit or acknowledgment for their contributions, they might not feel motivated to invest their time and effort into capturing and sharing lessons learned. Without incentives such as recognition, rewards, promotions, or bonuses, the perceived value of participating in the Lesson learned process diminishes, leading to reduced engagement and participation (Bresnen et al, 2022; Carrillo et al, 2004; Debs & Hubbard 2023; Duffield & Whitty, 2015). Incentives play a crucial role in motivating employees to actively engage in the LL process. Recognition for contributions can enhance an individual's sense of accomplishment and value

within the organization. Rewards and bonuses can provide tangible benefits that justify the time and effort spent on documenting and sharing lessons learned. Promotions linked to active participation in the LL process can further encourage employees to contribute their insights and experiences (Carrillo et al, 2004). When these incentives are absent, employees may prioritize other tasks that offer more immediate or visible benefits. This lack of motivation can result in incomplete or neglected documentation of valuable lessons, which in turn hampers the organization's ability to learn from past experiences and improve future performance (Kelly et al., 2017).

Lasty, the lack of clear guidelines and systematic lessons learned documentation influences the overall effectiveness of organizational learning, as it hampers the ability to uniformly capture, retain, and disseminate critical knowledge across the organization, leading to inconsistent improvements and the potential repetition of past mistakes (Naot et al., 2004). More than fifty percent of respondents in a survey conducted by Williams (2007) indicated that the absence of clear guidelines was a significant factor in the inadequate documentation of lessons learned. Furthermore, Carrillo et al (2014) mentioned it as the most influential barrier of knowledge management. Additionally, this lack of structured processes means there is no assurance for personnel that lessons learned are stored appropriately or reused effectively in future projects. This underscores the need for dedicated, enhanced storage solutions and systems that ensure lessons are not only saved but are also accessible and actionable for continuous organizational improvement (Wiewiora & Murphy, 2015). Recommended strategies to overcome this barrier include improving the knowledge-sharing process, which would yield significant benefits for the firm or organization (Martensson, 2000).

Table 1: Barriers lessons learned

Barriers lessons learned	source
Cultural	Williams, 2008; Koenig & Srikantaiah, 2004; Rhodes & Dawson, 2013; Maya et al., 2005; McCann & Buckner, 2004; Mason & Pauleen, 2003; De Long & Fahey, 2000; Carrillo et al., 2004; Duffield & Whitty, 2015; Milton, 2020.
Leadership	Davenport & Prusak, 1998; Weber et al., 2001; Carrillo et al., 2004; Rhodes & Dawson, 2013; Shokri-Ghasabeh & Chileshe, 2014; Edmondson, 2004; Longenecker, 2010.
Time	Le et al., 2017; Rubin, 2013; Levy, 2018; Yang et al., 2019; Wiewiora & Murphy, 2015; Williams, 2008; Shokri-Ghasabeh & Chileshe, 2014; Ellis et al., 2021.
Motivation and Incentives	Bresnen et al., 2022; Carrillo et al, 2004; Debs & Hubbard, 2023; Duffield & Whitty, 2015; Kelly et al., 2017.
Lack Systematic Documentation	Naot et al., 2004; Williams, 2007; Carrillo et al, 2014; Wiewiora & Murphy, 2015; Martensson, 2000.

2.1.3 Organizational Challenges in Implementing Lessons Learned

A divisional structure in an organization typically involves a setup where the company is divided into semi-autonomous units or divisions. Each division focuses on a specific aspect of the company's operations, such as a product line, geographic area, or market segment. This structure allows each division to operate independently while aligning with the overall goals of the organization (Mintzberg, 1980). Divisions work effectively because they allow a team to specifically focus on a single construction project or service, with a management structure that supports the primary strategic goals. Allocating specific resources to each division increases the likelihood that it will receive the necessary support from the company. Moreover, the specific focus of a division ensures that it can develop a common culture and team spirit, leading to better team morale and a deeper understanding of its own project portfolio. This is much more effective than having projects or services spread across multiple divisions within the organization (Mangla, 2015; Fairfield, 2016; Kuznetsova & Karpenko, 2018).

The divisional structure significantly impacts the management of lessons learned during tender processes in construction organizations. This setup often leads to knowledge silos and communication hurdles, which can severely affect project outcomes and the broader organizational learning environment. In discussing the divisional structure, it's important to recognize how this framework allows for specialization, which can be particularly advantageous in managing complex tenders tailored to specific market needs. Each division within an organization can focus on its segment of the market, developing expertise and strategies that are most effective for its specific conditions (Anokhov, 2020). However, this specialization often leads to the formation of silos, which can severely disrupt the flow of information between divisions. Such disruptions complicate coordination and hinder a comprehensive understanding of how individual tenders might impact the organization as a whole (Ayodele & Kajimo-Shakantu, 2021). When information remains confined within each division, the broader strategic implications and potential synergies may be overlooked, undermining the effectiveness of the organization's tender management (Gong et al., 2021). Moreover, the adoption of technology varies significantly across different divisions, which can further exacerbate communication barriers. Each division might choose systems and tools that best meet its specific needs, leading to a patchwork of technologies across the organization (Chen et al., 2021). This disparity makes it challenging to maintain a unified approach to digital processes, as each division operates on potentially incompatible platforms. This lack of standardized technology not only hampers the efficiency of information exchange but also complicates the process of aggregating data and insights at the organizational level, critical for strategic decision-making during tenders (Gamil et al., 2019). Effective coordination across these divisions becomes crucial, particularly when tenders involve multiple aspects of the organization. The challenge lies in ensuring that all divisions are aligned with the overall corporate strategy while still maintaining their operational independence (Demirkesen & Tezel, 2021). This balance is essential for the success of tenders that require cross-divisional collaboration. Divisions need to maintain their specialized focus and operational autonomy but also work in concert with the rest of the organization to leverage collective strengths and insights (Ayodele & Kajimo-Shakantu, 2021). By exploring these aspects of the divisional structure in this research, you can illuminate how these structural characteristics influence the effectiveness of communication during tender processes. Addressing the specific elements of silos, varied technological adoption, and the need for effective inter-divisional

coordination will provide a clearer understanding of the barriers to effective communication and coordination (Chelimo & Moronge, 2018).

While divisional structures allow each unit to focus on specific aspects of the company's operations, enhancing expertise and resource allocation, they also present challenges in managing lessons learned effectively across the broader organization. This specialization, although beneficial for targeted operations, often leads to the formation of knowledge silos and communication barriers. These barriers significantly impact how lessons are shared and utilized, affecting project outcomes and overall organizational learning (Ahmad & Bergsjö, 2021; Lesser & Fontaine, 2004).

According to Duffield & Whitty (2015), there is little evidence to suggest that lessons are consistently learned across various sectors. For example, an analysis of 10 major ICT business transformation projects revealed that, despite a wealth of available guidance, reports, and literature, organizations continue to repeat similar errors in areas such as planning, governance, project management, and tenders (Brouwer, 2011). One of the reasons is cultural differences between divisions (Cavaliere & Lombardi, 2015) . Organizational culture plays a significant role in shaping knowledge-sharing activities within companies. It not only influences the extent (Bhagat et al., 2002; Ford and Chan, 2003) but also the specific content of these knowledge-sharing processes (Kayworth and Leidner, 2003). This impact is especially pronounced in multinational corporations (MNCs), where cultural factors can dramatically affect employees' behaviors related to sharing and utilizing knowledge (Lucas, 2006). Furthermore, due to the technological disparities, it will be a challenge to integrate the different technologies used in each division (Chen et al., 2021). When divisions use disparate technological systems, each system might have its own method for documenting and storing information. This lack of uniformity can create challenges in aggregating and analyzing lessons learned across the organization (Shokri-Ghasabeh & Chileshe, 2014). For instance, one division might use a cloud-based platform that allows for real-time updates and easy access to lessons learned, while another might use a more traditional, localized database that isn't as accessible to other divisions (Tserng & Lin, 2004).

Building on the challenges outlined, it becomes evident that the presence of disparate technological systems and the diverse cultural landscapes within divisions underscore the necessity for implementing collaborative knowledge management systems (Dave & Koskela, 2009). Such systems would standardize the capture and dissemination of knowledge, ensuring that all divisions, regardless of their specific technologies or cultural backgrounds, have equal access to crucial lessons learned (Firestone & McElroy, 2012). This approach not only mitigates the issues caused by siloed information and cultural differences but also fosters a unified organizational knowledge base that enhances overall efficiency and effectiveness in managing tenders and projects (Vaz-Serra & Edwards, 2020; Dave & Koskela, 2009). From the identified challenges of diverse technological systems and varied cultural dynamics in divisional organizations, it is clear that collaborative knowledge management systems are crucial for harmonizing efforts across different divisions. By standardizing how knowledge is captured and disseminated, these systems ensure that every division has equal access to vital lessons learned, irrespective of the technological platforms or cultural environments they operate within.

2.1.4 Requirements Lessons learned

The Project Management Institute's (PMI) Project Management Body of Knowledge (PMBOK Guide) provides useful information for companies for implementantieng lessons learned practices. (Project Management Institute, 200). In reality, organizational learning from projects hardly ever happens, and even when it does, it doesn't produce the expected results.
(Atkinson et al., 2006; Milton, 2012; Schindler & Eppler, 2003; Williams, 2008) This discrepancy highlights the need to establish specific requirements for the application of Lessons learned in business processes. By formulating these requirements, organizations can ensure that the insights gained are relevant, validated, accessible, and integrated into their operations, thereby fostering a continuous improvement process (Chirumalla, 2016). In this chapter, the key requirements associated with lessons learned practices will be examined. Table 2 summarizes the main issues identified in the literature, providing a detailed overview of each problem along with its corresponding references.

Williams (2008) identifies various methods and formats for capturing lessons learned, such as lessons learned sessions, project debriefings, post-project reviews, after-action reviews, and post mortems (Schindler & Eppler, 2003). However, many organizations tend to view lessons learned reports as final products created only at the end of a project. This perspective often results in the low prioritization of capturing lessons, especially since team members are usually already assigned to new projects or busy with other reports. This delay can make it challenging to document crucial experiences in a timely manner (Kerzner, 2017; Schindler & Eppler, 2003).
To facilitate organizational learning and prevent the repetition of mistakes, continuous documentation and reporting of lessons learned is essential. Duffield and Whitty (2015) emphasize that ongoing documentation fosters organizational learning. Similarly, Kotnour (2000) highlights how continuous reporting helps build a valuable knowledge repository, ultimately improving the performance of future projects. Schindler and Eppler (2003) stress the importance of regularly updating lessons learned to maintain their relevance and ensure their integration into future projects. Kerzner (2017) critiques the common practice of treating lessons learned as an afterthought and underscores the necessity of capturing project insights promptly. Supporting this view, Anbari et al. (2008) explain that continuous lessons learned reporting is vital for enhancing project management competencies and overall organizational learning. By making the documentation of lessons learned a continuous and integral part of the project lifecycle, organizations can significantly benefit from the accumulated knowledge and improve their project outcomes. Despite the advantages of continuous documentation, another significant challenge arises from the problem of incomplete reporting.

Reports that lack sufficient detail and context make it difficult to understand and apply lessons effectively in future projects (Tan et al., 2006). Incomplete reporting creates gaps in organizational knowledge, hindering continuous improvement, as argued by Duffield and Whitty (2015). They stress the necessity of a comprehensive and systematic approach to ensure all valuable insights are captured and utilized. Newell and Edelman (2008) further underscore that incomplete reports result in lost knowledge, emphasizing the need for thorough documentation to build a dynamic learning capability. Similarly, Sense (2007) notes that incomplete lessons learned reporting prevents full knowledge transfer and hampers the learning process, advocating for structured environments that support comprehensive documentation. Julian (2008) adds that incomplete reports can lead to repeated mistakes and missed opportunities for improvement,

stressing the importance of detailed and continuous reporting to facilitate cross-project learning. Williams (2008) also explores the challenges organizations face in learning from projects, noting that incomplete reports contribute to these difficulties and emphasizing the necessity of comprehensive reporting to ensure effective knowledge capture and application.

To address these challenges effectively, multiple disciplines like, safety, project management, knowledge management, and system engineering can significantly benefit from the proper integration of lessons learned into business processes (Drupsteen & Guldenmund, 2014; Carrillo et al., 2013). This integration is crucial not only for project management but also for enhancing organizational knowledge management, fostering an enabling environment for collaboration, and promoting continuous learning and improvement across various sectors (Abbas et al. 2021; Vandeville & Shaikh, 1999). Furthermore, Abbas et al (2021) emphasizes the importance the of incorporating lessons learned is essential for continuous improvement and organizational learning. Integrating these lessons into business processes is crucial for achieving both long-term and short-term goals.

Another requirement for incorporating lessons learned is the validation and verification of lessons learned. Validating lessons learned is crucial before incorporating them into your process to ensure their accuracy and relevance. Unverified lessons can lead to the implementation of ineffective or even harmful practices, wasting resources and time (Fong & Yip, 2006). Validation ensures that the lessons are based on factual data and successful outcomes, providing a solid foundation for process improvement (Weber et al., 2000). Barriers to the effective implementation of lessons learned procedures include issues such as team availability, lack of a trusting environment, and lack of perceived value. These factors hinder the validation and integration of lessons learned into future projects (Carrillo et al., 2013; Disterer, 2002). Trust and legal issues also play significant roles in the effective use of lessons learned. For lessons to be validated and effectively applied, a trustworthy environment and clear understanding of legal implications are crucial. Trust and legal risks are major concerns (Arif, et al., 2015; Carrillo et al., 2013), although few companies face legal issues related to lessons learned, with contractors being more concerned about these matters than owners (Yohe, 2006). Furthermore, the transformation of post-project evaluation information into reusable knowledge is limited. This limitation affects the validation process, as lessons learned are not effectively shared or used. Transforming evaluation information into reusable knowledge remains a significant challenge, impacting the dissemination and practical application of lessons learned (Hwang, 2022; Yap and Toh, 2020). To ensure the effective utilization of lessons learned in knowledge management, validation and verification are essential. Addressing barriers such as team availability, trust issues, legal implications, and the effective dissemination of knowledge is critical. Validation and verification ensure that lessons are accurate, relevant, and beneficial, providing a solid foundation for continuous improvement and organizational learning.

For organizational learning and knowledge management it is crucial to determine ownership of lessons learned to eventually utilize the benefits of lessons learned (Eken et al., 2020; Shokri-Ghasabeh & Chileshe, 2014). Clear ownership ensures accountability and responsibility, which are vital for the successful implementation and follow-up of lessons learned. When ownership is established, specific individuals or teams are tasked with the responsibility of documenting, validating, and disseminating the lessons learned, thereby ensuring that the information is accurate and comprehensive. Ekenet al. (2020) describes different roles involved in ownership of lessons learned. The Project Coordinator plays a crucial role in defining projects in the system, ensuring the project's details are correctly entered and maintained. This role

involves creating, modifying, and deleting projects in the system. The Knowledge Manager is responsible for reviewing, editing, approving, and deleting lessons learned, ensuring the quality and relevance of the lessons before they are added to the organizational memory. The Knowledge Source role is assigned to employees who are qualified to contribute their experiences to the knowledge management system, where they are responsible for entering lessons learned into the system. Finally, the Knowledge Seeker role includes employees who are authorized to search and access lessons learned but cannot modify or add new information to the system. Each of these rolls have different task in lessons learned systems, Figure 6 showcases the different task of each role.

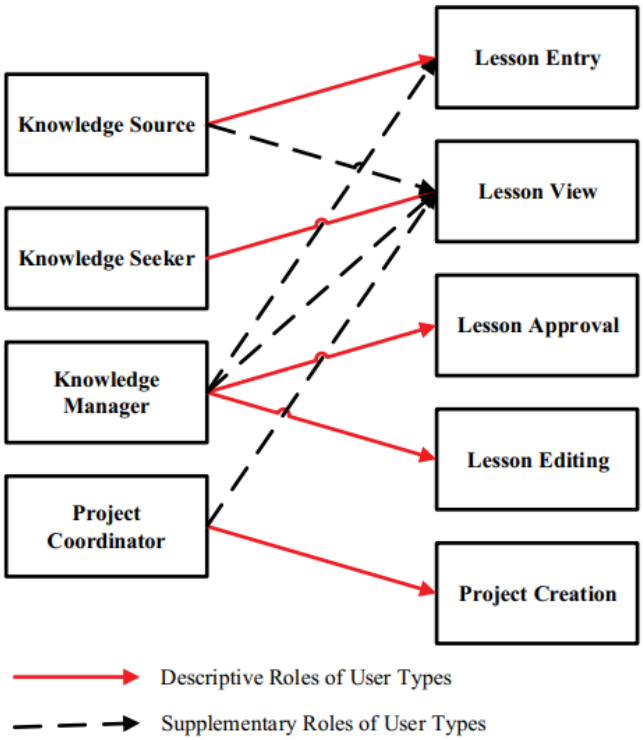


Figure 6: lessons learned users and their tasks (Eken et al., 2020)

Lastly, another crucial requirement for effectively utilizing lessons learned is the implementation of a standardized taxonomy (McClory et al., 2017; Williams, 2008). The adoption of a standardized taxonomy for lessons learned within a construction firm significantly enhances intra-organizational knowledge management processes (El-Diraby et al., 2005). By implementing a uniform framework for documenting and categorizing lessons, the firm ensures that critical information is systematically captured and easily accessible across all departments and projects. This standardization minimizes inconsistencies and ensures that all stakeholders interpret the lessons uniformly, reducing errors and enhancing project outcomes (Iyer et al., 2009). Furthermore, it streamlines the sharing and transfer of knowledge within the firm, crucial for projects that often involve overlapping skills and similar challenges. A standardized taxonomy thus serves not only to preserve valuable project insights but also to facilitate continuous learning and improvement, driving the firm towards higher efficiency and better risk management in its future endeavors (Eken, et al., 2020; Iyer et al., 200).

Table 2: Requirements lessons Learned

Requirements	Small Description	References
Continuous Documentation	Continuous documentation is crucial for preventing the repetition of mistakes and enhancing organizational learning. It helps build a valuable knowledge repository, improving future project performance.	Kerzner, 2017; Schindler & Eppler, 2003; Anbari et al., 2008; Duffield & Whitty, 2015; Kotnour, 2000
Comprehensive and Systematic Approach	A comprehensive approach is necessary to capture all valuable insights and utilize them, addressing the challenge of incomplete reporting which leads to knowledge gaps and hinders improvement.	Duffield & Whitty, 2015; Newell & Edelman, 2008; Sense, 2007; Julian, 2008
Integration into Processes	Proper integration of lessons learned into business processes is crucial for continuous improvement and achieving organizational goals. It fosters collaboration and continuous learning across various sectors.	Drupsteen & Guldenmund, 2014; Carrillo et al., 2013; Abbas et al., 2021
Validation and Verification	Validating and verifying lessons learned are essential to ensure their accuracy and relevance before implementation. This process addresses potential issues such as ineffective or harmful practices that waste resources and time.	Fong & Yip, 2006; Weber et al., 2000; Carrillo et al., 2013; Arif, et al., 2015; Hwang, 2022; Yap and Toh, 2020
Ownership of Lessons	Establishing clear ownership of lessons learned ensures accountability and responsibility, crucial for the successful implementation and follow-up. Different roles such as Project Coordinator and Knowledge Manager play specific tasks in this process.	Eken et al., 2020; Shokri-Ghasabeh & Chileshe, 2014
Standardized Taxonomy	Adopting a standardized taxonomy within an organization enhances knowledge management processes, ensuring that lessons are systematically captured and uniformly interpreted across all departments and projects. This facilitates knowledge sharing and continuous learning, reducing errors and enhancing project outcomes.	McClory et al., 2017; Williams, 2008; El-Diraby et al., 2005; Iyer et al., 2009; Eken, et al., 2020

Assigning clear ownership and accountability for the lessons learned process ensures that specific individuals or teams are responsible for capturing, documenting, and applying insights. Walker and Christenson (2005) emphasize the importance of having designated roles to manage lessons learned effectively. Lessons must be easily accessible and shareable within the organization. Latino et al. (2016) highlight the importance of a well-organized knowledge management system to facilitate the distribution and access to lessons learned.

2.2 Data Sharing

In this section, the focus is on data sharing practices within construction firms and their impact on project management. The discussion begins with an examination of how data is defined and utilized in this research, emphasizing the critical role of both structured and unstructured data (section 2.1). Section 2.2 then explores the benefits and workings of intra-organizational data sharing, highlighting the importance of effective communication and coordination across departments to optimize the use of shared information. This is followed by a detailed look at data sharing practices in divisional organizations (section 2.3), where common practices and typical information flows within large construction firms are analyzed. Section 2.4 identifies and discusses the key barriers to effective data sharing, including technological, cultural, and structural challenges. Finally, section 2.5 addresses the integration and accessibility of various types of data, underscoring the importance of compatibility and effective data management systems to enhance project outcomes.

2.2.1 Data

"Transmittable and storable information on which computer operations are performed" and originates from 1946 (Etymology Dictionary, 2019). Data can be broadly defined as pieces of information collected through observation, measurement, or creation that are often used for analysis, reasoning, or planning. This information can take many forms, ranging from numbers and text to images and sounds. The primary purpose of data is to serve as a factual basis for making decisions, conducting studies, or developing technologies (McClain & Cobb, 2001; Liu et al., 2019). The concept of data is central to nearly all aspects of modern life and is crucial in fields as diverse as science, business, healthcare, and technology. Data allows us to capture reality in a quantifiable and analyzable form, providing insights that might not be immediately obvious and enabling predictions about future trends and behaviors (Boesdorfer et al., 2020; Schenthal, 1960). For this study, data is defined as a mix of quantitative and qualitative elements, including structured and unstructured numbers, facts, statistics, and documents, which are analyzed for decision-making. This definition suits the research scope, ensuring that the data types addressed are directly relevant to the study's objectives and practical implications.

According to the reference by Bellinger, Castro, and Mills (2003), data becomes information when it is processed in a way that provides context and relevance. Specifically, the transformation of data into information involves organizing and interpreting raw data so that it gains meaning and can be utilized for decision-making or problem-solving. Ackoff (1989) describes the data, information, knowledge, and wisdom (DIKW) hierarchy in his work. Ackoff depicts a pyramid where data is filtered into information, information progresses into knowledge, and finally, knowledge is elevated into wisdom. Figure 7 showcases this pyramid.

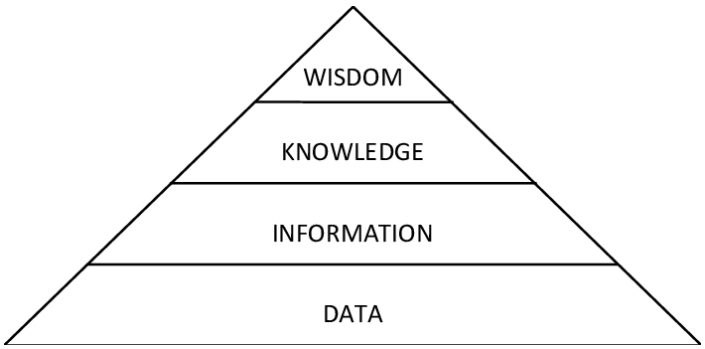


Figure 7: DIKW pyramid (Ackoff, 1989)

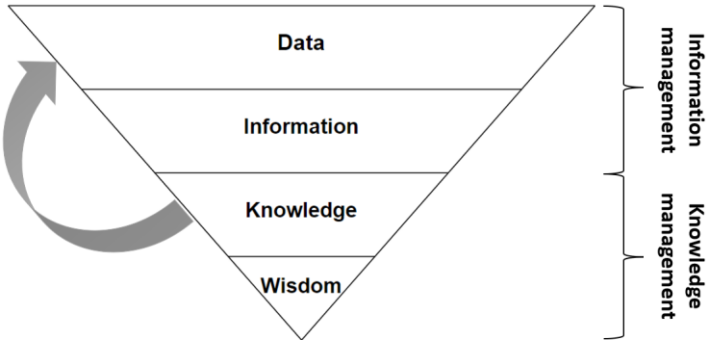


Figure 8: DIK pyramid with adaption (Own illustration)

Following 1987, numerous adaptations of the DIKW hierarchy were suggested by various researchers who had different views on the appropriate representation of the model. In 2007, Rowley reexamined the DIKW hierarchy, taking into account these various interpretations. Specifically, the definitions of the elements and the structure were reevaluated (Rowley, 2007). According to Ackoff (1989), wisdom is the pinnacle of the hierarchy. However, In the context of the inverted hierarchy, wisdom serves as the foundation that helps us determine relevant and meaningful data (Figure 8). Rowley states: "Typically information is defined in terms of data, knowledge in terms of information, and wisdom in terms of knowledge, but there is less consistency in the description of the processes that transform elements lower in the hierarchy into those above them" (Rowley, 2007, p. 177). This implies that wisdom provides direction for which data should be collected and analyzed. Furthermore, knowledge helps in organizing and contextualizing information. Rowley emphasizes that: "knowledge is the combination of data and information, to which is added expert opinion, skills, and experience, to result in a valuable asset which can be used to aid decision making" (Rowley, 2007, p. 223). This shows that knowledge forms the bridge between raw data and useful information, but wisdom is crucial in determining which knowledge is valuable.

Transforming knowledge into actionable data represents a complex challenge, particularly as data increases in both volume and complexity. According to studies (S. Chen et al., 2012; Van Hemert et al., 2009), knowledge is not defined merely by information, but rather through a process that determines which data and information are relevant and how they should be used. S. Chen et al. (2012, p. 114) states “Implicit knowledge is subjective, experience-based, and hard to articulate. Such knowledge is often context-dependent and context-specific”.
This process is not only technical but also social, goal-driven, context-bound, and culturally determined, which is essential for creating meaningful business insights. Establishing a robust feedback loop between knowledge management and information management is crucial for converting organizational knowledge into actionable data. This cycle facilitates the ongoing use of accumulated insights to generate further understanding and informed decision-making. Therefore, this research will not only look at methods for data mining and management but also how 'lessons learned' can be systematically integrated into organizational data flows, thus supporting and enhancing decision-making. This includes exploring how the complexity and increasing volume of data affect knowledge management within companies, particularly in terms of bridging the gap between knowledge and data for improved collaboration and reducing missed opportunities due to data silos (You & Wu, 2019; Teisserenc & Sepasgozar, 2021).

2.2.2 Intra-organizational data sharing

Data sharing involves the storage and preservation of data, but it is chiefly focused on enabling access for the utilization and reuse of data and is defined as the process of transmitting and/or receiving data between individuals (Tenopir et al., 2011). Figure 9 showcases the stage of the data life cycle. The data life cycle encompasses the various stages that data undergoes from initial creation to final disposition, ensuring its effective management and utilization throughout its existence. It begins with data acquisition, where data is collected from various sources, such as sensors, surveys, or transactions. Proper acquisition ensures that the data is accurate, relevant, and timely. Once acquired, data needs to be stored securely to ensure its integrity and accessibility. This stage involves saving data in databases, data warehouses, or cloud storage solutions, with appropriate backup and security measures. Next, during the data process and enrichment stage, raw data is cleaned, transformed, and enhanced to improve its quality and usability. This may involve removing duplicates, correcting errors, and integrating data from multiple sources to create a comprehensive dataset. In the use and share stage, processed data is then utilized for analysis, decision-making, and operational purposes, and shared with relevant stakeholders to ensure that the insights gained can inform strategic actions. Subsequently, data is archived to ensure it is preserved for long-term access. This involves storing data in a manner that maintains its integrity and availability over time. Finally, in the preserve and re-use stage, archived data is maintained and made available for future use and analysis, ensuring that valuable information continues to benefit the organization and inform new research or decisions (Rahul & Banyal, 2020; Badia, 2020; Wing, 2019).

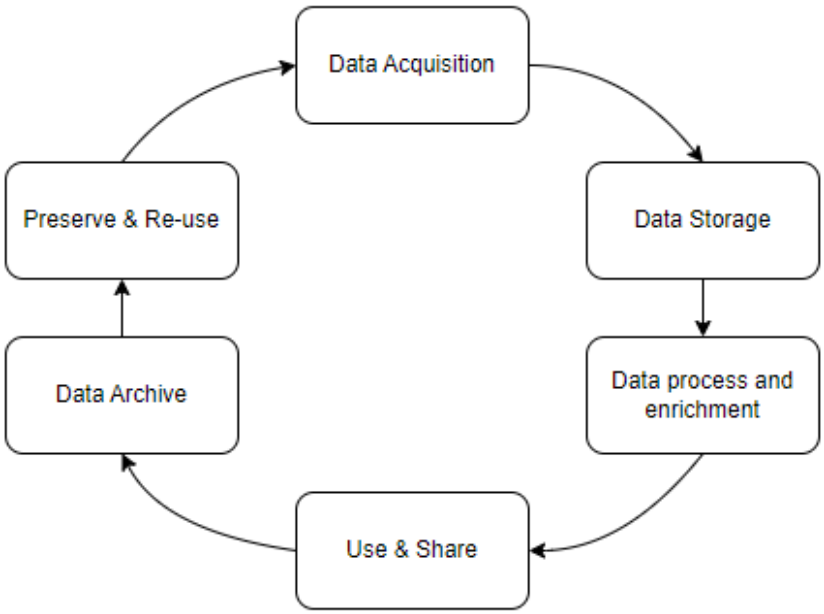


Figure 9: Data Life Cycle

Despite its importance, intra-organizational data sharing in the construction industry faces significant challenges. Technological limitations, such as incompatible data management systems and the lack of integrated platforms, hinder seamless data sharing (Abolbashari et al., 2018). Moreover, the organizational structure of construction firms, often characterized by divisional setups, leads to isolated knowledge pools and impedes the free flow of information across the

organization (Bühler et al., 2023). The absence of standardized processes for data management and sharing creates inconsistencies that undermine overall efficiency. Without clear guidelines, different divisions may develop their own practices, leading to a fragmented approach (You & Wu, 2019). Addressing these challenges is essential for enhancing data management and the utilization of lessons learned in the construction industry. Implementing robust data governance frameworks, standardizing data formats, and promoting a culture of data sharing are critical steps (Chen et al., 2021; Ayodele & Kajimo-Shakantu, 2021). Leveraging advanced technologies, such as data warehouses and secure data sharing platforms, can facilitate efficient and secure data exchange (Martínez-Rojas et al., 2016). Providing ongoing training and support ensures that employees understand the importance of data sharing and are equipped to manage and utilize shared data effectively (Manoharan et al., 2022).

To enhance the performance of an organization and ensure effective intra-organizational data sharing, it is essential to implement robust data governance frameworks. These frameworks standardize data formats and promote a culture of data sharing, which is critical for maintaining consistency and efficiency across departments (Chelimo & Moronge, 2018; Gamil, Rahman, & Nagapan, 2019). Leveraging advanced technologies such as data warehouses and secure data sharing platforms can facilitate efficient and secure data exchange, overcoming technological limitations and fostering better integration of data systems (Pellerin et al., 2022; Aziz & Ghuzdewan, 2023). Providing ongoing training and support ensures that employees understand the importance of data sharing and are equipped to manage and utilize shared data effectively (Manoharan et al., 2022). This holistic approach addresses the challenges posed by incompatible data management systems and isolated knowledge pools, ultimately improving organizational performance and competitiveness in the construction industry (Ayodele & Kajimo-Shakantu, 2021; You & Wu, 2019).

2.2.3 Data Sharing Practices in Divisional Organizations

In construction projects, effective intra-organizational data sharing is critical for efficient project management and successful tender submissions. Different departments, such as procurement, design, engineering, and sales, play distinct roles, each with specific information flows (Alreshidi et al., 2018). Figure 7 represents the social network of various stakeholders involved in the tendering process within construction firms. Each node in the network signifies a stakeholder, while the edges depict the communication pathways and interactions among them. This intricate web of connections highlights the necessity for robust communication channels to ensure smooth tender preparation and submission. Figure 8 delves deeper into the requirements for a cloud-based Building Information Modeling (BIM) governance platform, which addresses both socio-organizational and technical needs. Socio-organizational and legal requirements focus on improving communication functions, developing collaboration protocols, clarifying roles and responsibilities, raising awareness, providing help and support, standardizing data management policies, and offering training. These elements are crucial to foster a collaborative culture and ensure that all stakeholders are aligned in their efforts (Alreshidi et al., 2018).

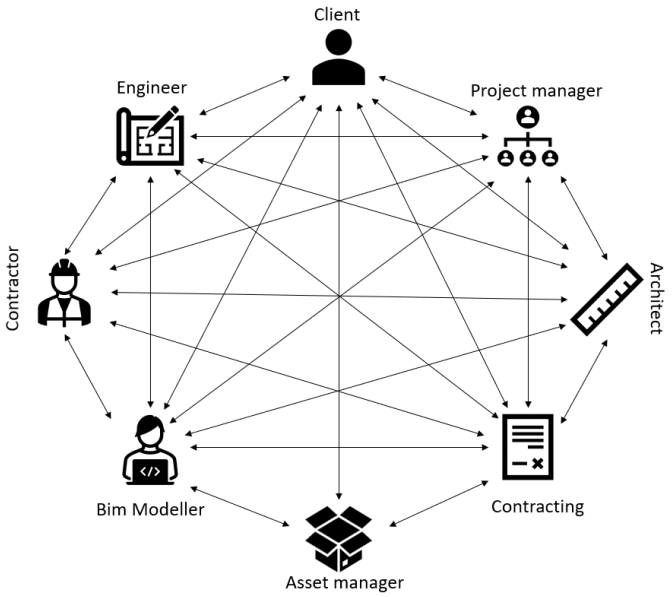


Figure 10: Conventional data sharing (Alreshidi et al., 2018)

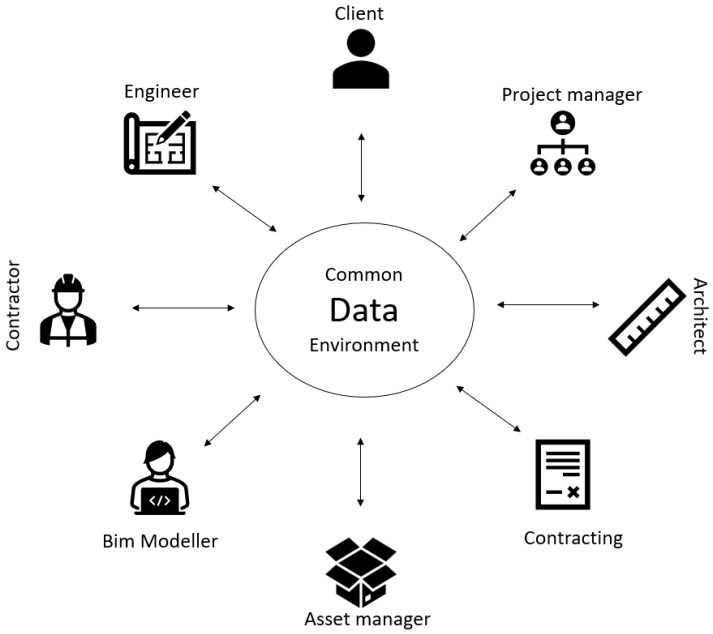


Figure 11:Common Data environment

These Figures (10 & 11) illustrate the contrast between conventional data sharing methods and the integration of a common data environment within construction projects, specifically during the tendering process. The conventional data sharing model highlights the challenges and inefficiencies associated with fragmented data exchange, while the common data environment demonstrates how a unified, cloud-based approach can significantly enhance collaboration and streamline data management. This approach effectively addresses the complex interaction needs of various stakeholders and overcomes barriers related to data governance and integration (Alreshidi et al., 2018; Shen et al., 2010).

The procurement department manages costs and budgets, performing cost analyses and negotiating with suppliers to ensure competitive tender documents (Chelimo & Moronge, 2018). The design department focuses on meeting customer specifications, complying with building codes, and integrating aesthetics with functionality, ensuring that all requirements are met within budget (Dimyadi et al., 2016). The engineering department ensures the feasibility and safety of designs, integrating the latest technologies and construction methods to enhance project efficiency and sustainability (Pellegrini et al., 2020). The sales and marketing department communicates project benefits to potential customers, develops compelling proposals, and conducts market research to inform the tender strategy (Dax et al., 2019).
Effective data sharing among these departments involves system integration and interdepartmental collaboration, facilitated by regular coordination meetings and project reviews. Implementing robust data governance frameworks, standardizing data formats, and leveraging advanced technologies such as data warehouses and secure data sharing platforms are essential for efficient and secure data exchange (Ayodele & Kajimo-Shakantu, 2021; Martínez-Rojas et al., 2016). Ongoing training and support ensure that employees understand the importance of data sharing and are equipped to manage shared data effectively (Chen et al., 2021). This cohesive approach enhances knowledge management practices, leading to improved project outcomes and a stronger competitive position in the market.

Despite its importance, intra-organizational data sharing in the construction industry faces significant challenges. Technological limitations, such as incompatible data management systems and the lack of integrated platforms, hinder seamless data sharing (Abolbashari et al., 2018). Moreover, the organizational structure of construction firms, often characterized by divisional setups, leads to isolated knowledge pools and impedes the free flow of information across the organization (Bühler et al., 2023). The absence of standardized processes for data management and sharing creates inconsistencies that undermine overall efficiency. Without clear guidelines, different divisions may develop their own practices, leading to a fragmented approach (You & Wu, 2019). Addressing these challenges is essential for enhancing data management and the utilization of lessons learned in the construction industry. Implementing robust data governance frameworks, standardizing data formats, and promoting a culture of data sharing are critical steps (Chen et al., 2021; Ayodele & Kajimo-Shakantu, 2021). Leveraging advanced technologies, such as data warehouses and secure data sharing platforms, can facilitate efficient and secure data exchange (Martínez-Rojas et al., 2016). Providing ongoing training and support ensures that employees understand the importance of data sharing and are equipped to manage and utilize shared data effectively (Manoharan et al., 2022).

Coordination among various stakeholders, such as architects, engineers, contractors, and clients, is crucial for the successful and efficient completion of projects. Mustapha et al. (2018) point out the significant negative impact that a lack of communication and coordination can have on construction projects. This issue occurs when various stakeholders such as architects, engineers, contractors, and clients are not well informed of each other's activities, decisions, or changes in the project, as well as when departments within a construction company are not aware of each other's activities (Qusef, Daradkah, Sammour, & Albadarneh, 2019). The importance of effective communication and coordination within construction projects cannot be overstated. When the flow of information is poor or unclear, complications quickly accumulate. Here follows a detailed list of the most common communication defects that undermine the efficiency and success of construction projects.

A common bottleneck in construction projects is the failure to share essential information in a timely manner, which directly affects project planning and execution. This is well illustrated by the example of an engineer who makes changes to the foundation design without communicating these changes timely to the planners or executors. Without the new information, contractors continue to work according to the old design, leading to necessary but delaying adjustments later in the construction process. Atout (2019) highlights how such communication inefficiencies during the tendering and construction phases significantly contribute to project delays. The study emphasizes the importance of clear objectives, adequate risk identification, and timely communication between the client, the consultant, and the contractor to prevent delays arising from misunderstandings or a lack of information about such design adjustments.

Furthermore, errors in communication can cause cost overruns (Gamil et al., 2019). This can manifest in various ways and lead to financial overruns. For example, the repetition of work resulting from incorrect or untimely communicated information. When, for example, a BIM specialist makes changes to the design, but these changes do not reach the construction team in time, work may have already begun on finalizing a tender. This leads to the possibility that work must be undone and redone, which is not only inefficient but also directly increases labor costs and project duration (Shin et al., 2018). Additionally, poor coordination between different departments, such as procurement, design, and execution, can overlook crucial data. A mismatch in scheduling can arise when materials arrive at the construction site too early or too late. This

results in additional storage costs or causes work stoppages, leading to further delays and costs. These examples illustrate how essential clear and timely communication is within the construction industry to reduce cost overruns and inefficiencies (Ariyawansha & Francis, 2022). A lack of coordination during a tender process can significantly affect the quality of the end product in several ways. During the tendering process, insufficient communication between designers and the estimation department can lead to the preparation of inaccurate bids. If crucial cost items are omitted or underestimated, this can result in a compromise on the quality of construction materials or methods to stay within budget. This puts the construction company under pressure to perform the work within the proposed costs and according to the planned schedule, which often proves unfeasible (Dandan et al., 2019). Once a contract based on these inaccurate bids is awarded, the mistakes and omissions often only come to light during the construction phase. This leads to necessary but costly changes and adjustments, which not only incur additional costs but also delay the completion of the project. Such scenarios underscore the importance of accurate and effective communication throughout the entire tendering process to ensure that projects are completed on time, within budget, and according to specifications (Deep et al., 2017).

Finally, inefficient use of time and resources during the tender process in a construction company is often a direct result of poor communication. During this process, approvals are often required from various levels within an organization before a bid can be submitted. If communication channels between these levels are not functioning efficiently, a lot of time can be lost waiting for necessary approvals and feedback. This can result in significant delays that jeopardize the deadlines for tender submission, often leading to rushed work and an increased chance of errors (Tandale et al., 2023). Moreover, without clear communication, collaboration between teams responsible for cost estimates, technical design, and project planning may be suboptimal. This can lead to an incorrect allocation of resources; for example, too many resources may be allocated to a less critical aspect of the bid, while critical areas remain understaffed. Such misallocations can undermine the quality of the tender documents and significantly reduce the chance of winning the tender (Wei et al., 2016).

In conclusion, addressing the challenges posed by organizational structure is critical for enhancing data management and the utilization of lessons learned in the construction industry. Implementing robust data governance frameworks, promoting a culture of data sharing, and providing ongoing training are essential steps to improve communication and coordination, ultimately leading to better project outcomes and competitive advantage (Chen et al., 2021; Ayodele & Kajimo-Shakantu, 2021; Martínez-Rojas et al., 2016; Manoharan et al., 2022).

2.2.4 Barriers to Effective Data Sharing

In construction projects, effective data sharing is paramount for the successful and efficient completion of projects. However, several significant barriers hinder this process, including technological, cultural, and structural obstacles.

One of the primary barriers to effective data sharing is the lack of effective communication and coordination among various stakeholders such as architects, engineers, contractors, and clients. Mustapha et al. (2018) highlight the significant negative impact that poor communication and coordination can have on construction projects. This issue arises when stakeholders are not well informed of each other's activities, decisions, or changes, as well as when departments within

a construction company are unaware of each other's activities (Qusef et al., 2019). Ineffective communication can lead to various complications, such as delays and cost overruns. For example, an engineer might change the foundation design without timely communication to planners or executors, leading to delays and increased costs (Atout, 2019; Ariyawansha & Francis, 2022). Errors in communication can also result in the repetition of work, further increasing labor costs and project duration (Shin et al., 2018). Poor coordination between departments can lead to scheduling mismatches, such as materials arriving too early or too late, causing additional storage costs or work stoppages (Ariyawansha & Francis, 2022). Additionally, insufficient communication during the tender process can result in inaccurate bids, compromising the quality of construction materials or methods to stay within budget (Dandan et al., 2019; Deep et al., 2017). Inefficient use of time and resources during the tender process is often a direct result of poor communication, leading to rushed work and an increased chance of errors (Tandale et al., 2023; Wei et al., 2016) .

Resistance to technological changes is another significant barrier to effective data sharing. In the construction industry, the introduction of new technologies often encounters resistance, leading to communication barriers. This resistance is often fueled by a lack of training and fear of the unknown, which undermines the efficiency and effectiveness of communication (Noruwa et al., 2020). When companies introduce new technologies without adequate training and support, employees may feel ill-equipped to use the technology effectively, leading to inefficiencies and longer project times (Pellegrini et al., 2020; Beer & Mulder, 2020). A lack of training can lead to data inconsistency and poor data accessibility, making it difficult for team members to access reliable information, negatively affecting the compilation of tender documents (Martínez-Rojas et al., 2016). Additionally, incomplete knowledge transfer due to inadequate training can result in misinterpretations and incorrect decisions during the tender process (Pellerin et al., 2022). Generational differences within a company can also cause resistance to new technologies. Younger workers might embrace new digital tools more readily, while older workers may prefer traditional methods, creating a divided workplace and communication barriers (Demirkesen & Tezel, 2021). Different generations also have varying learning styles, which can further complicate the adoption of new technologies (R. Wang et al., 2020).

Differences in information flows between departments within a construction company can also lead to communication barriers. Each department, such as procurement, design, engineering, and sales, has distinct information flows that can result in miscommunication and inefficiencies. The procurement department focuses on managing costs and budgets, the design department ensures that customer specifications are met, the engineering department ensures the feasibility and safety of designs, and the sales department communicates project benefits to potential customers (Chelimo & Moronge, 2018; Dimyadi et al., 2016; Pellegrini et al., 2020; Dax et al., 2019). However, differences in these information flows can lead to asymmetric information, where some departments do not have full knowledge of other departments' requirements, compromising project quality (Anokhov, 2020). High time pressure and strict deadlines in the tender phase can also complicate information flows, leading to rushed and inaccurate proposals (Hyun et al., 2020; Mikulík & Hanák, 2023). Additionally, discrepancies in technological adoption and the compatibility of different systems between departments can lead to information silos and inefficiencies (Teisserenc & Sepasgozar, 2021; Ayodele & Kajimo-Shakantu, 2021).

In summary, effective data sharing in construction firms is hindered by a lack of communication and coordination, resistance to technological changes, and differences in information flows. Addressing these barriers through robust data governance strategies,

adequate training, and integrated information systems is crucial for improving project outcomes and maintaining a competitive edge.

2.2.5 Data Integration and Accessibility

Throughout the lifecycle of a construction project, a substantial amount of data is generated. This data encompasses various aspects such as project management information, BIM details, GIS, and sensor data from construction machinery (Garyaev & Garyaeva, 2019). However, without integrated communication and information systems, this wealth of data often remains siloed within different departments or systems, leading to inefficiencies and coordination challenges. Ayodele and Kajimo-Shakantu (2021) argue that addressing these system integration issues is crucial for enhancing the efficiency and effectiveness of the tender process. By integrating various data sources into a unified system, construction companies can improve data accessibility and ensure that all stakeholders have access to the information they need to make informed decisions, ultimately leading to more successful project outcomes (Ayodele & Kajimo-Shakantu, 2021).

The types of data generated during a construction project are diverse, each serving distinct purposes and requiring unique handling and integration techniques. For instance, project management data includes schedules, budgets, and progress reports, which are essential for tracking project performance and ensuring adherence to timelines and financial constraints (Chelimo & Moronge, 2018). BIM data, on the other hand, provides detailed 3D models of building structures, facilitating design visualization, clash detection, and coordination among various stakeholders (Shin et al., 2018). Additionally, GIS data offers spatial information that supports site analysis, planning, and environmental impact assessments. This data type is crucial for ensuring that construction activities align with geographic and regulatory requirements (Anokhov, 2020). Sensor data from construction machinery provides real-time information on equipment usage, performance, and maintenance needs, enabling proactive management of resources and reduction of downtime (Ayodele & Kajimo-Shakantu, 2021). The integration of these varied data types poses significant challenges. For example, combining BIM data with GIS can enhance spatial analysis and project planning, while integrating project management data with sensor data can improve resource allocation and operational efficiency (Pellegrini et al., 2020). Effective data integration ensures that all relevant information is accessible in a cohesive manner, supporting comprehensive decision-making and enhancing overall project outcomes (Beer & Mulder, 2020). Addressing the challenges associated with integrating these diverse data types helps construction companies overcome information silos and improve communication and coordination across all project phases. This holistic approach to data management not only enhances the efficiency of the tender process but also contributes to the successful delivery of construction projects (Michaud et al., 2019).

The integration of data in construction projects not only involves combining different types of data but also addressing the differences between structured and unstructured data. As the construction industry becomes increasingly data-driven, understanding and effectively managing both structured and unstructured data is essential for optimizing project outcomes and enhancing efficiency (Soibelman et al., 2008). Structured data is primarily quantitative, consisting of measurable data types such as numbers, dates, and strings (Bilal et al., 2019). This type of data

can be organized and displayed in rows, columns, and relational databases, making it easily manageable and searchable through traditional database systems. Examples of structured data include numbers, dates, and strings that are often used in project schedules, budgets, and progress reports. Structured data is typically managed using Structured Query Language (SQL), which allows for efficient querying and manipulation of the data. It is estimated that structured data constitutes about 15% of enterprise data. Generally, structured data requires less storage space compared to unstructured data due to its organized nature. Due to its organized format, structured data is easier to manage and protect. The consistency and predictability of its format simplify data governance and security measures (Bilal et al., 2019; Soibelma et al., 2008). Unstructured data is primarily qualitative, including non-numeric information such as text, schedules, images, and videos. Unlike structured data, unstructured data cannot be easily organized into rows, columns, or relational databases because it lacks a predefined structure, making it more challenging to manage. Examples of unstructured data include emails, meeting notes, site images, videos, and sensor data from construction machinery, which provide rich context and insights but are more difficult to process. Managing unstructured data requires more advanced and diverse methods beyond SQL, such as natural language processing (NLP) and text mining. Unstructured data makes up an estimated 85% of enterprise data, reflecting its prevalence and the significant challenge it poses for data management (Bilal et al., 2019). This type of data requires more storage space due to its varied formats and often larger file sizes. Unstructured data is more difficult to manage and protect due to its lack of structure. The diverse and unpredictable nature of unstructured data necessitates more sophisticated data management and security strategies (Jiang et al., 2013; Bilal et al., 2016).

Given these complexities, the effective integration of both structured and unstructured data becomes crucial. Such integration can significantly enhance decision-making processes in construction projects (Tixier et al., 2016). The importance of working with accurate and integrated data cannot be overstated, as incorrect or siloed data can lead to unforeseen costs and delays later in the project. When project data is not properly integrated or managed, critical information can be overlooked, resulting in costly errors, rework, and schedule overruns. Ensuring that all data, both structured and unstructured, is accurate, up-to-date, and accessible to all relevant stakeholders is essential for preventing these issues. Proper data integration facilitates timely and informed decision-making, which is crucial for staying within budget and on schedule. Figure 12 showcases that rework due to changes are the most expensive. While the beginning of the project has the highest influence on the cost of the total project.

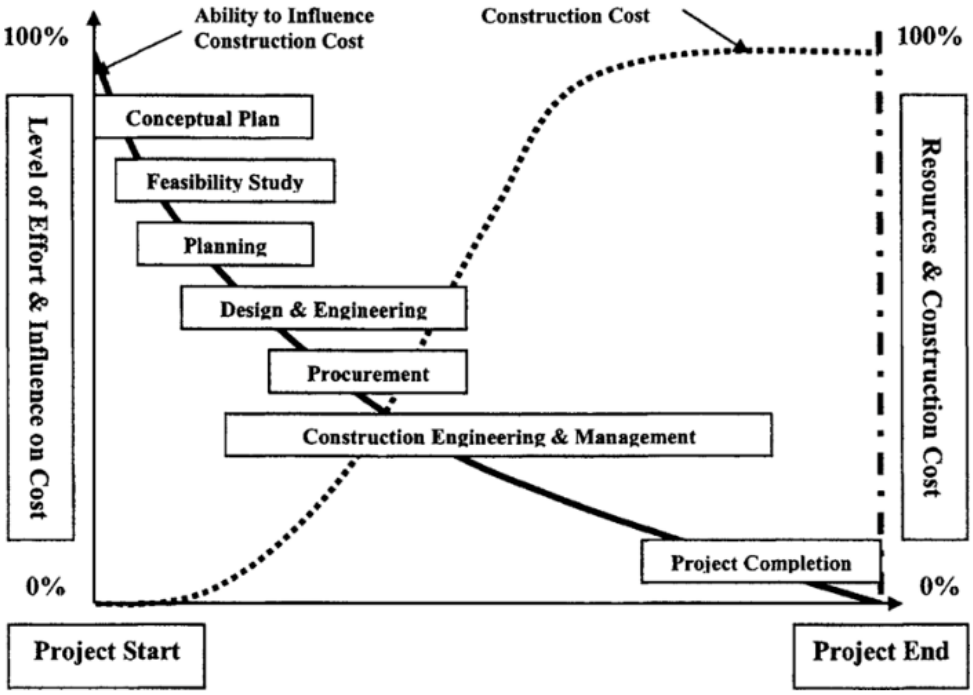


Figure 12: Influence of early decision making on life cycle project (Sinha et al., 2007)

Thus, the integration of diverse data types not only enhances decision-making but also safeguards against the financial and temporal risks associated with data mismanagement (Demirkesen & Ozorhon, 2017). In this context, data quality becomes a critical factor. The importance of data validation in ensuring that data is fit for its intended purpose is highlighted by formalizing validation requirements, which streamlines communication, enables process automation, and maintains ongoing data quality (Van der Loo & De Jonge, 2020). Additionally, a taxonomy-driven approach in requirements engineering is emphasized for its role in structuring and categorizing data dimensions, which is essential for improving the quality of data in construction applications (El-Shehaly et al., 2018). This approach ensures that all relevant aspects of data are considered during integration, leading to more reliable outcomes. Furthermore, critical dimensions of data quality, such as ownership and validation, play a significant role in understanding how data quality impacts the entire data lifecycle. These dimensions ensure that data remains relevant and reliable, thereby enhancing the value derived from data-sharing initiatives and improving decision-making processes (Albrecht et al., 2018).

2.3 Factor identification

At the conclusion of this literature review, a factor analysis has been conducted, identifying 19 key factors that have emerged from the research, shown in Table 3. These factors will serve as a foundational framework for further investigation, which will be elaborated upon in the methodology section.

In the subsequent case studies, these 19 factors will be tested to determine their presence and relevance within three distinct real-world cases. The goal is to examine whether these theoretical factors are applicable in practical scenarios and to identify the root causes associated

with them in actual practice. This approach will enable a thorough testing of the theoretical findings against contemporary activities in real-world contexts. A detailed explanation of these factors can be found in Appendix A.

Of these factors, it is important to highlight the specific influences they bear on the themes explored within this thesis:

- Factors 1, 3, 6, 8, 10, and 13 are particularly influenced by data sharing practices, as discussed in the chapter "Data Sharing Harmonization." These factors illustrate how effective data sharing can enhance the applicability and impact of lessons learned within an organization.
- Factors 2, 4, 5, 7, 9, 11, 12, 13, 14, 15, 16, 17, and 19 are significantly influenced by the broader lessons learned framework itself, as these factors encapsulate the key components necessary for the successful integration and application of lessons learned in organizational processes.

Table 3: Factors lessons learned

Factor	Sources
1. Searchability and Accessibility of Lessons Learned	Williams (2008), El-Diraby et al. (2005), Koenig & Srikantaiah (2004)
2. Shared Learning Sessions for Knowledge Exchange	Kotnour (2000), Maya et al. (2005), Duffield & Whitty (2015)
3. Use of Digital Platforms for Knowledge Sharing	McClory et al. (2017), Tserng & Lin (2004)
4. Mentorship and Coaching to Reinforce Lessons Application	Weber et al. (2000), Carrillo et al. (2013), De Long & Fahey (2000)
5. Top-Down Support for Prioritizing Lessons Learned Integration	Shokri-Ghasabeh & Chileshe (2014), Davenport & Prusak (1998), Milton (2020)
6. Encouraging Bottom-Up Communication to Capture Insights	Dave & Koskela (2009), Drupsteen & Guldenmund (2014), Bresnen et al. (2022), Mason & Pauleen (2003), Milton (2020)
7. E-Learning Modules to Train Employees on Lessons Learned	Fong & Yip (2006), Weber et al. (2000), Martínez-Rojas et al. (2016)
8. Formalized Processes for Capturing and Applying Lessons Learned	Drupsteen & Guldenmund (2014), Kerzner (2017), Wiewiora & Murphy (2015)
9. Continuous Improvement Cycles Driven by Lessons Learned	Duffield & Whitty (2015), Williams (2008), Newell & Edelman (2008)
10. Data Analytics to Identify Trends in Lessons Learned	Eken et al. (2020), Firestone & McElroy (2012), Martínez-Rojas et al. (2016)
11. Fostering a Learning-Oriented Culture for Knowledge Integration	Carrillo et al. (2013), Duffield & Whitty (2015), Naot et al. (2004)
12. Integration of Lessons Learned into the Tender Lifecycle	Abbas et al. (2021), McClory et al. (2017), Brouwer (2011)

13. Active Involvement of Management in Promoting Lessons Learned	Fong & Yip (2006), Shokri-Ghasabeh & Chileshe (2014), Le et al. (2017)
14. Effective Documentation Tools for Capturing Lessons Learned	McClory et al. (2017), Milton (2020), Wiewiora & Murphy (2015)
15. Motivation and Incentives to Encourage Participation in Lessons	Carrillo et al. (2004), Kelly et al. (2017), Bresnen et al. (2022), Levy (2018), Wiewiora & Murphy (2015)
16. Training Programs for Lessons Learned Best Practices	Fong & Yip (2006), Rhodes & Dawson (2013), Kerzner (2017)
17. Psychological Safety to Encourage Open Sharing of Insights	Rhodes & Dawson (2013), Edmondson (2004), Duffield & Whitty (2015)
18. Interdepartmental Communication for Cross-Project Learning	Dave & Koskela (2009), Ayodele & Kajimo-Shakantu (2021), Milton (2020)
19. Monitoring and Adjustments to Refine Lessons Learned Processes	Drupsteen & Guldenmund (2014), Levy (2018), Julian (2008)

2.4 Wrap Up

This section concludes by highlighting key barriers to effective lessons learned processes and data sharing in construction. It underscores the need for systematic integration and technological solutions to enhance knowledge retention and accessibility.

Lessons Learned

The literature reveals that construction companies often struggle to progress beyond the initial level of maturity in their lessons learned processes, as defined by Milton (2012). Most organizations remain at Level 1 - Reactive Capture, where lessons are documented but not systematically integrated into practices. The barriers to advancing these processes are significant and include cultural resistance, lack of leadership support, and insufficient time allocated for reflection (Williams, 2008; Carrillo et al., 2004; Shokri-Ghasabeh & Chileshe, 2014). These barriers create environments where lessons learned are underutilized, reducing their impact on future project success.

To overcome these challenges, the literature emphasizes the need for more systematic approaches to lessons learned. These approaches include continuous documentation, comprehensive analysis, and better integration of lessons into daily business processes (Duffield & Whitty, 2015). Additionally, validation of lessons learned is crucial to ensure they are relevant and actionable, with some literature suggesting the implementation of dedicated teams for this purpose (Fong & Yip, 2006; Carrillo et al., 2013).

Data Sharing

In terms of data sharing, the literature indicates that construction companies often rely on methods such as email for disseminating information. While this approach may be convenient, it is not ideally suited to the growing need for a CDE. Relying on these traditional methods can lead to the persistence of data silos and challenges in transforming knowledge into actionable data. The divisional structures common in construction firms further exacerbate this issue by isolating

data within specific departments, making it difficult for the organization as a whole to access and utilize this information effectively (Chen et al., 2021; Carrillo et al., 2014).

To address these issues, the literature advocates for the adoption of a CDE, which would integrate various data sources and make information more accessible across the organization. Such environments facilitate better data integration, standardization, and accessibility, ensuring that all relevant stakeholders can access the information they need in real-time (Ayodele & Kajimo-Shakantu, 2021). Additionally, there is a need for technological solutions that support data sharing across different platforms and systems to overcome the limitations of fragmented data management practices (Martínez-Rojas et al., 2016).

One important area that has not been extensively explored in existing research is how a GIS application can enhance knowledge management practices by linking lessons learned to geographic information. While GIS tools are traditionally used for managing spatial data, there is potential to integrate tender-related lessons learned documents into these systems, creating a central platform that allows for easy retrieval and use of lessons learned based on geographical locations. This would provide users with both spatial context and easy access to structured knowledge, streamlining the learning and data-sharing processes across projects and departments.

Revealed Lessons learned factors

In the literature, several key factors have been identified that influence the integration of lessons learned into project management processes, as shown in Table 18. These factors encompass a range of technological, organizational, and cultural barriers that can impede the effective application of lessons learned. A critical observation is the need for better communication channels, standardized processes, and supportive organizational culture to facilitate the integration of lessons learned. While the research highlights these barriers, it is essential to examine how these factors operate in real-world settings. The next phase of this research will explore how these identified barriers impact the integration of lessons learned in practice, providing a more in-depth understanding of their influence on the overall process.

In addition, although GIS applications primarily serve to manage geographical data, their potential to enhance knowledge management by linking lessons learned to specific project locations is also worth exploring. This research will briefly assess how such a system could provide added context and improve the accessibility of critical project knowledge.

3 Methodology

The methodology employed in this research serves as the backbone to answer the research questions. By employing a systematic approach that combines literature review, case studies, and interviews, this study aims to provide comprehensive insights into the challenges and opportunities associated with optimizing tender processes through digitalization and standardization. The methodology will help with systematic data collection, analysis, and synthesis. It will help with identification of challenges, and generation of actionable insights necessary to address the research questions effectively.

The validation of this research will begin with the literature review were conclusions will be drawn from analysis of exciting scientific papers related to integration of digital tools and the approach to departmental differences within a construction firm. The case studies serve as a practical examination of the research questions in real-world scenarios. And finally expert interviews offer in-depth, qualitative data from individuals directly involved in tender management and digital integration efforts. The integration of findings from literature review, case studies, and expert interviews facilitates a cross-validation process, where conclusions are tested against multiple sources of evidence.

3.1 Mixed research method

This research employs a mixed research method, integrating both quantitative and qualitative approaches to yield a comprehensive understanding of the intra-organizational data sharing processes during the tender phase in large construction companies like BAM. The rationale for adopting this methodological approach is grounded in several key benefits that align with the objectives and context of the study. According to Yin (2009) mixed methods research is beneficial because it allows for triangulation, which enhances the validity and reliability of the results by cross-verifying data through multiple sources or methodologies. Mixed methods research, by its nature, is more challenging to execute due to the complexity of integrating multiple methodologies. However, this approach is particularly well-suited for addressing broader and more complex research questions that single-method studies might not fully capture. In this study, the primary research method involves conducting case studies that examine contemporary projects within the organization. These case studies specifically focus on behavioral events related to data sharing, providing insights into the dynamics and challenges of intra-organizational communication during the tender phase in large construction companies. Yin (2014) identifies project-based elements and the presence of a 'how' research question, as seen in this study, as critical indicators for conducting a case study.

To robustly address the complexities of intra-organizational data networks during the tender processes at BAM, this research will implement three case studies. This Multi case study approach is strategically chosen to enhance the depth and reliability of the findings (Figure 13). Each case study will provide distinct insights into the dynamics of data sharing within different contexts or project environments at BAM, allowing for a more nuanced understanding of the organizational behaviors and procedural variations. This research employs an Multiple case study design to investigate data sharing practices within a construction firm during the tender

processes, with a specific focus on the incorporation and impact of lessons learned. Multiple case studies enable a comprehensive analysis by allowing you to examine the lessons learned process across different tenders or projects (Figure 14). Each case functions independently, offering insights into specific aspects of the lessons learned mechanism within its unique context (Yin, 2009). Firstly, Quantitative data will be collected by conducting a close-question survey. According to Krause (2002), this comprehensive approach ensures the reliability and validity of the survey items, making it a robust method for collecting quantitative data. To support the generalization of the survey outcomes, a large sample of respondents is needed.

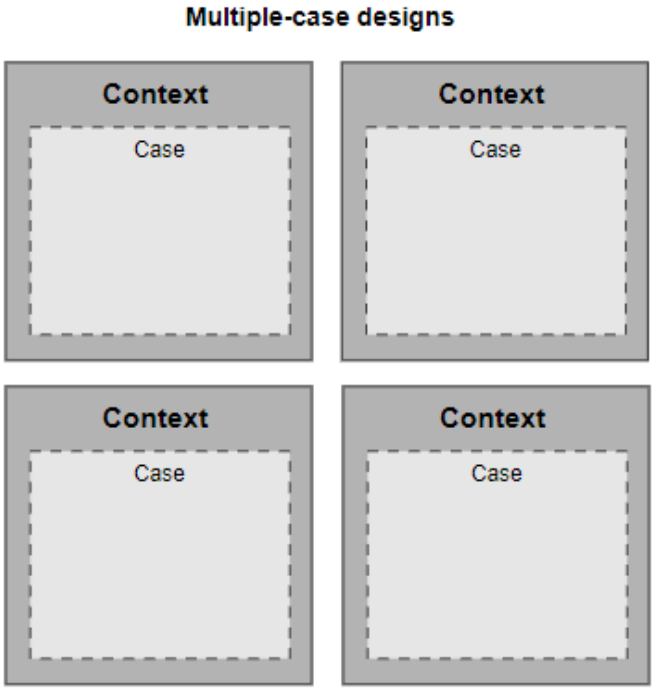


Figure 13: Multiple-case design (Yin, 2009)

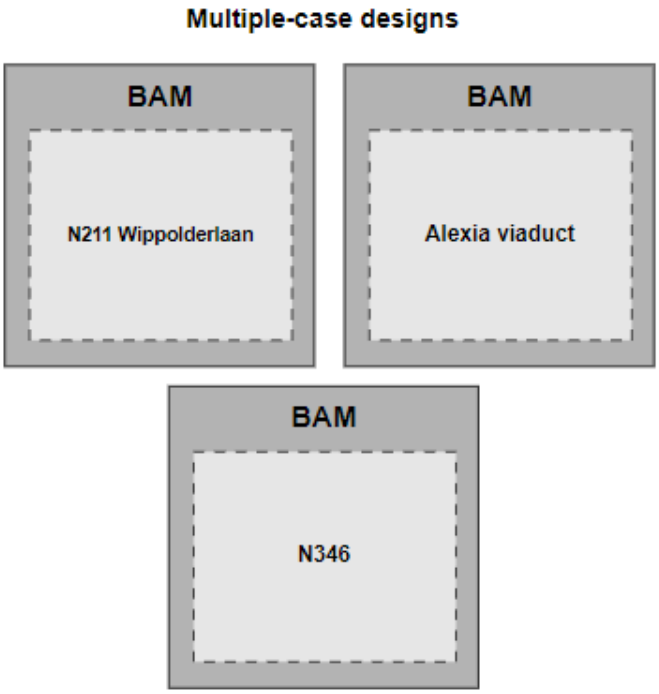


Figure 14: Multiple-case design this research

Secondly, from case studies, qualitative data typically includes interview transcripts, observation notes, documents such as project reports and correspondence, and responses from open-ended survey questions (Yin, 2009). This type of data provides rich, descriptive insights into people's experiences, attitudes, and the operational context within the case study, allowing for in-depth analysis of complex phenomena.

3.2 Case Preparation

In this research, the case studies are carefully chosen from recently completed tender processes at BAM. This selection ensures that the analysis is deeply rooted in the most current operational contexts, accurately reflecting the existing data sharing practices and feedback mechanisms within the company. Each case will provide a detailed look into how information and feedback are currently managed and utilized across various projects, drawing on the extensive information and knowledge from these recent activities. Through this comprehensive examination, the study aims to explore potential approaches for implementing a standardized feedback process across different departments and projects within BAM.

3.2.1 Exploratory interviews

In the context of my research on information streams within the tender process, there is decided to investigate several specific aspects aimed at gaining a deeper understanding of the dynamics and specific challenges experienced by experts (Ellis et al., 2011). This is done by doing exploratory interviews. The findings out of the interviews will be placed in Appendix B. The interviews will dive into some components that are based on the theoretical framework and the literature review. The questions will be based on these components to obtain a better understanding in the themes that are associated with tender process communication.
The decision to conduct exploratory interviews stems from the need to uncover new ideas and provide better direction for my research. These interviews offer an opportunity to gather in-depth insights from professionals who are directly involved in the tender process, allowing for a nuanced understanding of the challenges and opportunities they encounter. By engaging with experts, the interviews can reveal practical perspectives that may not be fully captured in the literature, thereby enriching the research with real-world experiences. The questions posed during the interviews were carefully designed to explore obstacles encountered in projects, experiences with communication, feedback processes, and the future potential of digital tools within the tender process. These areas were selected to ensure that the interviews would provide valuable data on the most pressing issues related to tender process communication, particularly in the context of ongoing digital transformation.

The respondents included a diverse group of professionals, each bringing unique expertise to the discussion. The participants were a BIM Specialist, Tender Manager, Planner, Digitalization Manager, and Knowledge Manager. Their combined insights will offer a comprehensive view of the tender process from multiple perspectives, facilitating a deeper understanding of the factors that influence communication and decision-making in this critical phase of construction projects.

According to Yin (2009), it is crucial that the cases selected for research are well-justified in terms of their relevance and suitability to the study's objectives. This ensures that the cases are not only representative but also contribute meaningfully to the research findings. Table 4 outlines the predefined criteria used to select the cases, demonstrating the alignment between these cases and the specific requirements of the study.

Table 4: Pre-defined condition for the cases

Project condition	Description
Phase	All projects should be finished tenders by BAM, won or lost
Data Network	Each case project should have been equipped with a well-maintained and presentable data-sharing network.
Time	Each Tender should have been completed in the last 18 months
Team size	The tender team sizes should have a minimum of 20 people
Scope	The project should all be the same type (rail, roads, infrastructures)

3.2.2 Desk research

The desk research was conducted to explore the organizational structures of the selected tenders and to understand how the various divisions within BAM Infra Civiel are represented in these processes. The company DMS, specifically the SharePoint of BAM Infra Civiel, was utilized to analyze the divisional structure and gather necessary information for the survey. This platform provided valuable insights into previous tenders, including details about the individuals involved and their respective roles within the tender process. By accessing this information, I was able to see how different divisions contributed to the overall process, which helped me to develop more targeted survey questions that accurately reflect the operational dynamics and complexities of the tender process.

3.2.3 Qualitative factor analysis

The qualitative factor analysis will be conducted as part of the case preparation to identify and understand the key factors highlighted in the literature review that influence the tender process. This analysis is intended to capture and describe the variability among observed correlated variables, while retaining those factors that are most meaningful and comprehensible to the researcher (Sovacool, 2013). The insights gained from this analysis will guide the in-depth interviews, which are essential for the subsequent RCA. By focusing on these factors early on, the interviews can be more targeted and relevant, ensuring a thorough examination of the underlying causes within the tender process.

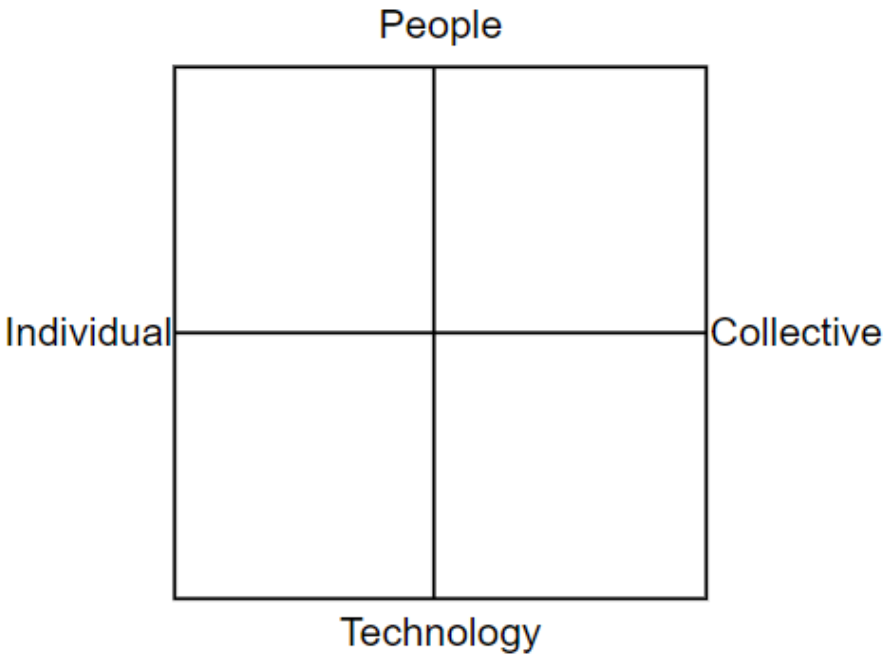


Figure 15:Qualitative Factor Grid

The grid depicted in Figure 15 is structured along two axes: "Individual-Collective" and "People-Technology." These axes represent two critical dimensions of data management within the tender

process (Delone & McLean, 2003). On this grid, the 19 lessons learned factors discussed in the literature and detailed in Table 2 will be plotted. This visual representation allows for the clustering and grouping of these factors, facilitating the identification of patterns and relationships. By organizing the factors within these dimensions, the analysis can yield statements that are both meaningful and actionable. These statements will serve as the foundation for the RCA which will be further explored through in-depth interviews with the respondents from the surveys. This approach ensures that the theoretical insights gained from the literature are thoroughly tested and validated in practical, real-world contexts.

3.2.4 GIS application

The GIS Application was developed to improve the documentation and sharing of lessons learned, best practices, and near-miss reports within the tender process. One of the primary reasons for developing this application is the challenge of fragmented data and inefficient communication between departments, as highlighted earlier in this study. The lack of a centralized system for managing and accessing knowledge documents makes it difficult for project teams to effectively apply lessons from previous projects. According to Ellis et al. (2021), fragmented knowledge transfer contributes to the repetition of mistakes and inefficiencies in the construction sector, underscoring the need for better-organized knowledge sharing. A critical factor for the success of the GIS application will be its integration with existing platforms such as SharePoint (a DMS) and Relatics (a MBSE). This integration ensures that knowledge and project documents are not only centrally managed but also easily accessible through a user-friendly interface. SharePoint will serve as the storage platform for documents, while Relatics will provide structured project data. The GIS application will act as a visual interface, linking these systems and associating documents and knowledge with geographical locations. This will not only place project information in context but will also enhance collaboration between departments, making knowledge easier to find and apply. The layout of this GIS application is being developed as a tool for the challenges identified, with the goal of making project knowledge more accessible across departments. During discussions with experts, the concept was further refined to focus on ensuring that the tool can be effectively integrated into existing workflows and systems. This reflects the need for a centralized, user-friendly platform, as discussed by AlMaian & Qammaz (2019), where knowledge will not only be stored but also easily accessed and applied.

The current GIS portal at BAM, as highlighted by the GIS specialist, is primarily used as a support tool for geographic visualization and data management during tenders. The GIS portal does not serve as a central repository for documents such as design information or inspection reports, instead, these documents are stored in SharePoint and linked to geographic objects displayed in the GIS. This allows data such as roads, bridges, or other project locations to be enriched with relevant documents, though the actual storage and management of these documents occur in SharePoint. In the context of a tender, a GIS map can be used to visualize project areas or locations relevant to the tender. However, a common problem is that the information collected during the tender phase in GIS is often not automatically transferred to the execution phase of the project. As a result, when a tender is won, a new project environment must be set up, which limits the full utilization of the information gathered in the earlier stages. This GIS application tries to facilitate real-time knowledge transfer, ensuring that essential information collected during the tender phase is seamlessly carried over into the execution phase.

By providing immediate access to critical documents linked to specific geographic locations, the application will prevent the loss of valuable insights during project transitions and ensure that lessons learned are actively applied throughout all project stages.

The development of the GIS portal arises from the observed need to address inefficiencies in knowledge sharing and the accessibility of important project documents, such as lessons learned, best practices, and near-miss reports. Prior to this project, it became clear that one of the main challenges in the tender process was the absence of a structured, centralized system for capturing and retrieving valuable project insights. Without such a system, knowledge sharing often becomes fragmented across departments, limiting the ability of teams to efficiently apply past knowledge to new projects, as noted in various studies (Beer & Mulder, 2020; Kululanga et al., 2001). In discussions with a GIS specialist, the importance of integrating a digital tool to streamline knowledge accessibility was emphasized. These insights reinforced the need for a portal that could visually represent projects and related documents, making it easier for users to locate and apply relevant lessons learned. This approach reflects findings from broader industry research advocating for digital platforms to facilitate knowledge transfer and reduce data fragmentation (Eken et al., 2020)

The GIS application design that will be developed aims to enhance the documentation and accessibility of lessons learned reports within tender processes. The core functionalities envisioned for the portal include the ability for users to upload documents related to lessons learned and categorize them based on various criteria such as project phase, type of knowledge, or geographical location. This categorization would enable users to easily filter and search for specific documents, significantly improving the accessibility of critical knowledge. Filters would allow for searches based on project type, project phase, and location, making it easier for employees to retrieve relevant lessons that can be applied to ongoing projects. The tool is being designed with a user-friendly interface to ensure that employees can easily navigate through these filters, allowing them to quickly find the necessary documents. Additionally, the portal will feature metadata tagging, ensuring that each document contains essential contextual information, such as project details, geographical data, team involvement, and key insights, to streamline future knowledge retrieval and application.

The analysis of case study outcomes will focus on determining the most suitable application of the GIS application, whether it aligns more closely with strategic decision-making, technical project planning, or operational efficiency. By examining how the portal supports different functions within the tender process, the study will evaluate whether the GIS application offers the greatest value at a strategic level, by enhancing long-term planning and knowledge management; at a technical level, by supporting efficient project design and coordination; or at an operational level, by facilitating real-time access to critical information during project execution. This investigation will clarify the optimal role of the GIS portal within the organization's workflows.

Integration of analyses

A key feature of the GIS application design could be its ability to incorporate findings from the SNA and RCA. Through these analyses, the portal identifies which roles or departments are critical nodes for knowledge sharing within the organization. For example, departments or roles identified as central figures in the knowledge-sharing network are prioritized within the portal's

design, ensuring that these key actors are both the recipients and contributors of vital lessons learned. By making these insights visible, the portal helps streamline communication across these critical points, fostering more effective collaboration and knowledge transfer between departments.

This GIS application aims to address previously identified organizational barriers, such as the over-reliance on informal communication channels and the absence of structured top-down support for knowledge sharing. By providing a formalized platform where lessons can be easily uploaded, retrieved, and applied, the GIS application encourages a transition from siloed, informal knowledge-sharing practices to more structured processes. Furthermore, by involving top management and aligning lessons learned with strategic objectives, the tool supports a culture of continuous learning, encouraging employees at all levels to share and apply project insights (Carrillo et al., 2004). This directly addresses the challenges of fragmented communication and limited organizational learning commonly seen in the construction industry (Shokri-Ghasabeh & Chileshe, 2014).

Designed to integrate seamlessly with the existing DMS infrastructure, the GIS application ensures that knowledge documents are not isolated but accessible across different departments. This integration reduces data silos and guarantees that lessons learned are shared efficiently, preventing them from being confined to individual projects. According to Carrillo et al. (2013), integrating digital platforms across organizational boundaries streamlines knowledge flows and mitigates inefficiencies in capturing and utilizing project insights. The GIS application builds on this concept by providing a centralized visual interface for accessing project data and lessons learned, complementing and enhancing the organization's existing knowledge management systems. The design of the GIS application was critically evaluated during the validation process, where feedback from various experts, including those from knowledge management and GIS fields, was gathered. Their input on feasibility and practicality has been instrumental in refining the application's features. This validation confirmed the importance of aligning the application with long-term strategic goals, ensuring that it fosters continuous learning and operational improvements across all projects (Duffield & Whitty, 2015).

3.3 Social Network analysis

Network theory is an extensive and versatile theoretical framework used to study the complex interactions and relationships between different entities or actors within a network. This theory is applied in various disciplines such as sociology, economics, organizational studies, and computer science ("Network Science: Theory And Practice", 2010). Figure 16 showcases design of an simple network diagram.

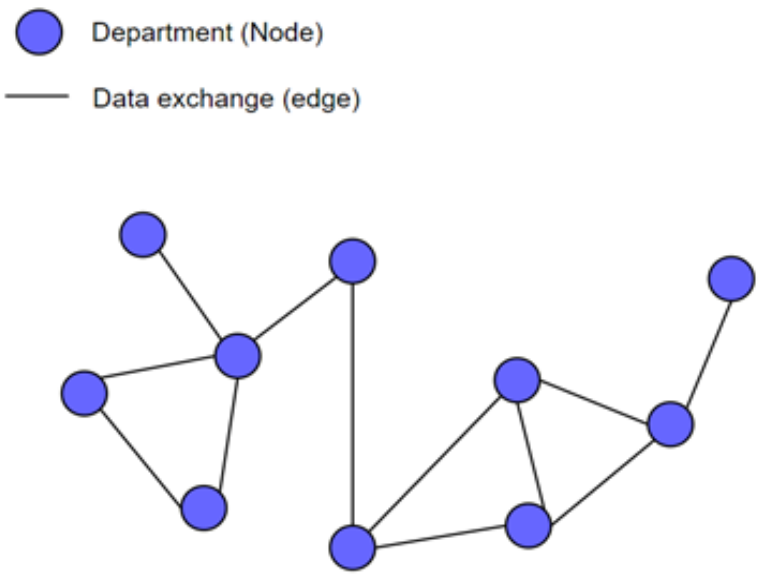


Figure 16: Example network diagram

3.3.1 Network theory principles

A core aspect of network theory is the structure of the network, which looks at how nodes (or actors) and connections (or edges) between them are organized. This can range from social and information networks to technological networks, with various network topologies such as stars, rings, and complete networks (Deverashetti & Pradhan, 2018). Further, network theory delves into the dynamics of interactions within these networks. It analyzes how information, influence, or resources flow within the network, studying who communicates with whom, how influential certain nodes are, and how changes in one part of the network can affect the rest (Latora et al., 2017). In the context of organizations, network theory can be used to investigate communication patterns, collaboration arrangements, and workflow efficiency. It helps organizations understand the connections and dependencies between departments or teams and optimize them (Deverashetti & Pradhan, 2018).

3.3.2 Survey

Surveys are a fundamental component in conducting SNA, particularly in studies aiming to decipher the complex relational dynamics within organizations. The utilization of surveys allows for the collection of detailed interaction data while also serving to validate SNA techniques. This

approach has been effectively demonstrated in research that applies community-detection algorithms to infer organizational structures from interaction data collected via surveys (Joblin & Mauerer, 2016). Similarly, the importance of SNA in understanding project organization within engineering contexts has been emphasized, where surveys are instrumental in capturing the intricate interconnections that dictate project outcomes (Chinowsky & Taylor, 2012). In this research, employing surveys will enable a comprehensive mapping of feedback processes and data sharing networks within the construction firm. This method will not only uncover how information flows and where bottlenecks or facilitators exist but also ensure the accuracy of the network models developed, providing a robust foundation for enhancing communication and collaboration effectiveness in tender processes.

3.3.3 Graph analysis

Python will be used to visualize the data network between departments and se how non-human actors influence the network. The network will be implemented for each case study that will be conducted. The case studies will then be compared with each other to find similarities and differences and analyze them according to the theory from (Yin, 2014).

To begin the data preparation and cleaning process for the survey data collected via Qualtrics, you will need to import this data into Python. Table 5 showcases the visual elements and their description that are used in the network diagram.

Table 5: Description visual elements SNA

ELEMENTS	DESCRIPTION
NODES	The nodes showcase the stakeholders (departments) that are involved in tender management processes and software tools that improve communication. All the nodes will have different colors to distinguish them from one and other. • **Project / Design Management**: Oversees the overall design and planning of construction projects, ensuring that architectural and engineering plans meet client specifications and regulatory standards. • **Project Assistent**: Supports project managers by handling administrative duties, scheduling, and coordination tasks to ensure the smooth progression of the project phases. • **Costing Department**: This node represents the department responsible for preparing cost estimates and budgets. They provide critical financial data necessary for determining project costs and budgets. • **Engineering**: Responsible for the technical aspects of construction projects, including the development of engineering solutions, feasibility studies, and ensuring compliance with engineering standards. • **Contracting Department**: This node represents the legal department responsible for compliance with laws and regulations and contract management. They play a crucial role in ensuring that all tender documents are legally sound. • **Tender Management**: Manages the process of preparing and submitting tenders, which includes analyzing project requirements, preparing bids, and negotiating contracts

	• **Modeling/BIM**: Utilizes BIM software to create detailed 3D models of construction projects which integrate information about design, construction, logistics, and maintenance. • **Construction Management**: Oversees the actual construction phase, managing onsite resources, ensuring safety standards, and coordinating between different stakeholders to keep the project on track. • **Systems Engineer:** Designs and integrates the complex systems within a construction project, such as electrical, plumbing, and HVAC systems, ensuring they meet operational requirements. • **Sustainability:** Focuses on incorporating sustainable practices and materials into construction projects to minimize environmental impact and ensure energy efficiency. • **Risk Management:** Identifies, analyzes, and mitigates risks associated with construction projects, which can include financial, safety, legal, and environmental risks. **Software tools:** • Relatics • PMI/ TMI • SharePoint • Autodesk • Microsoft Teams • Whatsapp
EDGES	In the network diagram analyzing communication within a construction company during the tendering process, the edges represent the various types of interactions and information flows between different departments and key personnel. These edges capture how information, decisions, and resources are exchanged to facilitate the tendering process. - *Frequency:* Each edge has a designated frequency that is determined by the amount of time data exchange takes place between two nodes. The widths are defined based on the following frequencies: o *Multiple times a week:* 10 o *Weekly:* 7 o *Monthly:* 4 o *Occasionally:* 1 - *Value*: The value is based on how the node estimates the value of the connection. The following values are: o *Very high:* 10 o *High;* 7 o *Moderate:* 4 o *Low:* 1

LAYOUT	The layout of your graph has been done using the **Kamada-Kawai layout**. This is an algorithm commonly used to visualize graphs in a way that clearly represents the structure and relationships between the nodes. ○ **Minimum Energy Positioning**: Treats edges as springs with optimal lengths, pulling strongly connected nodes closer. ○ **Node Balance**: Seeks equilibrium, arranging nodes naturally and emphasizing strong connections. ○ **Network Structure**: Highlights clusters and communities, making the network's structure visually clear.

Network centrality is a fundamental metric within network theory that helps identify which departments within an organization are central and essential to the communication network. This measure is crucial for understanding which departments act as nodes in the transfer of information, based on their connections, influence, and strategic positioning within the organization. Identifying these key departments is of great importance for optimizing communication flows and improving interdepartmental collaboration (Ioannidis et al., 2019; Hossain & Wu, 2009; Lukka & Vinnari, 2017; Steen et al., 2006). The types of network centralities are:

- **Betweenness centrality:** measures the extent to which a node (e.g., a department or key personnel) lies on the shortest path between other nodes in the network, identifying nodes that act as critical bridges in the communication network. Nodes with high betweenness centrality are likely to be key intermediaries in the tender process. For example, the project management department or the project manager might have high betweenness centrality, indicating their crucial role in coordinating communication and facilitating information flow between other departments. Identifying these nodes can help understand where communication bottlenecks or key dependencies exist.
- **Density:** Is the ratio of actual connections to possible connections in the network, providing an overall measure of how interconnected the network is. A higher density indicates a well-connected network with frequent communication between departments, suggesting good collaboration and information sharing. A lower density might reveal areas where departments are isolated or where communication is sparse, potentially indicating data silos that could hinder the tendering process. The Girvan-Newman method is an excellent technique for identifying these data silos because it detects communities by progressively removing edges with high betweenness centrality, highlighting isolated clusters (Despalatovic et al., 2014).
- **Network clustering:** Count the actual amount of triangles inside a network devided by the potential amount of triangles will be represented in the clustering coefficient. The clustering coefficient can be used in the Louvain method. The Louvain method detects communities by maximizing modularity, identifying clusters with strong internal connections and weak external connections. This helps recognizing identifying communities within the network. The clustering coefficient supports this process by evaluating the density of connections within these communities (Que et al., 2015; Traag et al., 2019) .

- **Eccentricity:** is the greatest distance between that node and any other node in the network, reflecting how far a node is from the furthest node in the network. Nodes with lower eccentricity are more central and accessible within the network, while nodes with higher eccentricity are more peripheral. This metric helps identify which departments or individuals are central to the communication network and which ones might be at the periphery, potentially missing out on critical information exchanges. Departments with high eccentricity might require better integration into the communication flow to ensure they are not excluded from important discussions.
- **Closeness centrality:** measures how close a node is to all other nodes in the network, based on the shortest paths, indicating the efficiency with which information can spread from a node to all others. Departments or individuals with high closeness centrality can quickly disseminate information to the entire network, suggesting they are strategically positioned for effective communication. This could be indicative of roles like the procurement manager or the project manager, who need to rapidly share information across departments.
- **Degree centrality:** Degree centrality is the number of direct connections a node has, showing the immediate communication activity of a node. Nodes with high degree centrality are highly connected within the network, indicating active communication roles. For example, the design department might have high degree centrality due to its interactions with both the project management and cost estimation departments. This metric helps identify the most communicative departments or roles within the tendering process.

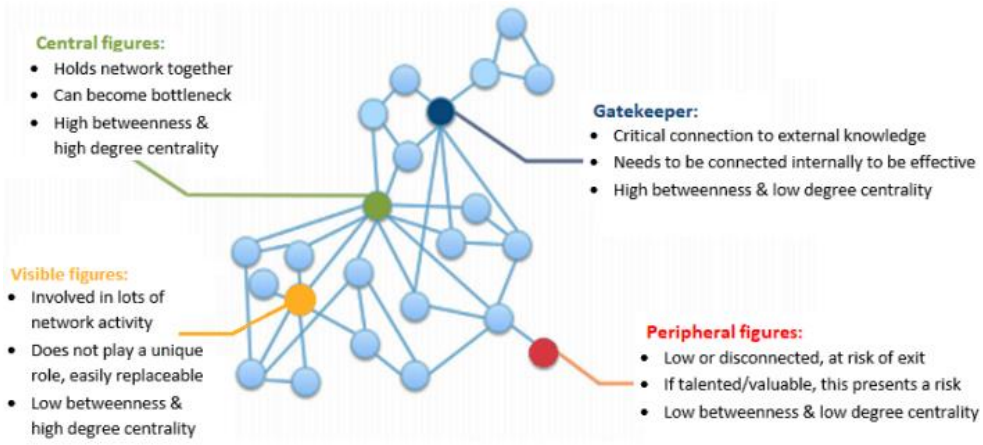


Figure 17:Node types in the network (Based on McDowell, Horn, Witkowski, & Miller, 2016)

By applying these centrality measurements, we can gain insights into the structure of the communication network within the organization (Figure 17**Error! Reference source not found.**) . This allows us to identify which departments need enhanced communication channels or support to increase the overall efficiency and effectiveness of the organization. Focusing on these key departments can lead to targeted interventions that result in better alignment and collaboration between departments, ultimately leading to a more streamlined and productive organizational process (Hossain & Wu, 2009). The dynamics of a network within an organization refer to how the network changes and adapts over time. This includes the formation of new connections between departments and the breaking of existing connections, which affects the

structure and functionality of the communication network. Just as in technological networks in information technology and computer networks, network theory is used to understand and manage this dynamic. In technological contexts, the theory aids in grasping network architectures, data flow management, and network security, finding parallel applications in managing organizational communication networks. Understanding this dynamic is crucial for managing change processes within the organization and helps anticipate future communication challenges (Hossain & Wu, 2009). Network theory offers a powerful toolset to understand how systems function and how they can be optimized by focusing on their interconnectivity and the relationships between their components. For research on tender processes and digital integration within a construction company, it can be particularly useful to analyze how information and decisions flow through the organization and how these flows can be improved through digital tools (Yu et al., 2015).

3.4 Root cause analysis

Incorporating RCA into this research on data sharing and lessons learned within tender processes of a construction firm is fundamental to achieving a comprehensive understanding and sustainable improvement. RCA delves deep to identify and address underlying causes of issues, rather than merely treating their symptoms (Vliet, 2010; Rosenfeld, 2014). In combination with a literature study and the findings out of the SNA, it can be utilized as a validation method. A RCA could validate the statements that derive from the SNA and the literature review.

3.4.1 RCA principles

The principles of RCA are exemplified in a modern context by Vo, Kongar, and Suárez-Barraza (2020), who demonstrate its application within Industry 4.0 to solve quality control issues in manufacturing. This study underscores the importance of leveraging digital tools and fostering collaboration across various stakeholders to enhance the effectiveness of RCA. By integrating digital technologies, RCA can not only pinpoint root causes more efficiently but also facilitate a more dynamic and inclusive problem-solving process. This approach aligns with the needs of a construction firm engaged in tender processes, where data sharing and lessons learned are critical.

This research will use the RCA to identify both root causes that have hindered feedback processes and those who have facilitated them. Vliet (2010) describes steps that outlines the basic principles of doing a RCA. which will be conducted accordingly:

1. **Observation Definition**: The study begins by establishing a clear definition and description of the scenario under investigation. In this research, the focus is on conducting a problem analysis and gaining a contextual understanding of intra-organizational data sharing within the construction industry.
2. **Data Collection**: This step involves collecting factual information to create a detailed picture of the scenario being studied. For this research, this is accomplished through a comprehensive review of relevant literature and the collection of empirical data from case studies.
3. **Identification of Potential Causes**: In this phase, all potential factors contributing to the observed phenomenon are identified. The research articulates these factors and patterns, derived from SNA, into testable hypotheses.
4. **Root Cause Analysis**: This step involves a deeper exploration of the identified causes by systematically questioning why they occur, aiming to uncover the fundamental reasons. The study employs in-depth interviews with selected participants to identify the root causes impacting data sharing practices.
5. **Solution Recommendation and Implementation**: This phase involves proposing actions that can address the identified root causes or enhance successful practices already in place. The research concludes with strategic recommendations aimed at improving data sharing practices.
6. **Effectiveness Monitoring**: The final step of RCA involves assessing the impact of the implemented solutions to ensure they effectively address the identified issues. Although this research does not include the monitoring phase, it is recommended that the implementing organization undertake this task, or it could be the focus of future studies.

3.4.2 In depth interviews

In-depth structured interviews offer the advantage of gathering detailed and consistent data across participants, ensuring comparability in responses. They allow the researcher to focus on specific topics, thoroughly exploring complex issues while minimizing interviewer bias. This method also enables participants to elaborate on their answers, potentially revealing new insights and themes that might not emerge in other formats (Rowley, 2012). As a result, structured interviews provide a comprehensive understanding of the research subject.

The 5 Whys method will be employed to delve deeply into the issues discussed during the interviews, allowing us to systematically uncover the root cause of the problems identified. This approach is particularly effective because it encourages a thorough exploration of the underlying factors, moving beyond surface-level symptoms to reveal the core issue (Erdhianto, 2021). Once the root cause is established, the interviewee's response can be thoughtfully categorized into one of the four categories outlined in Table 6, ensuring a structured and meaningful analysis of the data.

Table 6: Categories for interviews

Reading guide			
Agree with the statement and also applies to me in the tender (Enabling factor)	Disagree with the statement but applies to me in the tender (Enabling factor)	Agree with the statement but it does not apply to me in the tender (Limiting Factor)	Disagree with the statement and it does not apply to me in the tender (Limiting factor)
Five times why	Five times why	Five times why	Five times why
Root cause enabling factor	Root cause enabling factor	Root cause limiting factor	Root cause limiting factor

3.5 Synthesis

In this research, the primary objective is to explore the dynamics of lessons learned within the tender processes of a multinational construction firm. Utilizing a multiple case study design across various projects, this study critically examines how lessons learned are currently managed and shared between departments. A key focus is to avoid the common pitfalls associated with case study research, as highlighted by Yin (2009), where research might narrowly focus on individual cases without synthesizing findings across the broader organizational context.

By treating each project as a distinct unit of analysis while systematically integrating and comparing findings, this research aims to uncover patterns and inconsistencies in how lessons learned are communicated and utilized. The goal is to identify effective practices and barriers to efficient information exchange concerning lessons learned during the tender process. The overarching aim is to develop a standardized approach for managing lessons learned across the organization's tender processes. This standardization is expected to streamline communication, reduce redundancies, and ensure that valuable insights from past tenders are effectively incorporated into new projects. By enhancing the lessons learned process, the research seeks to

contribute to more accurate and efficient tendering practices, which can be consistently applied not only within the current organizational framework but also adapted to other projects or client portfolios, thus driving broader improvements in organizational effectiveness and project success.

3.5.1 Validation of the results

In order to validate the findings derived from this research, interviews were conducted with experts from within the company BAM. These experts, who hold key roles in various departments relevant to the case studies, were selected for their knowledge and experience in the areas explored in this thesis. The primary objective of these interviews was to present the results from the case studies and gather their input on whether the data had been interpreted correctly. The experts were asked to provide feedback on the accuracy and completeness of the identified root causes, as well as on the practical relevance of the lessons learned.

Their insights were valuable in ensuring that the conclusions drawn from the data aligned with real-world practices within BAM. The experts also offered critical reflections on certain assumptions made during the analysis, allowing for a deeper understanding of the enabling and limiting factors identified in the tender processes. This validation process not only confirmed that the findings were correctly interpreted but also strengthened the credibility of the research by integrating expert judgment into the final analysis. Additionally, their feedback helped refine the recommendations and highlighted areas where further research may be necessary to explore overlooked aspects or nuances in the data.

II Case study

4. Case preparations

In this chapter, the groundwork for the case preparations is outlined. In section 4.1, exploratory interviews were conducted to gather insights from key individuals involved in the tender processes. These interviews helped shape the survey design presented in section 4.2. Additionally, a qualitative factor analysis was performed to derive statements used in the in-depth interviews for the RCA. These steps ensured that the interviews addressed the most relevant factors influencing lessons learned and knowledge-sharing practices within the tender process.

4.1 Exploratory interviews

In this section, the exploratory interviews are discussed. Four individuals, each representing a different discipline, change management, modeling, digital expertise, and IT management, were interviewed to gather diverse perspectives on knowledge sharing within tender processes. These interviews were instrumental in shaping the direction of the subsequent survey and RCA.

In the interviews, digital platforms like SharePoint (DMS) and Relatics (MBSE) were highlighted as key tools for centralizing knowledge documentation and managing projects. These platforms are intended to facilitate easy access to information across different departments and streamline communication. However, a recurring issue identified was the inconsistent use of these platforms. Many employees are resistant to adopting new technologies, leading to a lack of uniformity in how these tools are used across teams. This inconsistency creates inefficiencies in sharing critical insights, such as lessons learned from projects. Some respondents mentioned that despite having access to these digital platforms, informal methods of communication, like email and direct contact, are still frequently preferred. This reliance on informal channels means that valuable information often goes undocumented, making it inaccessible to others. While tools like email and face-to-face conversations are convenient and widely used for quick exchanges, they bypass the formal knowledge management systems, leading to information silos. Efforts to standardize knowledge sharing have been made, including the introduction of object type libraries, which aim to reduce inefficiencies during the tendering process and promote a more consistent documentation approach. However, these initiatives face adoption challenges, as many employees are either unfamiliar with or hesitant to embrace these tools. This reluctance exacerbates the difficulty of ensuring lessons learned are effectively communicated across teams and departments. Another significant point raised was the role of structured project reviews, which are intended to capture and disseminate lessons learned at key project milestones. However, even when these reviews occur, there is often limited follow-through. Insights are sometimes confined to the team conducting the review, rather than being shared more broadly within the organization.

Overall, the interviews revealed a fragmented approach to knowledge sharing. Although the tools are available, they are not fully utilized. Informal methods, like email and direct contact, dominate over formal systems, and there is inconsistent follow-up after project reviews. Addressing these issues will be crucial for enhancing the efficiency and effectiveness of knowledge sharing within the organization.

A prominent obstacle to effective knowledge sharing identified in the interviews is the presence of communication silos and fragmentation within the organization. Departments often operate independently, which restricts the flow of crucial insights and lessons learned between teams. This lack of interdepartmental collaboration not only delays the practical application of valuable knowledge but also leads to inefficiencies in project execution. In several cases, differences in communication styles, such as the use of varying levels of technical detail or specialized terminology, further exacerbate misunderstandings, diminishing the impact of knowledge-sharing efforts. Technological barriers also play a significant role in hindering smooth communication across departments. The inconsistent use of tools and platforms results in a disjointed approach to information documentation and sharing. Without a standardized system, knowledge remains isolated within departments, deepening the silos. Additionally, the lack of integration between internal systems and those of external partners further limits the exchange of knowledge, making it difficult for employees to access valuable insights from past projects.Cultural and organizational resistance to change adds another layer of complexity to this issue. Many employees prefer traditional methods of communication and documentation, exhibiting reluctance to embrace new tools and technologies. This resistance complicates efforts to establish new knowledge-sharing processes. Employees are often hesitant to move away from familiar systems, making it challenging to foster a culture of openness and collaboration.

These barriers to knowledge sharing highlight a recurring theme: the tension between individual practices and collective organizational efforts. While technological tools are available to streamline communication and centralize knowledge, the reluctance of individuals to adopt these systems underscores a deeper challenge, balancing the efficiency of technology with the human element. The divide between informal, personal approaches and formal, collective processes is a crucial issue that warrants further investigation. In the case study that follows, we will explore how these barriers manifest at both the individual and organizational levels, and how addressing this tension between technology and people could improve knowledge sharing across the organization.

4.2 Survey

The survey was carefully structured to capture essential insights into knowledge sharing and the use of lessons learned during the tender process. It was designed around four main areas, each aimed at gathering critical data to improve collaboration and efficiency.

The first part of the survey focused on mapping the communication networks of respondents. Participants were asked to specify with whom they had contact during the tender, as well as the frequency and value of these interactions. This data was instrumental in creating a SNA, which helped identify key individuals who play a crucial role in disseminating and applying knowledge. By examining these communication patterns, the survey aimed to highlight the most influential figures in the knowledge-sharing ecosystem of the tender process.

The second area of the survey explored the tools respondents used for data sharing. It sought to determine whether informal methods, such as email and face-to-face communication, were more frequently employed than centralized digital platforms. This distinction was critical in revealing whether knowledge sharing remained primarily informal or if structured systems were in place for documenting and distributing lessons learned. Understanding the balance between these approaches sheds light on how effectively information flows across teams and how accessible valuable insights are to different groups.

The third focus was on how lessons learned were utilized during the tender process. Respondents were asked whether they regularly consulted these lessons, where they typically found them, and how they recorded their own insights. The survey also inquired about which stages of the tender process lessons learned were applied, offering a deeper understanding of whether these insights were integrated into everyday practices and decision-making. This element of the survey helped to uncover any gaps or inconsistencies in the application of lessons learned, providing a clearer picture of how well these resources are utilized.

Lastly, the survey gathered reflections on the overall experience of respondents in relation to the above elements. The participants were all individuals directly involved in the tender process, ensuring that the feedback was rooted in practical, real-world experiences. By distributing the survey via email, respondents were given an accessible and convenient platform to share their insights, which also allowed for broad participation and efficient data collection.

4.3 Qualitative factor analysis

Following the completion of the case studies, an important step is conducting a qualitative analysis of the factors influencing lessons learned, as identified in the literature review. This analysis is essential for developing a set of statements or hypotheses that can be tested and validated during the in-depth interviews. Figure 18 showcases the qualitative factor grids with the lessons learned factors their numbers, these are stated in Appendix A.

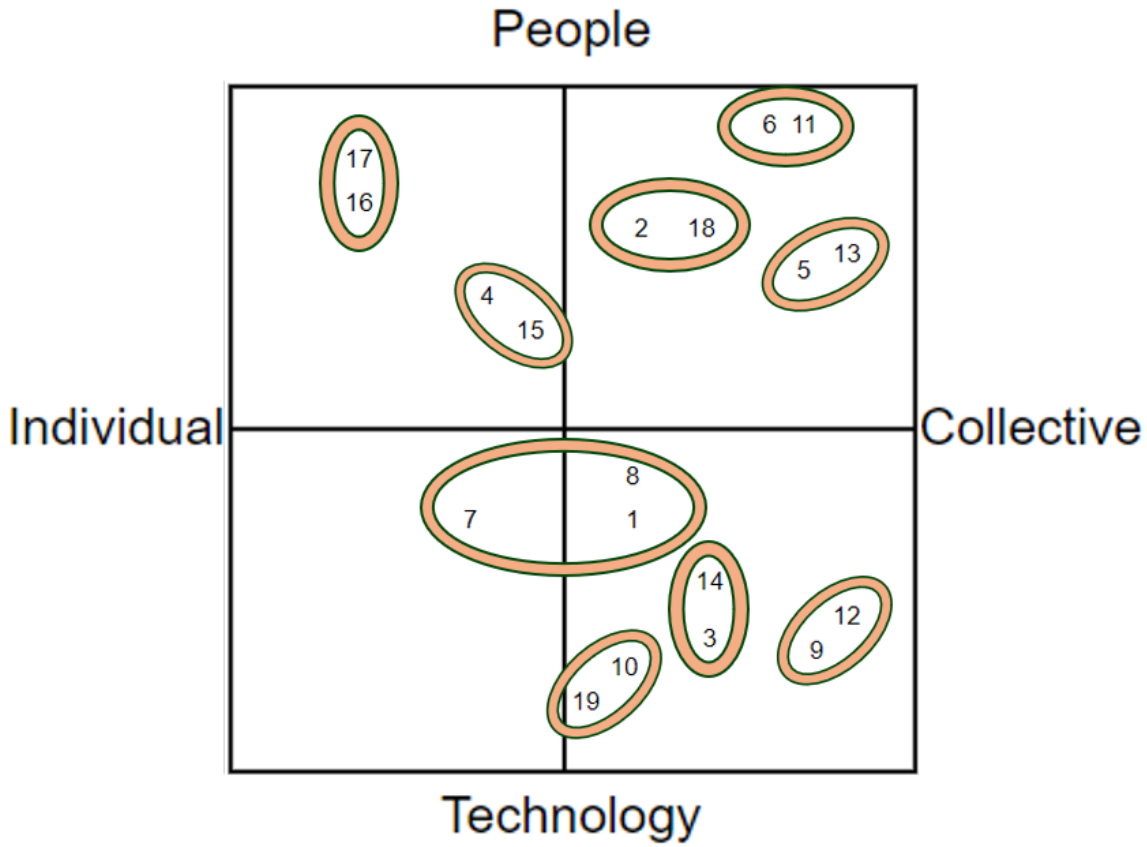


Figure 18: Grouped factors

The qualitative factor grid illustrated here is a strategic tool for visualizing the distribution of lessons learned factors across two critical dimensions: People and Technology. The grid is divided into four quadrants, each representing a unique intersection of these dimensions, helping to categorize the factors based on whether they are more individual or collective in nature, within the context of either people or technology. At the top of the grid, the focus is on "People," where the factors are divided into individual and collective aspects. On the left side, under "Individual," we see factors that pertain to the personal, human elements of lessons learned, those influenced by individual behaviors, access to knowledge, and personal experiences within the organization. These factors reflect how individuals contribute to or hinder the learning process based on their own actions or interactions. On the right side, still within the "People" domain, but moving towards "Collective," the factors represent broader, group-oriented aspects of lessons learned. These are shaped by the collective behavior, culture, and shared practices within teams or the organization as a whole. Here, the focus shifts from individual contributions to how groups, departments, or even the entire organization processes and applies lessons learned.

At the bottom of the grid, the emphasis shifts to "Technology." The left side, under "Individual," highlights factors related to personal access to and use of technological tools. These are the technological aspects that affect individual performance, whether an employee has the right tools, the necessary software, or the personal technical know-how to effectively participate in the lessons learned process. On the right, under "Collective" within the Technology domain, the factors broaden to include infrastructure, systems, and programs that are shared across the organization. These are the technological frameworks that support or hinder collective efforts, encompassing everything from the robustness of the data-sharing networks to the effectiveness of collaborative platforms.

By mapping these 19 lessons learned factors onto this grid, it becomes easier to identify clusters of related factors. These clusters, which are stated in Table 7, help in forming cohesive statements that will be used in the RCA, providing a structured approach to exploring and addressing the underlying issues within the tender process. The visual representation offered by this grid thus plays a critical role in organizing and synthesizing the complex interactions between people and technology in the lessons learned process.

Table 7: Lessons learned factors categorized

#	Lessons Learned Factors	#	Categorized Statements
5	Top-Down Support	1	Leadership drives the integration of lessons learned in tender processes.
13	Involvement of Management		
17	Psychological Safety	2	The organization values bottom-up communication and takes input from all levels into account during the process.
16	Ongoing Training Programs		
7	E-Learning Modules for Lessons Learned	3	It is clear where to find lessons learned reports of older tenders.
8	Formalized Processes		
1	Searchability and Accessibility		
2	Shared Learning Sessions	4	Lessons learned during the tender process are easily communicated and accessible.
18	Interdepartmental Communication		
14	Effective Documentation Tools	5	Standardized lessons learned documents would help streamline the sharing and application of knowledge.
3	Digital Platforms		
10	Data Analytics	6	A reliable and impactful Lessons learned repository would enhance Lessons reporting.
19	Monitoring and Adjustments		
9	Continuous Improvement Cycles	7	Lessons learned should be discussed more frequently during tender meetings.
12	Integration into Project Lifecycle		
4	Mentorship and Coaching	8	Mentorship and incentives are key to fostering a proactive lessons learned culture.
15	Motivation and Incentives		
6	Bottom-up Communication	9	I trust that lessons learned documents are reliable
11	Learning-Oriented Culture		

5. Social network analysis

In this research, three case studies were conducted using SNA techniques implemented in Python within the Spyder environment, the code can be found in the Appendix D. Each case study aimed to visualize and understand the relationships and interactions present in the respective datasets. The methodology applied to each case study involved the following steps: To begin with, the datasets were imported from CSV files into pandas DataFrames. These datasets were then used to construct graphs using the NetworkX library in Python. Nodes in the graphs represent the entities, while edges represent the relationships between these entities. Additional attributes such as color, frequency, and weight were assigned to each edge to provide more detailed information about the connections. The Python code first reads the datasets from the CSV files. Missing values in the color attributes of nodes were handled by filling them with a default color. Once the data was cleaned and prepared, nodes and edges were added to the graphs. Each node was assigned a color based on its role, and each edge was given attributes such as frequency and weight. To visualize the networks, the Kamada-Kawai layout was used to position the nodes. This layout algorithm helps in displaying the graphs in a visually appealing and understandable manner. The nodes were colored according to their roles, and the edges were styled based on their frequency and weight attributes. For instance, edges with different frequencies were represented with different line styles such as dotted, dash dot, dashed, and solid lines, while their thickness was varied according to their weights.

Furthermore, various statistical analyses were performed on the networks. The shortest path lengths between all pairs of nodes were calculated to understand the minimum distances within the networks. Additionally, centrality measures such as betweenness centrality and eigenvector centrality were computed to identify the most influential nodes in the networks. Betweenness centrality highlights nodes that act as bridges in the network, while eigenvector centrality measures the influence of a node based on the connectivity and importance of its neighbors.

In summary, these network analyses provided valuable insights into the structure and dynamics of the datasets. By visualizing the networks and calculating key statistical measures, we were able to identify important nodes and understand the nature of the relationships within the networks. This analysis serves as a robust method to explore and interpret complex data, highlighting the strengths of using Python and NetworkX for SNA.

5.1 Survey collection

A total of 39 responses were collected out of a possible 105, yielding a response rate of approximately 38%. These responses were gathered from personnel who have been directly involved in tender processes within BAM. Chart 1 showcases the distribution of the tenders, the respondents were involved in. The distribution of roles among the respondents is depicted in Chart 2, This diverse participation provides a solid foundation for analyzing the dynamics and challenges within the tender processes at BAM.

The survey was conducted using Qualtrics, leveraging a paid account provided by TU Delft. This platform allowed for the efficient collection and management of data, ensuring that the survey reached the intended participants and that the responses were securely stored and easily accessible for analysis.

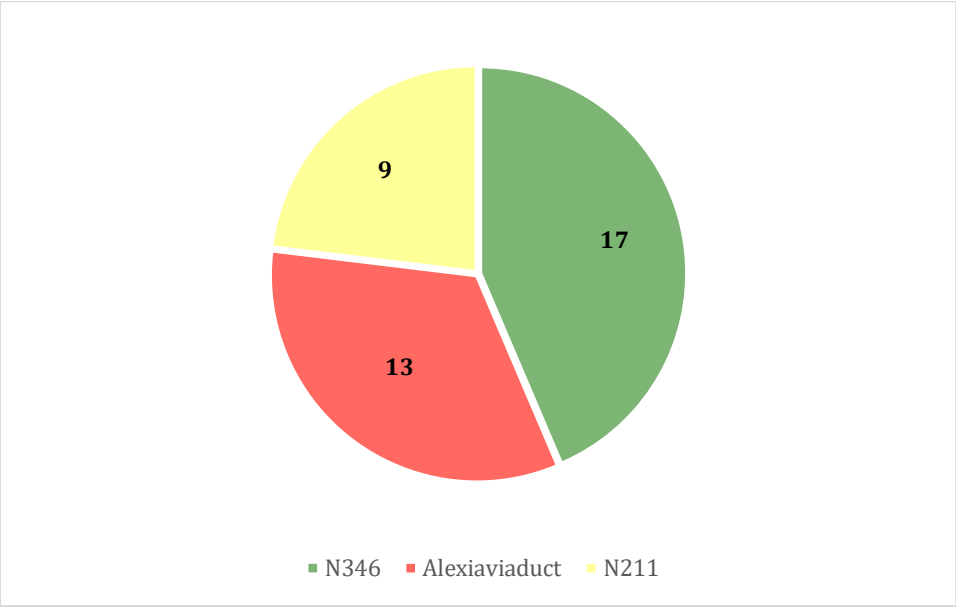


Chart 1: Tender distribution survey

The full survey instrument used for data collection, provided in Appendix C, was carefully designed to capture both quantitative and qualitative data, enabling a comprehensive analysis of the dynamics and challenges present within BAM's tender processes.

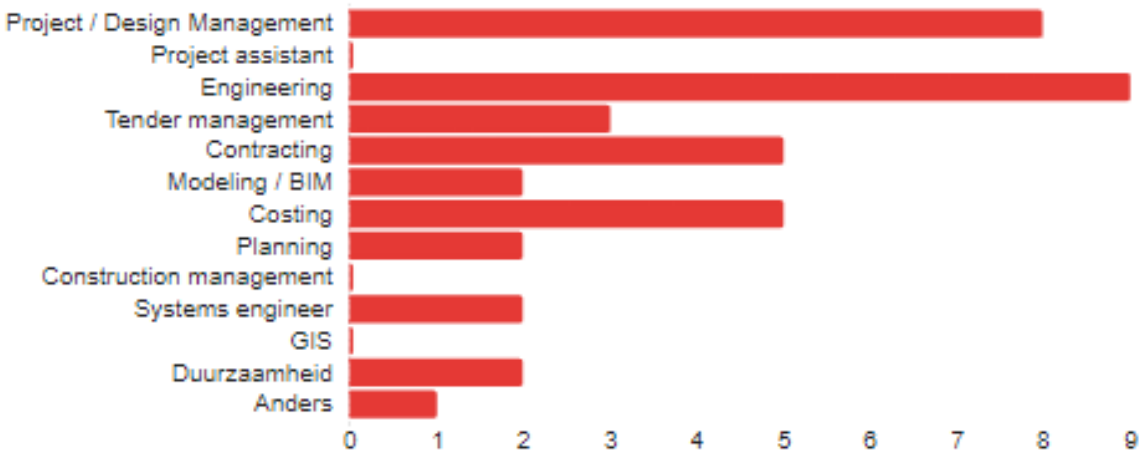


Chart 2: Role distribution survey

5.2 N346 Schakel

The N346 project features the construction of a new bypass with the Nettelhorsterbrug bridge over the Twentekanaal, enhancing traffic flow between the Achterhoek, the A1 motorway, and the Stedendriehoek area. This nearly four-kilometer-long provincial road includes several new intersections and aims to segregate local and through traffic, significantly improving traffic safety. Parallel roads along Kwinkweerd and Goorseweg are designed specifically for local traffic.

A new pedestrian and cycling bridge will connect the existing Lochemse bridge to the station, further boosting accessibility and safety for non-motorized traffic. The project's design integrates seamlessly into the landscape, maintaining the region's green character with tree-lined avenues and estates, thereby preserving and enhancing its scenic and historic value.

This infrastructure development balances efficiency, safety, and environmental aesthetics, with initial visuals of the road and bridge illustrating how the project will complement the existing environment. This comprehensive approach ensures the project not only meets current transport needs but also respects and enhances the area's natural beauty.

5.2.1 Results: mapping data-sharing network

In the evaluation of the tender process for project N346, SNA was implemented to explore the patterns of communication and collaboration among the 17 participants involved. The resultant network graph, showcasing 39 nodes connected by 72 edges (Figure 19), offers a detailed view of the structural dynamics within the network. The average degree of 3.69 suggests that each node is connected to nearly four other nodes, indicating a network with moderately diverse information paths. Such connectivity is crucial in a tender process as it reflects the flow of information necessary for effective decision-making. Table 8 accompanying the diagram highlights a network density of 9.7%, pointing to the selective but effective use of connections among nodes. This level of density suggests that while the network isn't overly saturated with connections, the existing links are vital for the strategic communication essential to the project's requirements.

Chart 3 shows the frequency of use for various data-sharing platforms during the tender process. It highlights that Email is the most commonly used tool, followed closely by Phone and Face-to-Face interactions. In contrast, platforms like BIM/ACC and Chat applications are used much less frequently, indicating a preference for more traditional communication methods over newer digital tools.

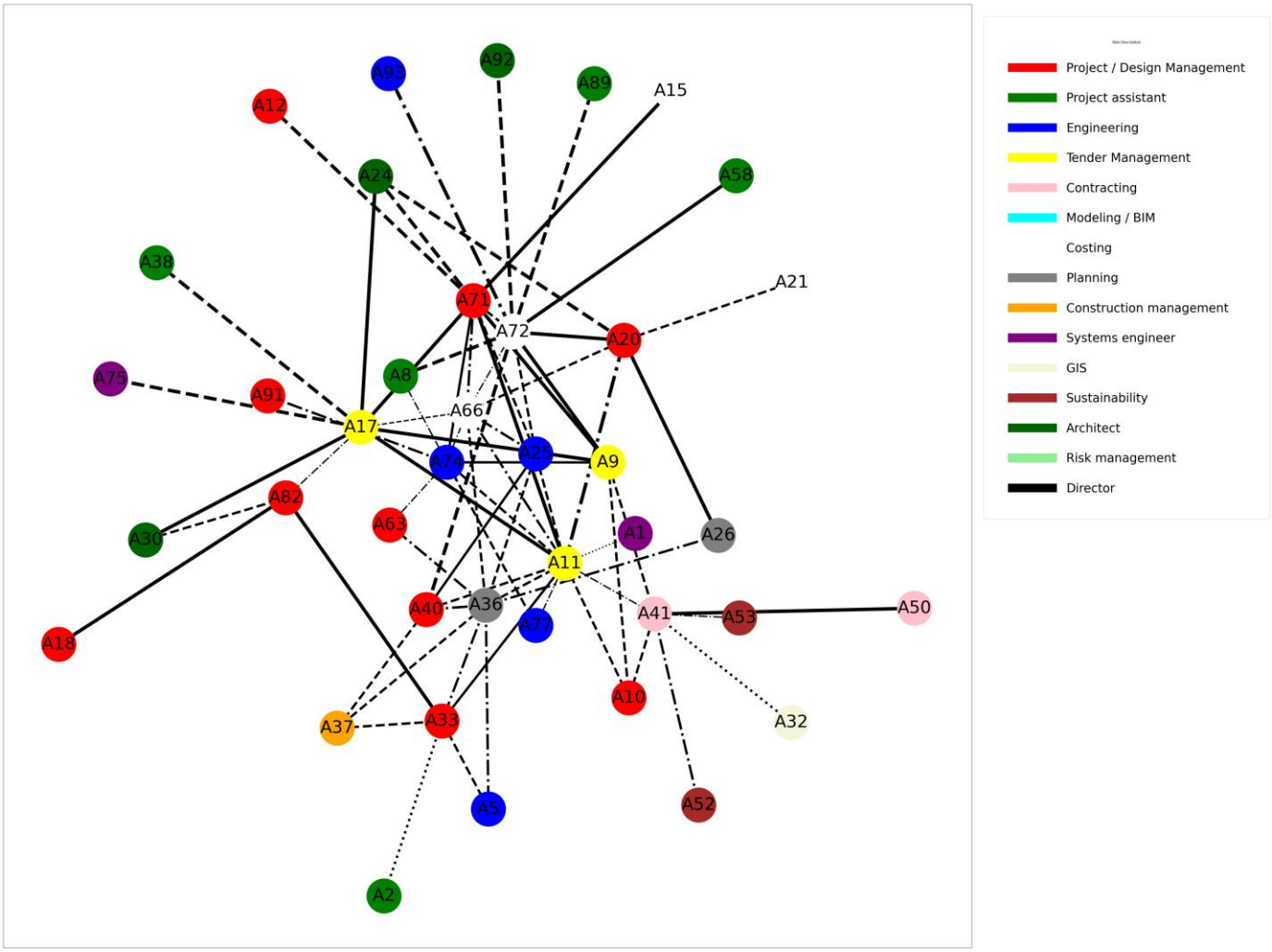


Figure 19: Data-sharing network N346 tender

Components	Statistics
Nodes	39
Edges	72
Graph density	9,7%
Averag eclustering coefficient	21,5%
Average degree	3,69
Average frequency of data exchange	6.7 / (10.0)
Average indicated value of data	7.6 / (10.0)

Table 8: Network information N346

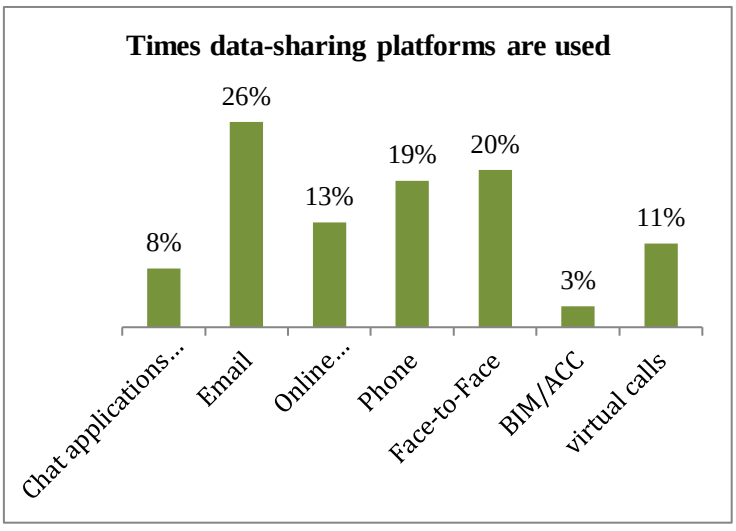


Chart 3: Frequency data sharing tools

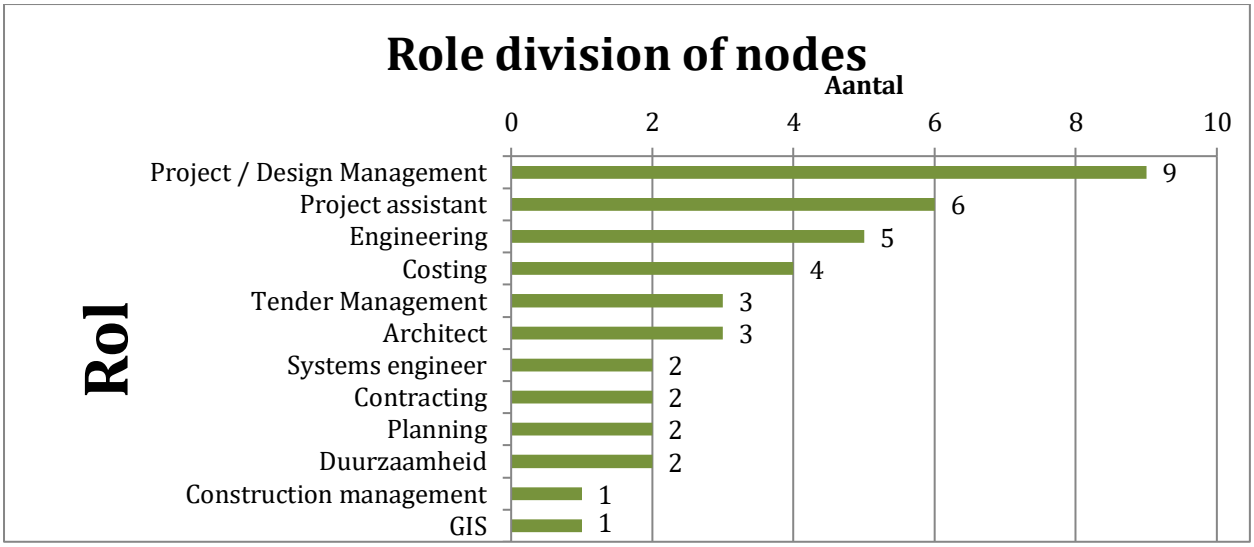


Chart 4: Role distribution nodes

Furthermore, the clustering coefficient of 21.5% reveals a moderate tendency for nodes to cluster into groups. This pattern is indicative of the presence of sub-groups within the network that might be collaborating closely, potentially leading to more efficient problem-solving sessions or focused task completion efforts. Data exchange metrics also provide valuable insights, with communication frequency averaging 6.7 on a scale from 1 to 10, indicating regular interactions among the nodes. The perceived value of these interactions, rated at 7.6, underscores the importance and utility of the information being shared, enhancing the overall productivity and alignment within the project.

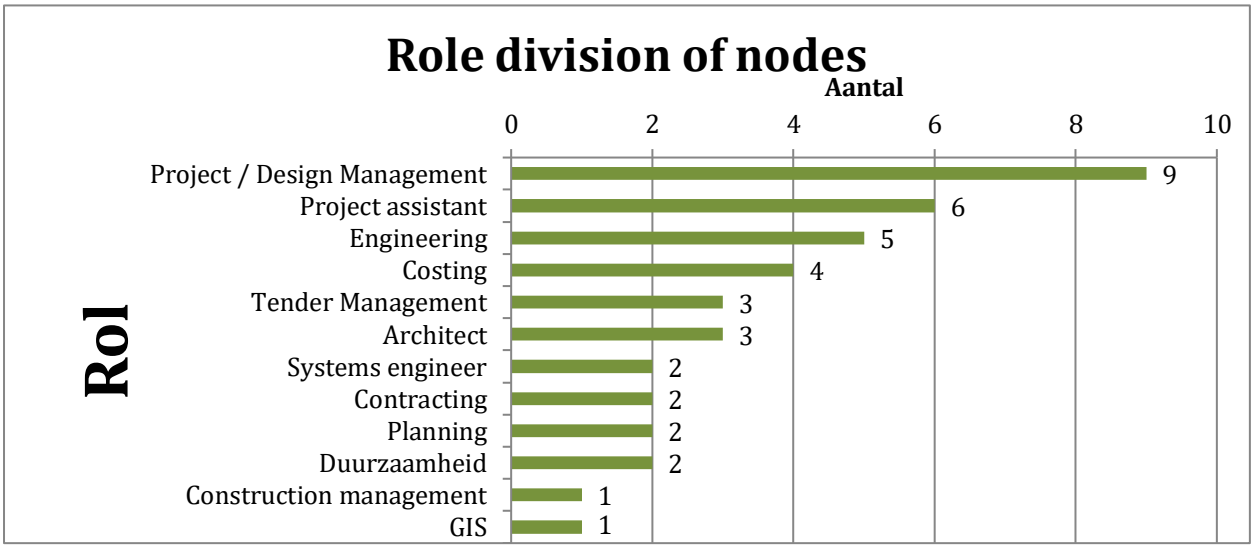


Chart 4 illustrates the distribution of roles among the nodes involved in the tender within the Royal BAM Group. The lengths of the bars represent the number of respondents per role. The category "Project / Design Management" includes the most respondents, spread across roles such as Project Assistant and Engineering, indicating a significant involvement in project design and management. There is also a notable number of respondents in "Tender Management," essential for managing the procurement processes that are critical for acquiring new projects. Furthermore, roles related to modeling and BIM are well represented, highlighting the adoption of advanced technologies in project planning and execution. A smaller number of respondents are

involved in "Construction Management," supporting the operational phase of projects. Roles in "GIS and Sustainability" show that the tender includes a focus on geographical information systems and sustainability initiatives, contributing to environmental responsibility and project efficiency. Each role plays a crucial part in the successful execution of projects within the Royal BAM Group, and the diversity in involvement demonstrates a multidisciplinary approach to tender processes.

Chart 5 illustrates the preferred communication tools used by respondents during the tender process. It is evident that Email is the dominant tool, with the highest number of respondents favoring it for communication. This is followed by Face-to-Face interactions and Phone calls, indicating a preference for more direct and personal forms of communication. Notably, newer digital tools such as Chat applications (e.g., MS Teams) and online collaboration platforms are less frequently used, which may suggest a reliance on more traditional communication methods among the respondents.

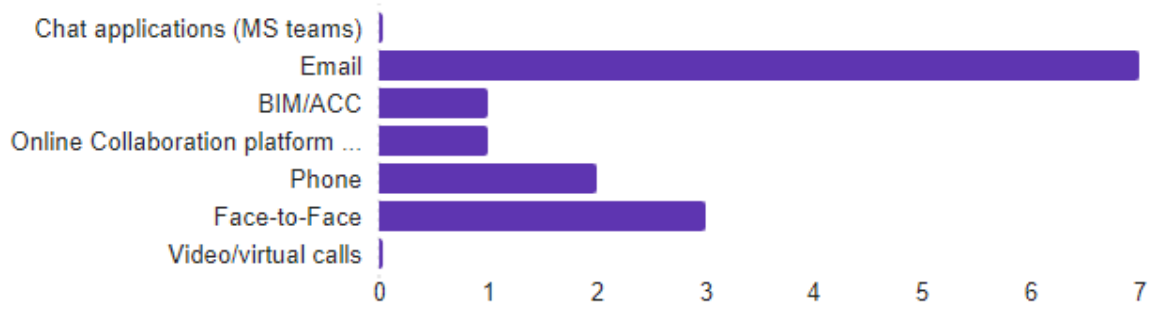


Chart 5: Preferred tools respondents

5.2.2 Lessons learned

The survey conducted as part of the N346 project case study provides valuable insights into the use and application of lessons learned within tender processes. The data in Chart 6 reveals a noteworthy trend: while a majority of respondents engage with lessons learned, there is also a substantial portion who reported not using these insights.

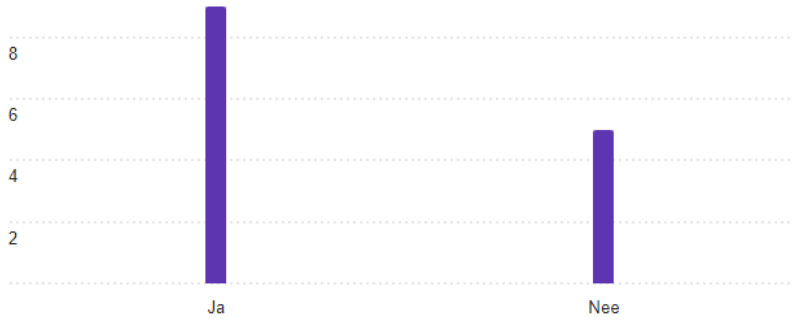


Chart 6: lessons learned used

A significant observation is that a considerable number of respondents indicated that they do not utilize lessons learned in their tender processes. This discrepancy highlights a potential gap in how lessons learned are integrated into practice. The fact that a large segment of the respondents

does not apply these insights suggests challenges in fully embedding the lessons learned into the project workflows. For those who do engage with lessons learned, the survey shows, in Chart 7, a preference for "Project evaluatie" as the primary method for capturing and reviewing these insights. SharePoint is also prominently used, reflecting its role in storing and retrieving lessons learned effectively. However, tools like Relatics and Microsoft Teams, though used, are less central in this process, indicating possible areas for improvement in tool integration. A particularly notable finding is the specific application of lessons learned to technical challenges such as the design and implementation of "roundabouts and crossings". This illustrates that when lessons learned are applied, they have a tangible impact on addressing complex issues during the early stages of the project.

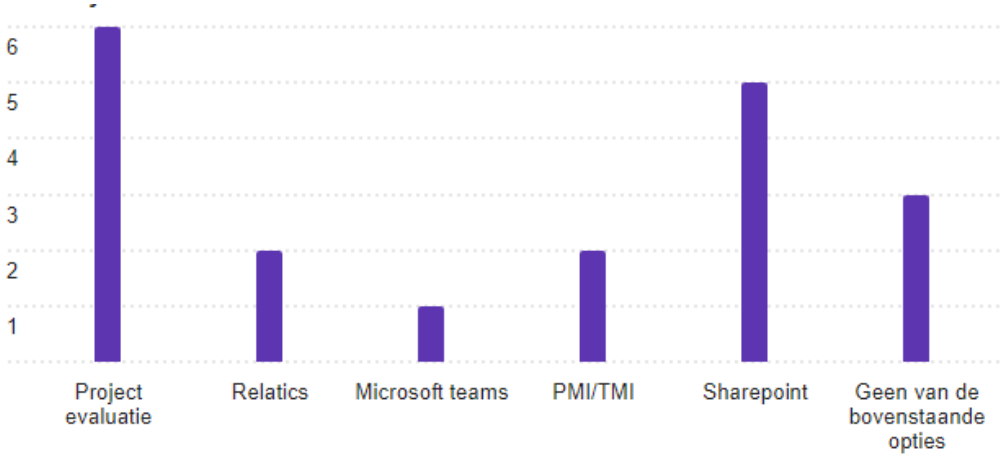


Chart 7: Tools division for lessons learned notation and reviewing

The survey findings underscore the importance of lessons learned in the tender process, while also highlighting significant areas where improvements can be made. The substantial number of respondents not using lessons learned points to a critical area for development, emphasizing the need for better integration and more consistent application throughout the project lifecycle. Additionally, enhancing the accessibility and usability of tools for managing lessons learned could ensure that valuable insights are more effectively utilized, contributing to better project outcomes and continuous improvement in the construction industry. These observations provide a basis for further exploration and analysis in subsequent case studies, aiming to develop strategies to enhance the effective application of lessons learned in the construction industry.

5.2.3 Analysis Network N346

In the next section of my thesis, I will discuss the analysis of nodes, edges, and metrics. These metrics are presented in a table shown in the Appendix E. The screenshot displays the most influential nodes, determined primarily by eigenvector centrality. A71 is associated with Project / Design Management, A11 and A17 with Tender Management, and A72 with Costing. The analysis reveals that these nodes are the most connected in the network, which makes sense given their roles. Project / Design Management (A71) is a central function that requires constant communication and coordination across various departments, making it logical for this node to have high connectivity. This role often involves overseeing the entire project lifecycle, ensuring

that design specifications are met and that all project components are aligned. Consequently, A71 needs to maintain extensive interactions with multiple nodes, which is reflected in its high degree centrality and eigenvector centrality. Tender Management (A11 and A17) also necessitates extensive interaction with different stakeholders to manage bids and contracts, explaining their high centrality. These roles involve critical tasks such as preparing and evaluating tender documents, negotiating with contractors, and ensuring compliance with regulations. The nature of this work requires frequent communication with various departments, suppliers, and regulatory bodies, which justifies the high connectivity of A11 and A17 in the network. Costing (A72), being crucial for budgeting and financial planning, interacts with numerous other nodes to gather and distribute financial information. This role involves collecting cost data, analyzing financial implications, and providing cost estimates, which requires constant interaction with project managers, procurement, and finance departments. Hence, the high centrality of A72 is expected due to its integral role in maintaining the financial health of projects. Interestingly, A11 stands out with higher closeness centrality and betweenness centrality compared to the other nodes. This indicates that A11 is not only well-connected but also plays a pivotal role in bridging different parts of the network. Closeness centrality measures how quickly a node can access other nodes in the network, while betweenness centrality indicates the extent to which a node lies on the shortest paths between other nodes. The high values for A11 suggest that it is strategically positioned to facilitate efficient communication and information flow within the network. This dual importance could be due to the nature of Tender Management, which often involves coordinating various processes and stakeholders, thus requiring a central position in the network. The high values in these metrics for A11 highlight its significant role in facilitating communication and data flow within the network. Overall, the analysis underscores the logical importance of nodes involved in Project / Design Management, Tender Management, and Costing, aligning with their central functions in the network. The additional observation of A11's notable closeness and betweenness centrality further emphasizes the critical bridging role that Tender Management plays in maintaining network connectivity. This comprehensive analysis provides valuable insights into the structure and dynamics of the network, highlighting the essential roles of these key nodes.

In contrast to the most influential nodes, the nodes A52 (Sustainability), A32 (GIS), and A53 (Sustainability) exhibit the lowest connectivity within the network. These nodes have the lowest values across various centrality measures, such as degree centrality, betweenness centrality, and eigenvector centrality. This indicates that they are less integral to the overall structure and information flow of the network. The low degree centrality suggests that these nodes have fewer direct connections to other nodes. Their low betweenness centrality implies that they rarely act as bridges or intermediaries in the network, indicating that information or resources seldom pass through them. Additionally, their low eigenvector centrality means that they are not well-connected to other influential or well-connected nodes. The primary reason for this low connectivity is likely due to the specialized nature of their roles. Nodes representing sustainability and GIS are typically consulted for specific, technical information rather than being central figures in the project management or decision-making processes. These nodes are likely involved in the network only when particular expertise is needed, leading to their limited interactions with other nodes. Consequently, they are not as central or influential in the overall network dynamics, reflecting their specialized, consultative roles.

The N346 project case study, analyzed through quantitative research methods, investigates the utilization of lessons learned within the tender process. The study reveals both engagement with and gaps in the use of these insights, highlighting various tools and methods employed. Specific applications of lessons learned during early project phases are also examined. Some observations will be discussed further to provide qualitative elaboration, offering a deeper understanding of their implications for future projects. These are some findings:

- Data silos: In the network you can see that the jurist (contracting) is connected only to individuals from sustainability, GIS, and contracting, this limited interaction forms a data silo (Figure 20). Such a silo impedes the jurist's ability to access and share insights across the broader network, which can have significant implications for the lessons learned process in tendering and project management. The survey data shows that while many respondents engage with lessons learned, a substantial portion do not utilize these insights. This discrepancy underscores a critical gap in integrating lessons learned into practice, likely exacerbated by data silos that hinder comprehensive knowledge sharing. Data silos hinder the flow of knowledge and can result in repeated mistakes and missed opportunities for improvement. As noted by Bilal et al. (2016), the construction industry's fragmented data management practices limit the effective sharing and application of insights. Addressing these silos by improving data sharing practices and integrating tools for managing lessons learned can help facilitate continuous improvement in the industry.

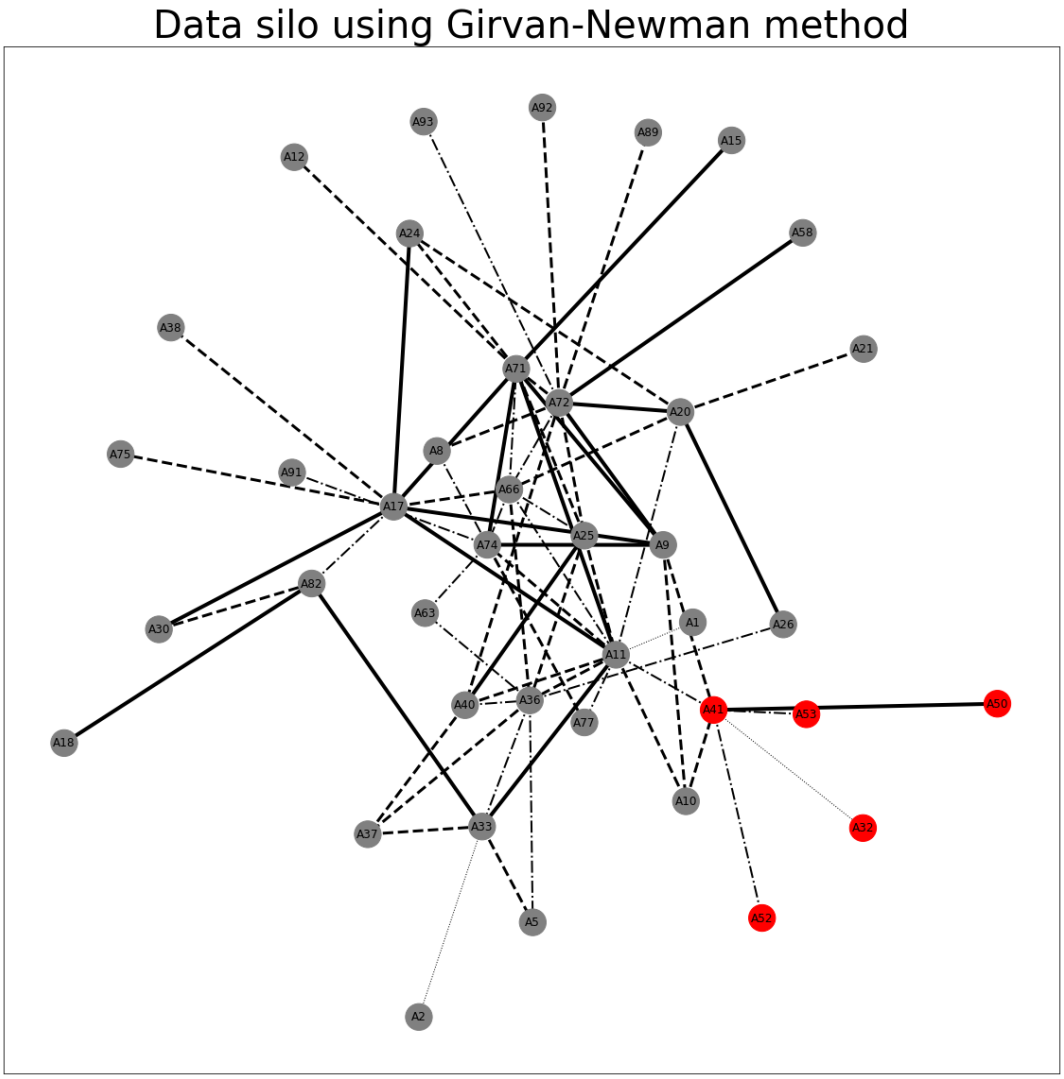


Figure 20: Data silo N346

- Tools that are used: In the SNA email emerges as the most frequently used tool for sharing lessons learned, followed by SharePoint. This preference for email is likely due to its widespread accessibility and ease of use. Email allows quick dissemination of information to multiple stakeholders, supports detailed, structured communication, and provides a record of communication for tracking purposes. The study by Erhardt et al. (2016) highlights how the affordances of email (asynchronicity, editability, persistence, and replicability) influence team learning over time, emphasizing its role in effective communication. SharePoint, as the second most used tool, is logical due to its capabilities in storing, organizing, and sharing documents in a collaborative environment. It serves as a centralized repository, making it easier to retrieve and apply insights in future projects, thus reducing data silos by providing a single source of truth (Carrillo et al., 2013). SharePoint supports collaborative editing and sharing, ensuring that valuable insights are accessible to all team members and can be acted upon promptly (Ahmad & Bergsjö, 2021). Its integration with other Microsoft tools, such as Teams and Outlook, enhances its utility and ease of use for managing lessons learned (Alreshidi et al., 2018). The survey from the N346 project case study shows that many respondents do not use lessons learned in tender processes, indicating a gap due to fragmented tool usage and data silos. The preference for "Project evaluation" highlights its

importance in capturing insights, but SharePoint offers better continuous documentation and centralized storage, reducing data silos and supporting ongoing knowledge sharing (Carrillo et al., 2013).

- Network density: Network density is a crucial metric in understanding the connectivity and efficiency of information systems. In a study of the N346 project, it was found that the network density was only 9.7%, which is considered low. Low network density can indicate fragmented information systems and hinder effective communication and knowledge sharing. Studies have shown that lower density in innovation networks can lead to inefficiencies, particularly in explorative innovation scenarios (Hua et al., 2022). Furthermore, maintaining robust network connectivity is essential for preventing the high risk of innovation failure that can occur in sparsely connected networks. This is supported by research that highlights the importance of network connectivity for the effective aggregation and dissemination of information, thereby improving overall network performance. Therefore, addressing the low network density and improving interconnectivity within information systems are critical steps toward enhancing communication and learning within the network.

5.2.4 Node types analysis

In the analysis of the N346 project, special attention will be directed towards the roles of gatekeepers and central nodes within the network. These node types are critical for their ability to control and facilitate the flow of information, which is essential in managing tender processes effectively. Gatekeepers regulate information access, potentially influencing project communication dynamics, while central nodes, as key connectors, play a pivotal role in disseminating vital data and lessons learned throughout the network. This focus will help uncover how these nodes impact the overall communication and knowledge sharing in the project.

Gatekeepers

In the SNA of the N346 project, as depicted in Figure 21 several key nodes function as gatekeepers: A72, A20, A71, A11, A17, A74, A33, A82, and A41. Particularly, nodes A41 and A72 are highlighted as central to the network's functionality. These gatekeepers play a crucial role not just in facilitating or obstructing information flow but also in maintaining the structural integrity of the network. Their strategic importance is underscored by the potential impact of their removal from the network, which could isolate certain nodes and sever critical communication links. This scenario would significantly disrupt the project's operational flow, underscoring the gatekeepers' role in sustaining the connectivity and coherence of the network. Their departure could lead to the exclusion of certain nodes from the network, which might impede the collective capability to share vital project data and make informed decisions efficiently.

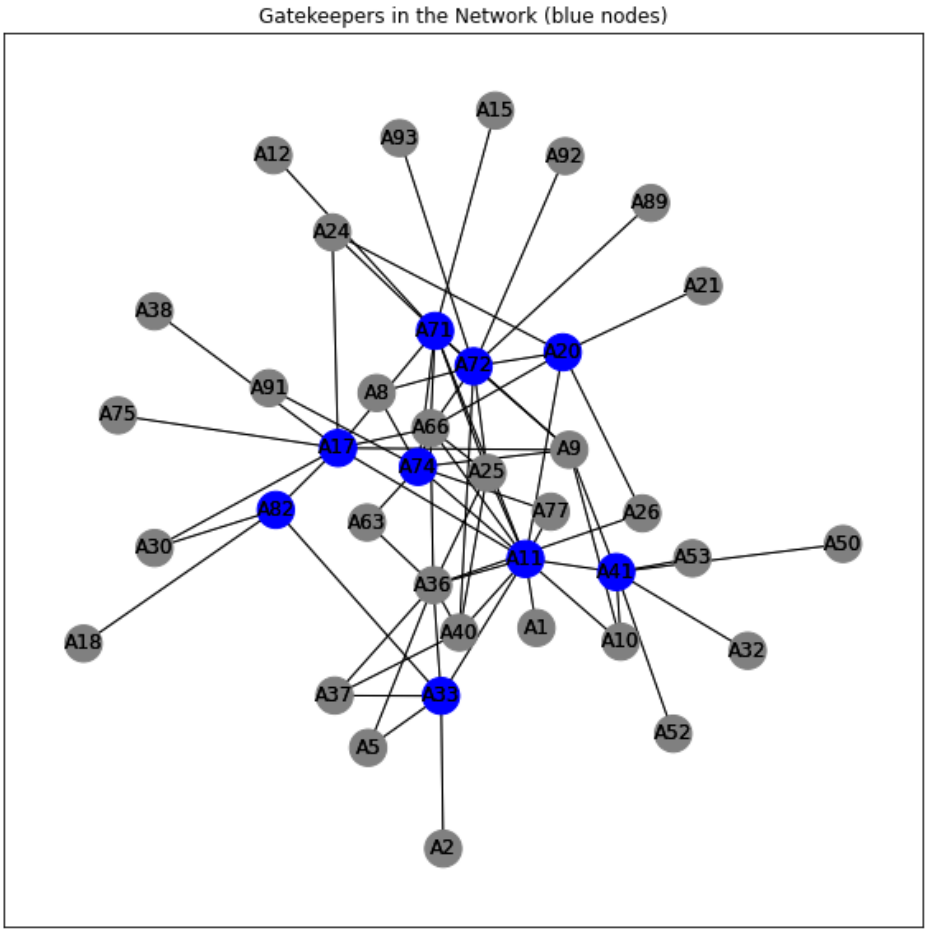


Figure 21: Gatekeepers N346

Figure 22 and Figure 23 showcase the graphs with the respective removal of node A41 and A72. The removal of these critical gatekeepers leads to the emergence of isolated nodes within the network, which can significantly disrupt the flow of information. As these nodes become disconnected, the lessons learned and crucial insights held by them may no longer be accessible to the rest of the network. This isolation not only hampers the overall knowledge-sharing process but also risks the loss of valuable project data that is essential for informed decision-making. Consequently, the network's ability to effectively manage and integrate lessons learned is compromised, highlighting the vital role that gatekeepers play in maintaining the cohesion and functionality of the project's communication structure.

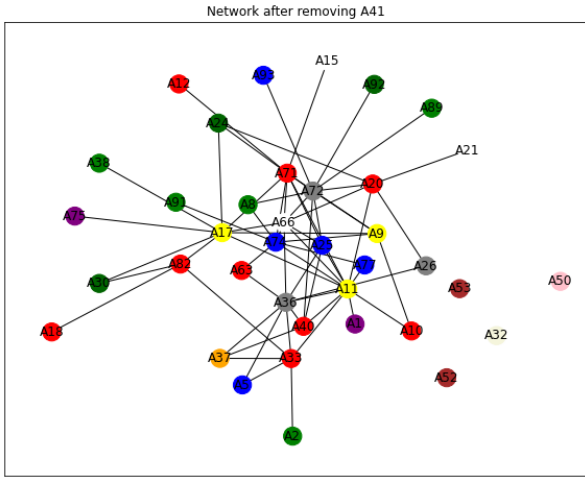


Figure 22: Network after removing A41

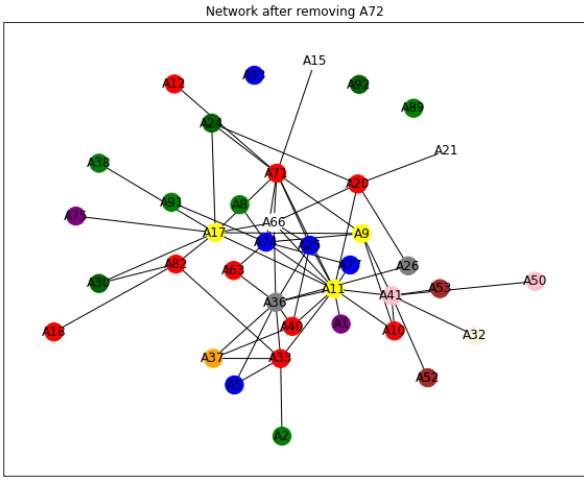


Figure 23: Network after removing A72

Central figures

In the analysis of the network depicted in Figure 24, two central figures are highlighted in green: node A66, the calculator, and node A11, the tender manager. These nodes are crucial to the network's operation due to their central positions, which allow them to influence and facilitate communication and data flow across the project. As central nodes, A66 and A11 play pivotal roles in ensuring that critical information, such as lessons learned, is efficiently disseminated throughout the network. Their positions enable them to connect various parts of the network, ensuring that knowledge and insights gained during the tender process are accessible to all relevant actors. The prominence of these nodes underscores their importance in maintaining the network's integrity and ensuring that the project benefits from a well-informed and coordinated approach.

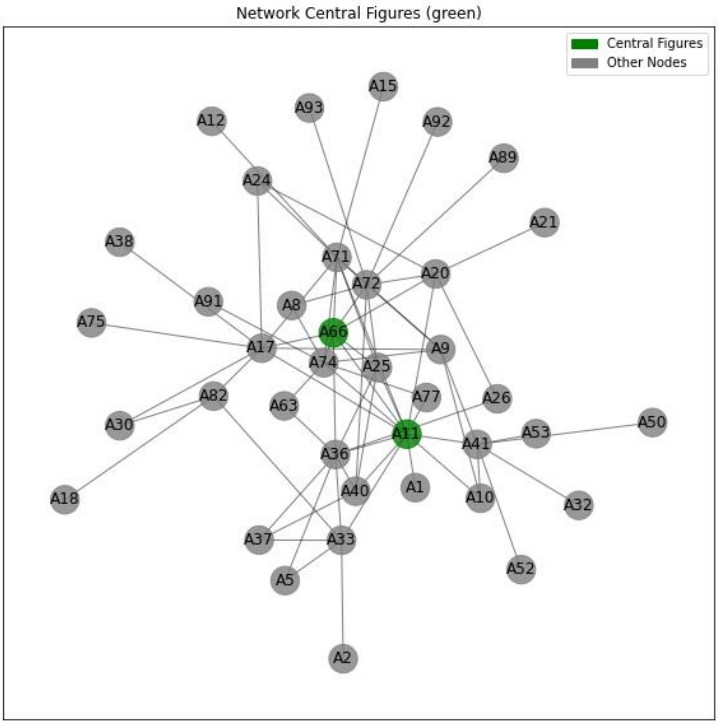


Figure 24: Centrak figures N346

The network visualization after the removal of node A66, as shown in the Figure 25, demonstrates that despite the removal of this central node, the network remains largely cohesive. This resilience can be attributed to the high density of the network, which ensures that information flow and data sharing continue relatively unimpeded. The overall structure retains its integrity, minimizing the potential loss of critical data and maintaining effective communication channels.

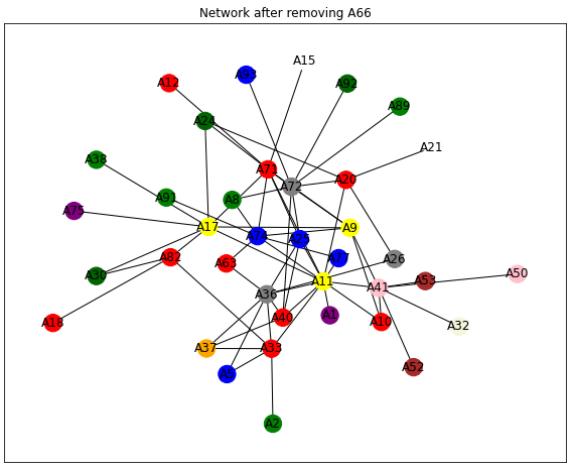


Figure 25: Network after removing A66

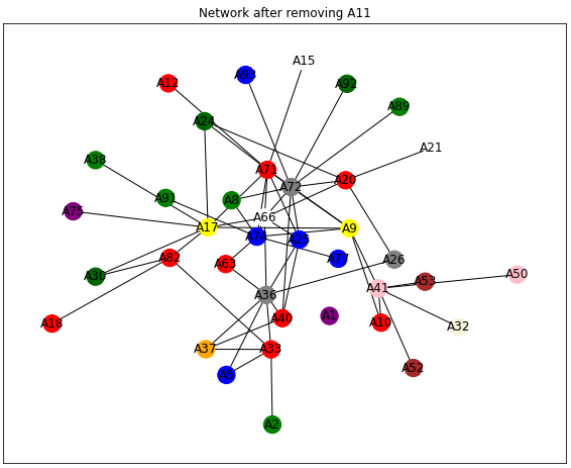


Figure 26:Network after removing A11

However, if node A11, the tender manager, were to be removed, the impact would be more severe (Figure 26). The removal of A11 would cause node A1, a systems engineer, to become isolated from the rest of the network. This disconnection would break the network's cohesion, resulting in fragmentation. The systems engineer, A1, would no longer be integrated into the primary

communication flow, leading to potential loss of critical information and lessons learned that A1 may hold. This scenario highlights the importance of maintaining the integrity of central nodes like A11, whose presence is crucial for ensuring that all parts of the network remain connected and functional.

5.3 Prinses Alexia viaduct

The Prinses Alexia Viaduct is a significant infrastructure project in the Port of Rotterdam, intended to ensure future access to the areas around Prinses Alexiahaven. The viaduct will replace a level crossing on the Maasvlakteweg and is essential for safe and efficient traffic flow as container handling and industrial activities in the area increase. The construction of the viaduct includes creating an overpass over the Maasvlakteweg, industrial pipeline strips, utilities, the Container Exchange Route (CER), and railways. This project is part of a broader initiative to make the port more sustainable and future-proof through strategic investments in infrastructure and green energy projects. This project is part of broader efforts within the Port of Rotterdam to create a more sustainable harbor, which includes investing in projects such as the construction of a national hydrogen network and the expansion of capacities for the storage and transport of CO2 under the North Sea.

5.3.1 Results: mapping data-sharing network

In the evaluation of the tender process for the Alexiaviaduct project, SNA was utilized to investigate the communication and collaboration patterns among the stakeholders, based on responses from 13 participants involved in the survey. The findings are visually represented in the network graph (Figure 27) and detailed in accompanying Table 1Table 9. The network graph now shows a configuration of 37 nodes interconnected by 64 edges. This layout provides an updated view of the structural dynamics within the network. With an average degree of 3.45, it is evident that each node is connected to approximately three other nodes, confirming a moderately interconnected network. Such connectivity is essential for fostering effective communication channels crucial for strategic decision-making in the tender process.
Chart 8 shows that email and face-to-face interactions are the most frequently used platforms for data sharing, standing out with noticeably higher usage compared to other methods. While other platforms like phone calls, online collaboration tools, and video calls are also utilized, they are less predominant. Notably, BIM/ACC tools are used minimally.

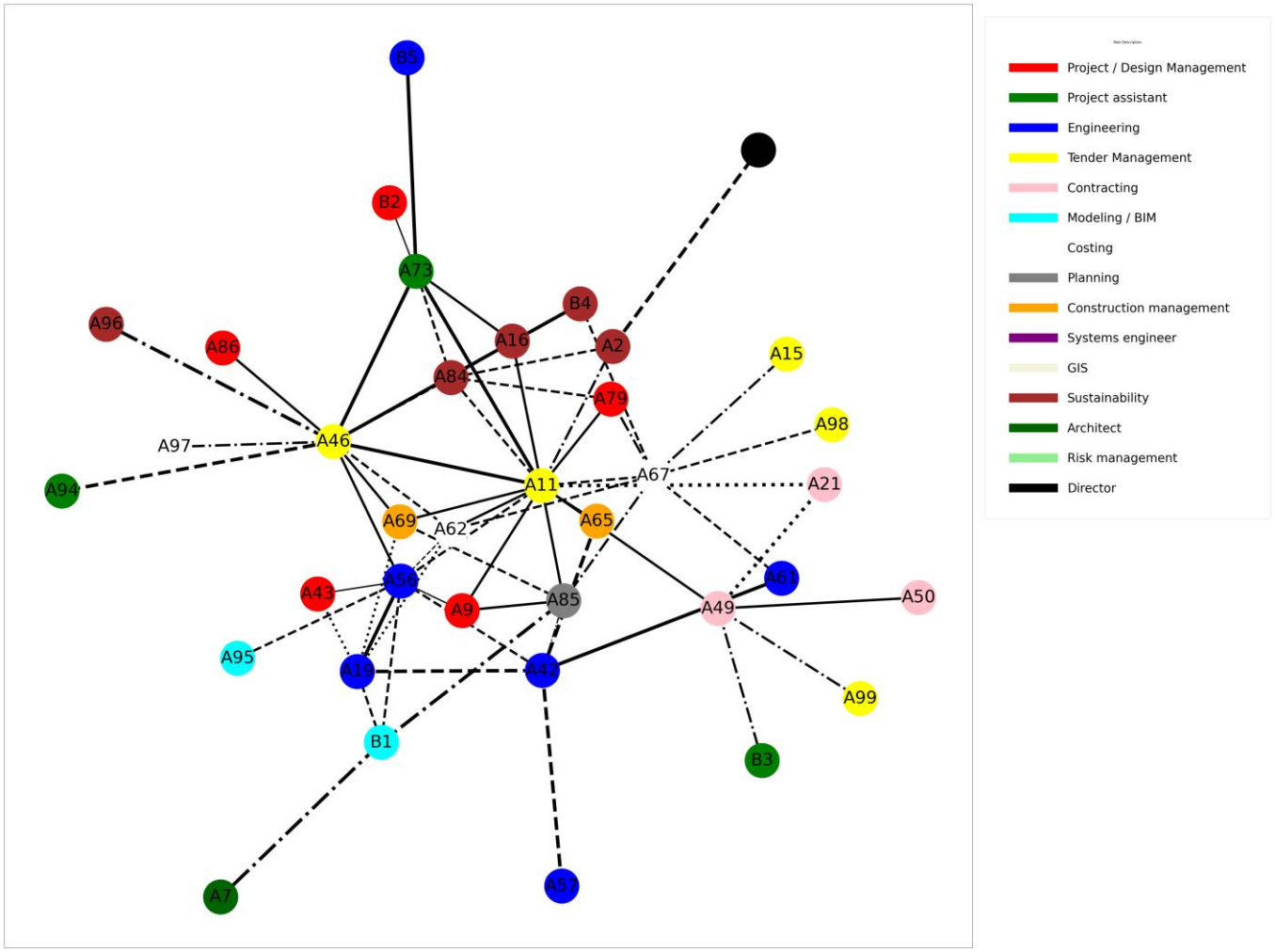
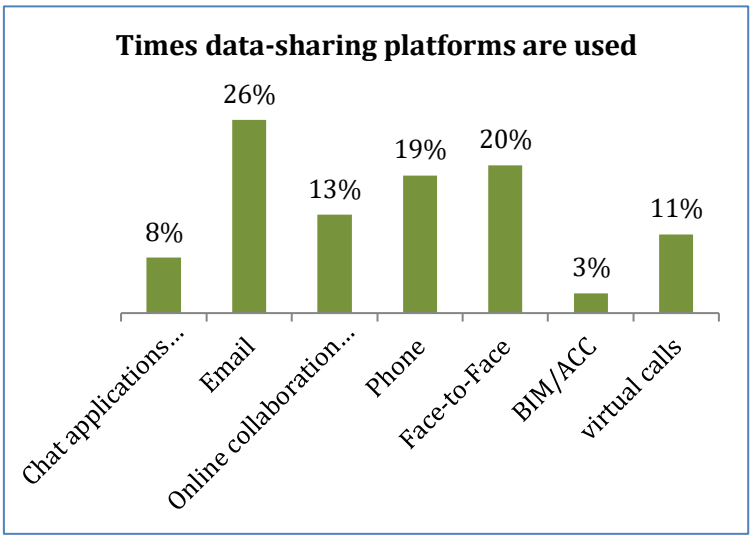


Figure 27: Data-sharing network tender Alexia viaduct

Table 9: Network information Alexiaviaduct

Components	Statistics
Nodes	37
Edges	64
Graph density	9,6%
Average clustering coefficient	20,9%
Average degree	3,45
Average frequency of data exchange	7.0/ (10.0)
Average indicated value of data	7.5 / (10.0)

Chart 8: Platforms used Alexia viaduct



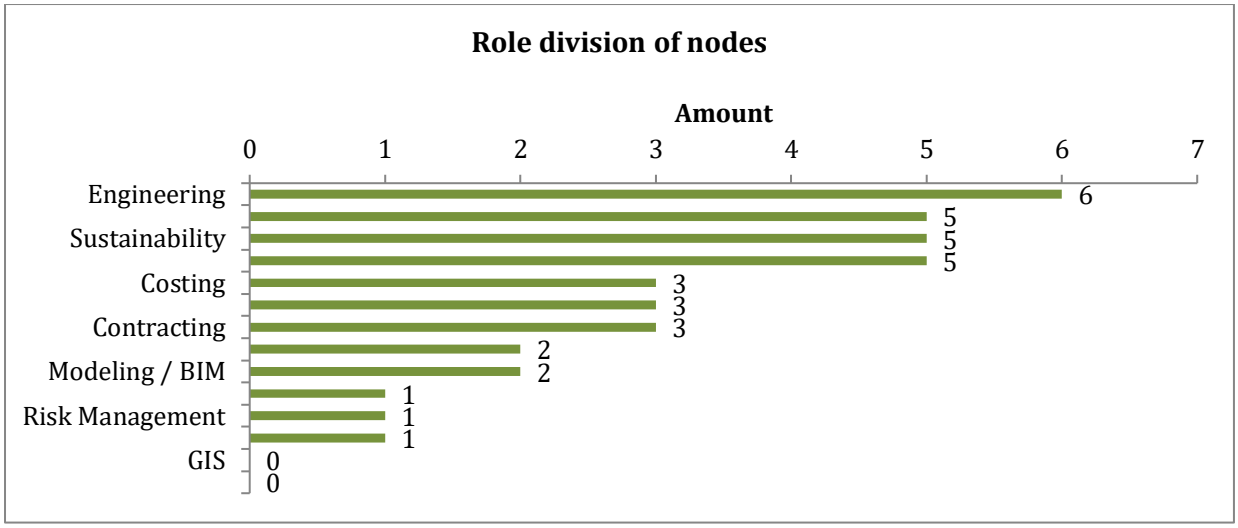


Chart 9: Roles nodes Alexia viaduct

The network density is recorded at 9.6%, suggesting a calculated and strategic use of connections within the network. This density level indicates that while the network isn't fully utilizing all potential connections, the established links are crucial for the effective dissemination of information among key participants. The average clustering coefficient for the Alexia viaduct project is 20.9%. This table suggests that the network has a moderate tendency for nodes to cluster, which can facilitate collaboration within these groups. This level of clustering is beneficial for effective information sharing and problem-solving among connected stakeholders, without implying a direct comparison to previous data unless such earlier measurements have been explicitly discussed in the study. If this is a first-time measurement, then it should be treated as a standalone statistic that indicates the current state of clustering within the network. The data exchange metrics have also been updated, showing an average frequency of data exchange rated at 7.0 out of 10. This reflects a consistently high level of communication within the network. The average indicated value of data remains at 7.5, underscoring the high utility and relevance of the information being shared, reinforcing the impact of communications in the tender process for the Alexia viaduct.

Chart 9 displays the role division of nodes within the project, showing a diverse distribution of roles involved in the tender process. Engineering is the most represented role, followed closely by Tender Management, Sustainability, and Project/Design Management. Other roles like Costing, Project Assistance, and Contracting are also well-represented, while roles such as GIS and Systems Engineering are not present in this division. This distribution highlights the prominence of technical and management functions in the tender process, with certain specialized roles being less involved.

5.3.2 Lessons learned

The case study on the tender process for the Prinses Alexia viaduct, informed by survey responses, provides critical insights into the adoption and integration of "lessons learned" mechanisms throughout the tender stages. From the outset, respondents noted challenges in locating lessons learned, particularly as projects transition from the orientation to the startup

phase. The survey responses underscore a recurring theme: lessons learned are often difficult to find and inconsistently applied across different stages of the tender process. This issue is particularly significant during critical phases such as pre-qualification, the initial startup, and subsequent reviews. The statistical data from the survey, reflecting on the platforms used for managing lessons learned, shows a pronounced preference for 'Project Evaluation' and 'SharePoint'. These platforms evidently serve as the primary repositories and access points for lessons learned, underscoring their importance in facilitating the effective recall and application of past insights, as depicted in Chart 10, which details the tools used. Additionally, the statistics reveal that 6 out of 10 respondents indicate they use lessons learned, while 4 do not, highlighting a significant gap in the application of these insights. This distribution is visually represented in Chart 11, which illustrates the "Yes/No" responses regarding the use of lessons learned.

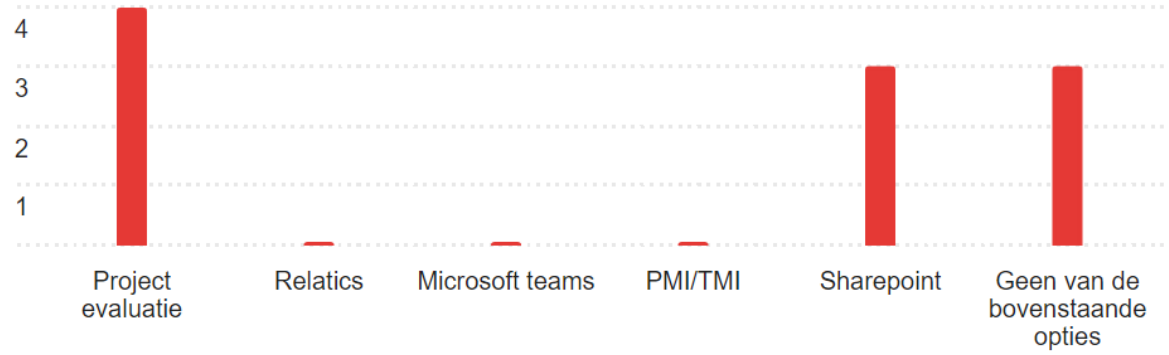


Chart 10: Tools used for lessons learned notation and reviewing

However, the survey also reveals that other potentially valuable tools like 'Relatics' and 'Microsoft Teams' are underutilized. This suggests a potential misalignment between the available tools and their actual deployment in capturing and disseminating lessons learned effectively. This gap underscores a critical area of concern: the embedding of lessons learned into the project lifecycle is not yet a standard practice, suggesting a disconnect between the recognition of their value and their practical application.

Chart 11: usage of lessons learned

5.3.3 Analysis Network Prinses Alexia viaduct

In the SNA of tender N346, various nodes are highlighted for their crucial roles within the project. A11, the Tender Manager, exhibits the highest eigenvector centrality (0.474), illustrating significant influence and connectivity within the network. This role necessitates extensive interactions for managing tenders, as reflected by its high degree centrality (0.417) and betweenness centrality (0.61), emphasizing its function as a critical communication hub and

bridge between different sections of the network. Additionally, A46 and A73, both Tender Strategists, also possess significant centralities, though less than A11. A46 has an eigenvector centrality of 0.255 and plays an essential role in strategic tender planning, supported by a betweenness centrality of 0.514, which indicates its importance in facilitating communication among network members. A73, with a lower eigenvector centrality of 0.11, may have a more focused or specialized role, resulting in less central but still crucial network positions. Furthermore, A56, the Constructor, shows a respectable eigenvector centrality of 0.257, positioning him as a key player within the project's construction aspects. Though not as central as the tender managers or strategists, his role in the network still supports important operational connections, evidenced by his closeness centrality and betweenness centrality of 0.507 and 0.215, respectively. A84, focused on Sustainability, has an eigenvector centrality of 0.247, somewhat comparable to A56, indicating an important, albeit specialized role within the network. Despite his lower overall centrality, this node has a high clustering coefficient (0.467), indicating strong local connections critical for integrating sustainability practices within project phases. This analysis illustrates the dynamics and significance of each of these nodes within the tender N346 network, with each role contributing to the overall efficiency and effectiveness of the tendering process.

In the following section, I will detail the most crucial findings from the SNA of the tender process. These insights are supported by relevant literature, emphasizing the pivotal roles and interconnectivity of key nodes within the network. This synthesis not only aligns with established theoretical frameworks but also adds empirical weight to the discussion on network dynamics in tender management. This integration of theory and practice serves to deepen our understanding of strategic interactions within complex projects.

- Tools: Survey results indicate that email is the most frequently used tool for communication within the tender process. It stands out not only for its high usage rate but also as the favorite among respondents. This preference highlights email's effectiveness and essential role in managing and exchanging information (Erhardt et al., 2016). The consistency in its use suggests it is integral to the daily operations of the tender process. Furthermore, findings reveal that 75% of data exchange within the tender process occurs via non-collaborative platforms. This heavy reliance on traditional methods like email highlights a significant area for improvement. Non-collaborative tools, while effective for straightforward communication, often lack the dynamic features that foster real-time collaboration and integration of insights (Ahmad & Bergsjö, 2021; Alreshidi et al, 2018). As a result, this can lead to inefficiencies, a slower response time, and potential barriers in optimizing the flow of information across different project stages.
- Density: The network density in this analysis stands at 9.6%, nearly mirroring the density observed in the previous case study. Such a low network density indicates that only a small fraction of possible connections are being utilized (Hossain & Wu, 2009). This underutilization can lead to several disadvantages, including reduced communication efficiency and potential isolation of key stakeholders. Additionally, low density might hinder the flow of information, making it difficult to achieve comprehensive collaboration and timely decision-making across the network (Chinowsky & Taylor, 2012).
- Tender manager as central node: The tender manager A11 is identified as the central point of the network. This central position means that A11 is the primary hub through which most communications and information exchanges occur (Ahmad & Bergsjö, 2021). Being the

central node, A11 facilitates the majority of interactions among stakeholders, acting as a key conduit for data transfer (Anokhov, 2020). This role places A11 at a strategic vantage point, where they have a comprehensive view of the entire tender process (Goffin & Koners, 2011). As the central node, A11 can influence the flow of information and ensure that all relevant parties are kept informed and engaged (Demirkesen & Tezel, 2021). The centrality of A11 within the network highlights their pivotal role in maintaining network coherence and operational efficiency (Shen et al., 2010).

- Similar network information as in Tender N346: The average statistics in this analysis closely mirror those observed in the previous case study. The values for key metrics such as network density, average clustering coefficient, and average degree are remarkably similar between the two studies. For instance, the network density stands at 9.6%, compared to 9.7% in the previous case, and the average clustering coefficient is 20.9%, compared to 21.5% previously. The average degree is also consistent, with 3.45 in the current analysis versus 3.69 previously. This consistency indicates stable structural characteristics within the networks under study, suggesting common patterns in communication and collaboration dynamics (Ackoff, 1989). Additionally, metrics related to the frequency and value of data exchange further reinforce the similarities, highlighting recurring trends in how information flows and is perceived within these networks (Shokri-Ghasabeh & Chileshe, 2014),

5.3.4 Node type analysis

In this section on the Alexia Viaduct tender, I will discuss the relevant gatekeepers and central figures within the network. These roles are crucial for understanding the dynamics and information exchange within the tender process.

Gatekeepers

In the analysis of the Alexia Viaduct project, as shown in Figure 28: Gatekeepers Alexia viaduct, nodes A46 (tender manager) and A49 (contract manager) are identified as the key gatekeepers with the most influence on the network's structure.

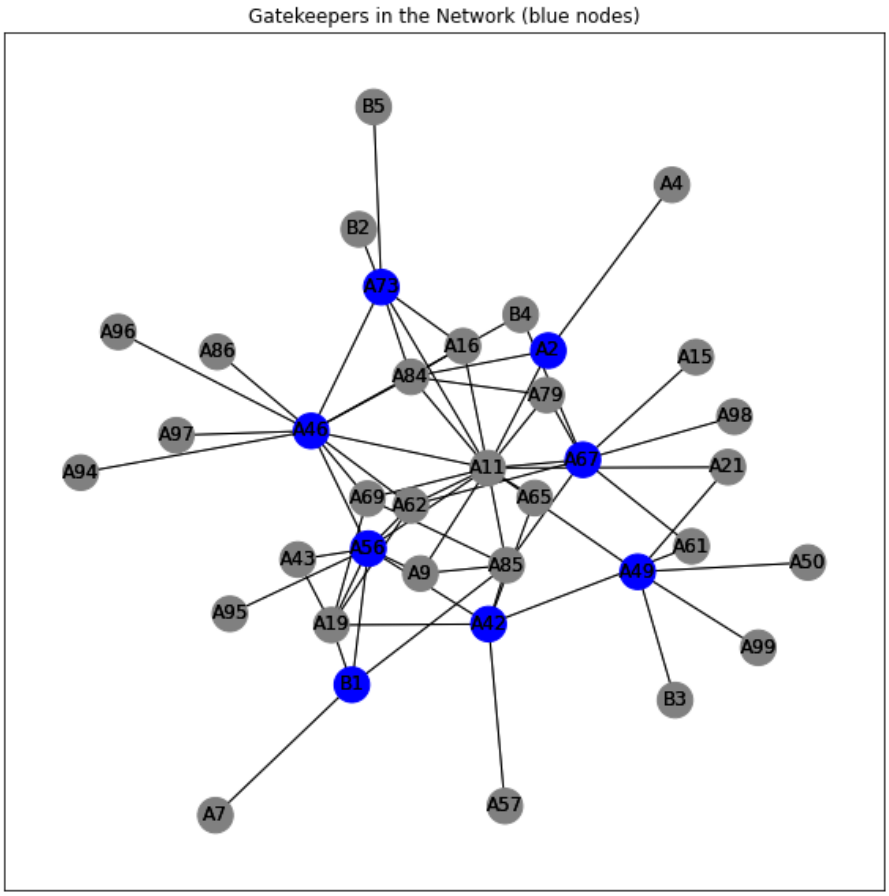


Figure 28: Gatekeepers Alexia viaduct

Their removal would have significant consequences for the network's integrity. Node A46, the tender manager, plays a crucial role in maintaining the network's cohesion. If A46 were to be removed, as is shown in Figure 29 it would result in the disconnection of four other nodes, leading to substantial fragmentation within the network. This would isolate these nodes, cutting them off from critical information flows and potentially leading to a loss of vital project knowledge and communication.

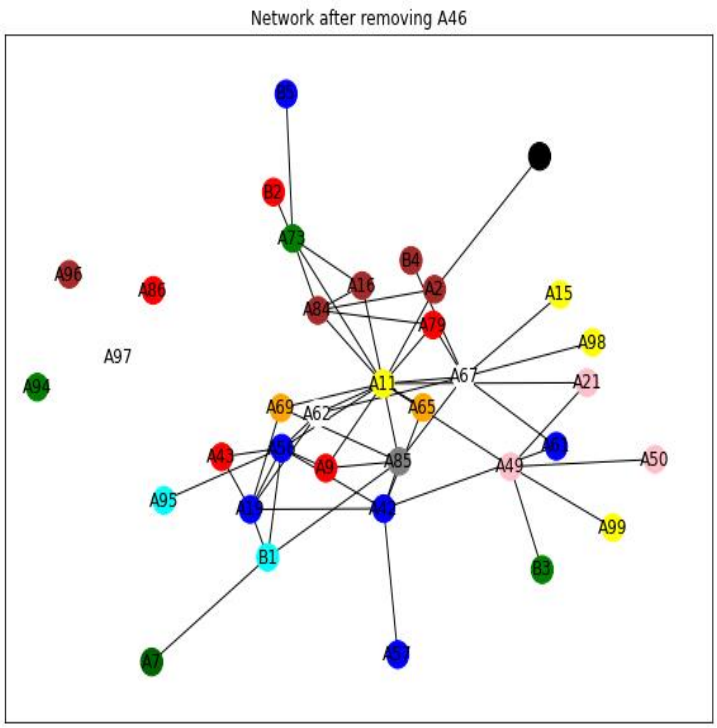


Figure 29: Network after removal A46

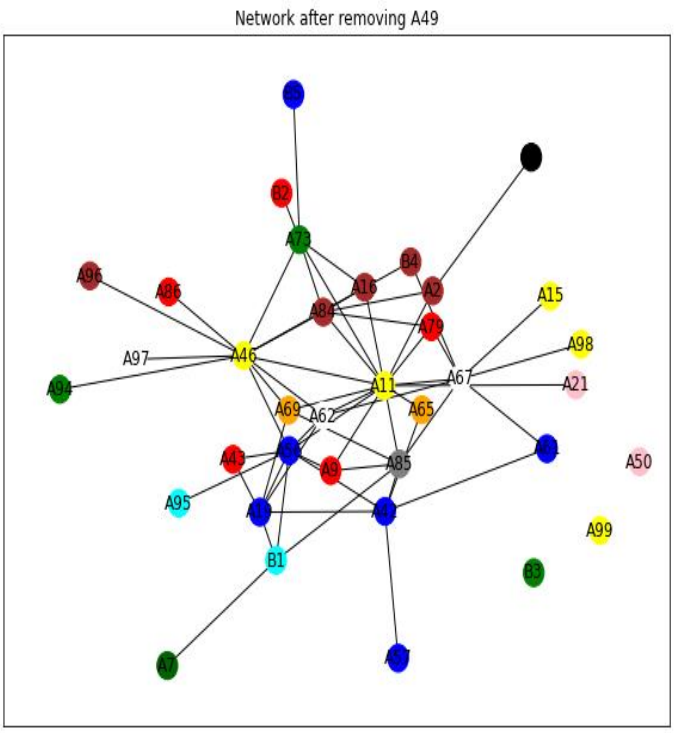


Figure 30: Network after removal A49

Similarly, node A49, the contract manager, also has a significant impact, but with a slightly different focus. The removal of A49 would lead to the loss of three nodes from the network (Figure 30). Importantly, these nodes are directly related to the contracting department, which is a key stakeholder in the tender process. The disconnection of these nodes would not only fragment the network but also risk the loss of crucial contracting-related insights and coordination, which are essential for the project's success. The loss of A49 would thus represent a substantial disruption, particularly in terms of maintaining the continuity and effectiveness of the contracting department's role within the network In Figure 31, the network visualization using the Girvan-Newman method reveals the presence of a data silo within the network, represented by the red nodes (Despalatovic et al., 2014). These nodes are isolated from the main communication flow, forming a cluster that is largely disconnected from the rest of the network. Node A49, the contract manager, is identified as the crucial link connecting this data silo to the broader network. The role of A49 is vital as it ensures that the information and insights within the data silo are accessible to the rest of the network. Without A49, the nodes within this silo would be completely isolated, preventing important contracting-related data from being integrated into the overall project communication and decision-making processes (Anokhov, 2020). This scenario underscores the importance of A49 in maintaining network cohesion and preventing the siloing of critical information.

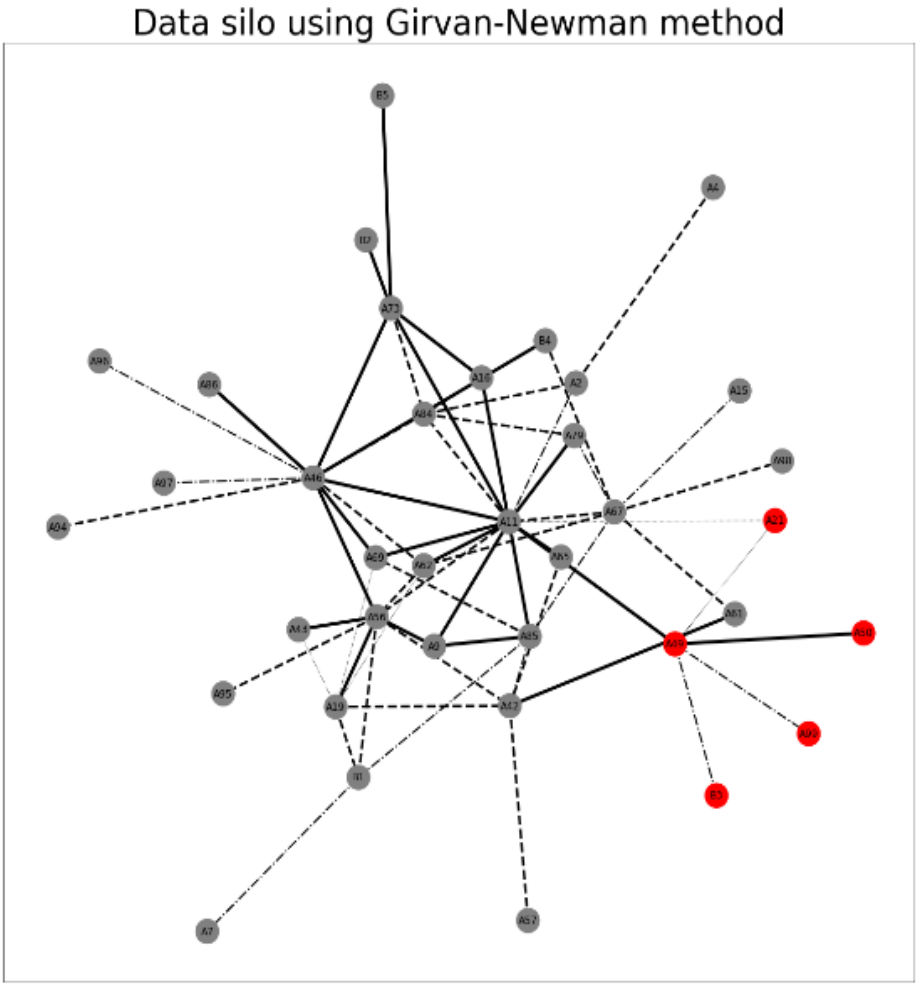


Figure 31: Data silo Alexia viaduct

Central figures

In the SNA of the Alexia Viaduct tender, three central figures stand out: A46, the tender strategist; A11, the tender manager; and A56, the civil engineer (Figure 32). These individuals are pivotal within the network, acting as primary hubs that manage and distribute key information during the tendering process. In the SNA, A11, the tender manager, emerges as the most central figure among the nodes (Figure 34). Despite this central position, the removal of A11 does not immediately suggest a significant impact on the network's overall connectivity. The reason for this is that the remaining nodes are well-connected, which helps maintain the network's integrity even in the absence of A11. A46, the tender strategist, is also a central figure within the network but functions differently. As a gatekeeper, A46 plays a critical role in controlling the flow of information. However, the significance of A46 as a central node is somewhat diminished due to the node's primary connections being with peripheral figures rather than with other central or highly influential nodes

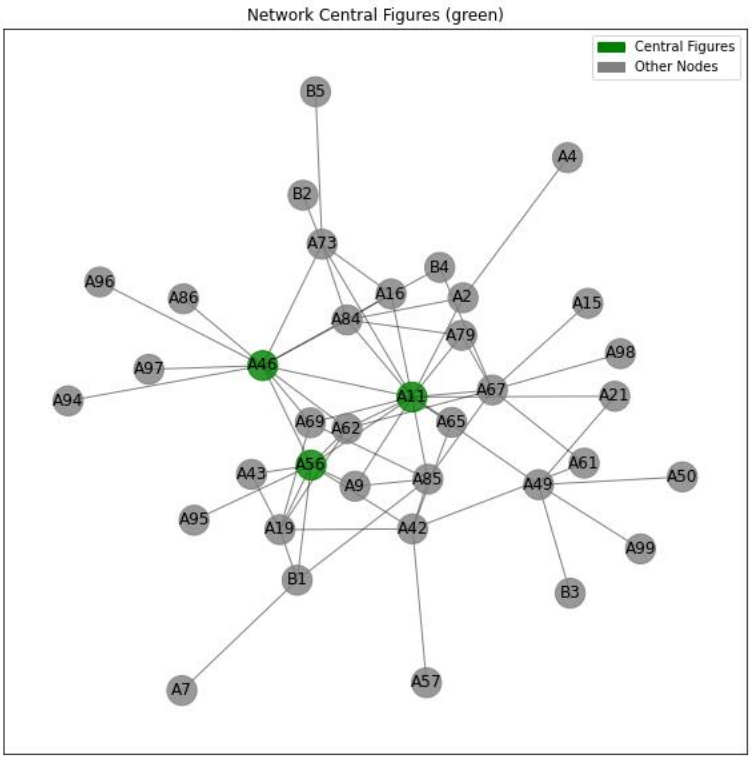


Figure 32: Central figures Alexia viaduct

A56, the civil engineer, stands out for the strong connections maintained with other engineers within the network. This role is particularly crucial because neither A45 nor A11 have direct connections with the engineering cluster. A56's position ensures that engineering-related information flows efficiently within this segment of the network, maintaining the technical integrity of the project while keeping the engineering team integrated with the broader network (Figure 33).

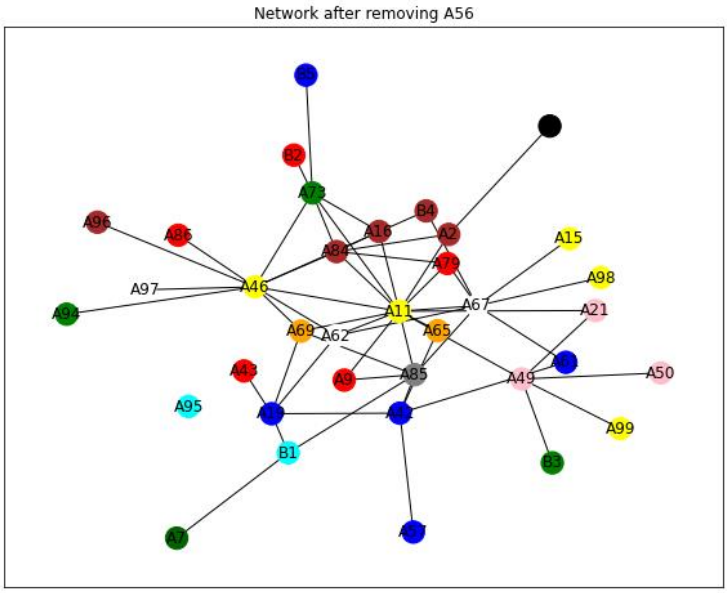


Figure 33: Network after removing A56

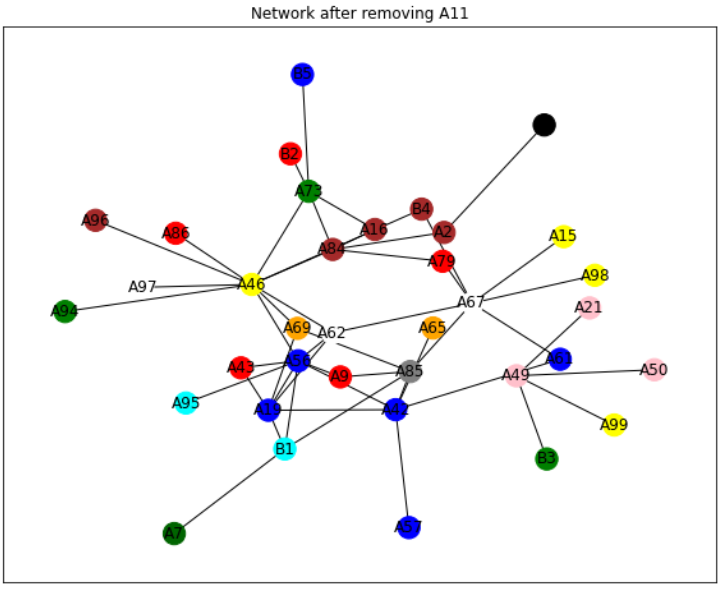


Figure 34: Network after removing A11

5.4 N211 Wippolderlaan

The recent tender for the N211 Wippolderlaan involves a major reconstruction of this section of road between the A4 and the N222. The project, led by the Province of South Holland and carried out by the contractor consortium Westlandse Entree, includes widening the road from two to three lanes in both directions. Additionally, two grade-separated intersections, a roundabout, and a fly-over will be constructed, and the Zwethzone recreational area will be partially redesigned.

5.4.1 Results: mapping data-sharing network

The analysis of the organizational network shown in Figure 35, based on survey data from nine respondents, is depicted in the accompanying network diagram and summarized in the data Table 10 provided. The network consists of 34 nodes and 44 edges, as shown in the diagram. The graph density, calculated at 7.8%, highlights a lower degree of interconnectivity within the network. This suggests that, while operational, the network is not optimally interconnected, which could potentially indicate the presence of isolated departments or groups that could lead to inefficiencies in information sharing and collaboration during critical processes like tendering (Despalatovic et al., 2014). The average clustering coefficient stands at 8.9%, suggesting the presence of clusters within the network where nodes are more tightly knit. This local clustering might indicate efficient sub-group operations but also suggests that broader network integration is needed to ensure cohesive functioning across the entire organization. The presence of such clusters indicates areas where internal connections are strong but external links are weaker, potentially identifying operational silos within the organization that could benefit from enhanced inter-departmental connectivity (Que et al., 2015; Traag et al., 2019).

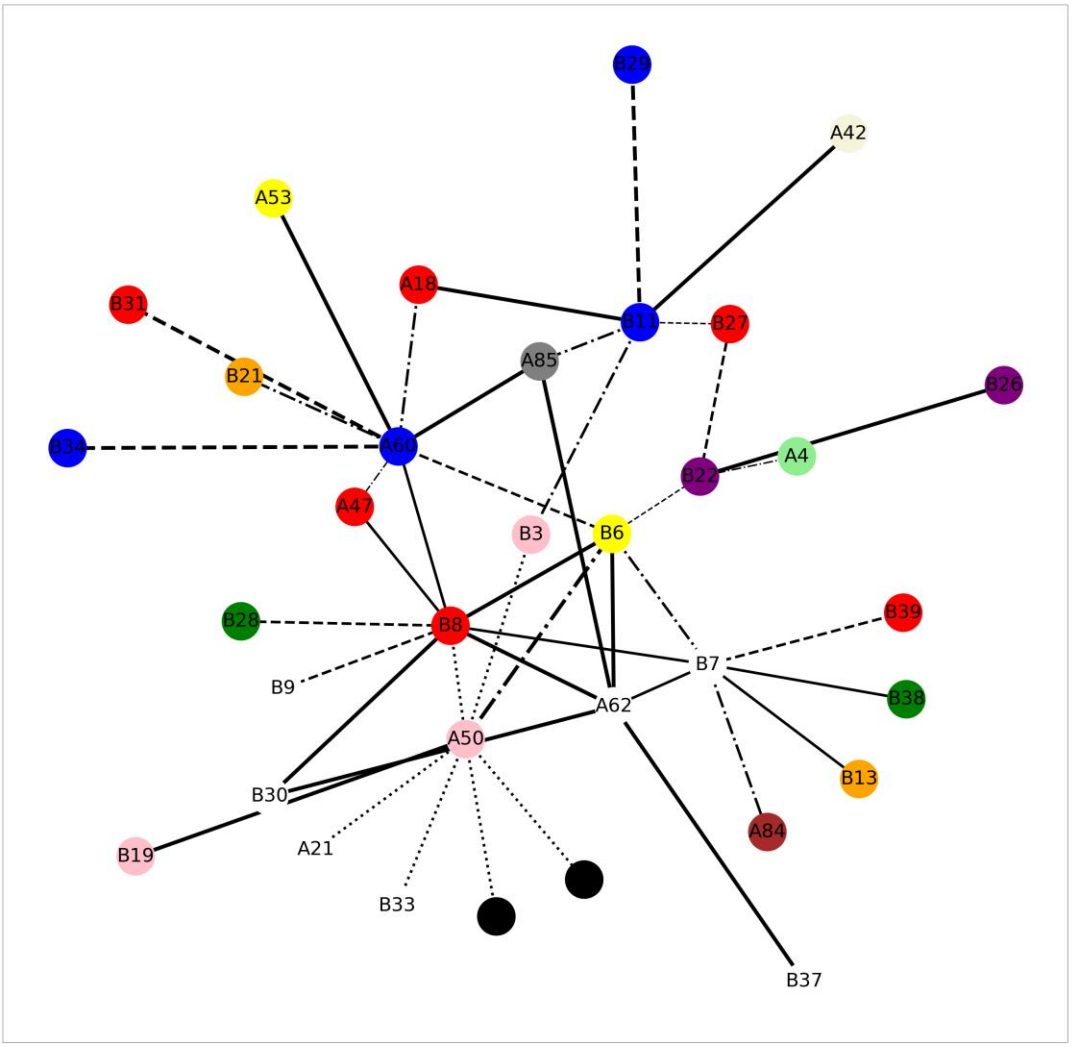


Figure 35: Data-sharing network N211 Wippolderlaan tender

Components	Statistics
Nodes	34
Edges	44
Graph density	7,8%
Average clustering coefficient	8,9%
Average degree	2,59
Average frequency of data exchange	6,9/ (10.0)
Average indicated value of data	7.9 / (10.0)

Table 10: Network information N211

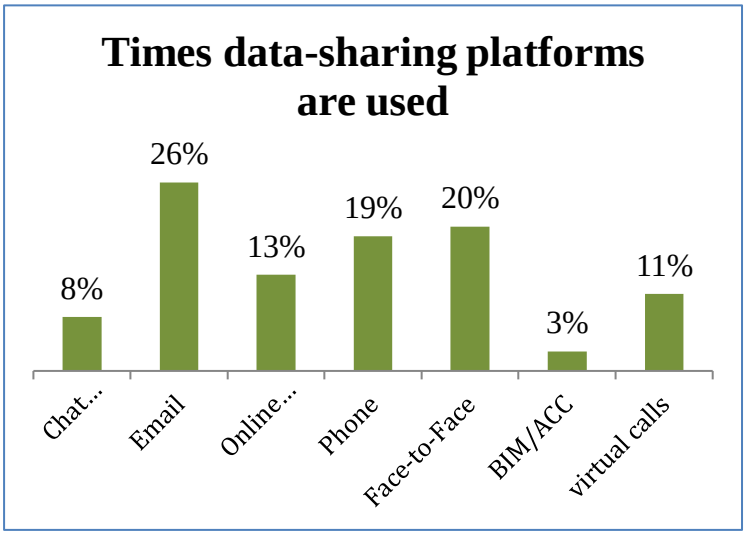


Chart 12: Platforms used N211

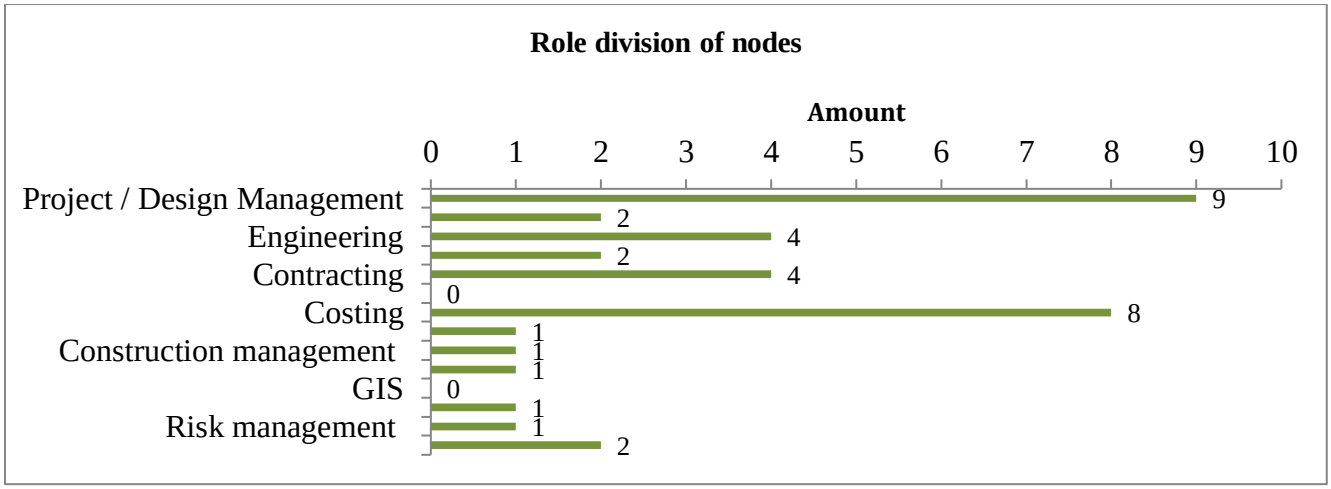


Chart 13: Role division N211

Upon reviewing the network diagram, it's noticeable that node A50, representing a procurement officer, is directly connected to two different types of directors. This structural detail suggests that the procurement officer is central to bridging strategic and operational communications within the organization. The connectivity with multiple directorial roles likely enhances the officer's ability to influence decisions, integrate diverse inputs into the procurement process, and streamline communications across high-level managerial functions. Such a configuration highlights the critical role of the procurement officer in facilitating effective organizational operations and decision-making.

Chart 13 displays the role division of nodes within the Alexia Viaduct tender, highlighting the involvement of various roles in the process. Project/Design Management is the most represented role, with a significant presence, followed by Costing, which also plays a major part. Engineering and Contracting roles are moderately represented, while other roles such as Planning, Construction Management, and Sustainability have minimal representation. The distribution suggests a strong focus on project management and cost analysis, with less emphasis on other specialized functions within the tender process.

Chart 14 tender highlights a preference for communication and data sharing tools during the tendering process, with email emerging as the most favored medium. This trend mirrors observations from previous case studies, where email consistently ranks as the top choice due to its widespread accessibility, archival capabilities, and formal communication structure. The preference for email underscores its integral role in ensuring a documented, traceable, and formal exchange of information, which is crucial in the meticulous environment of tender management.

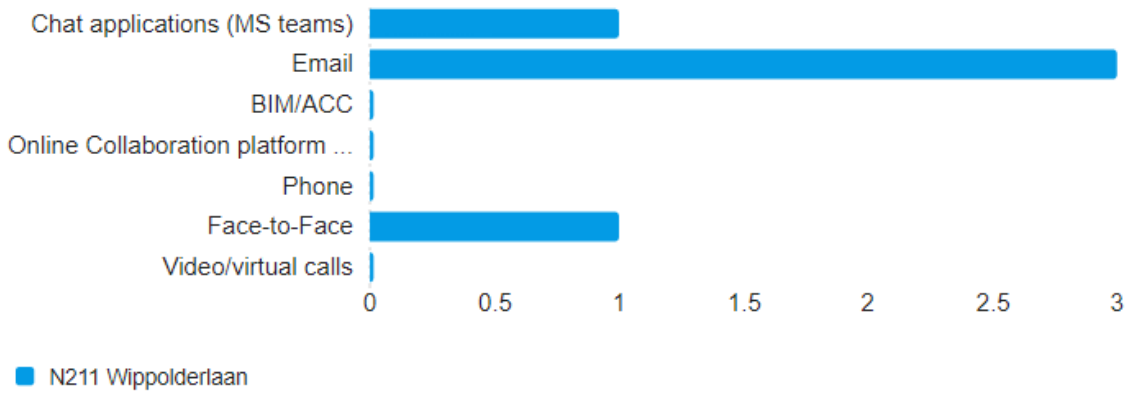


Chart 14: Favorite tools respondents for data sharing

Interestingly, face-to-face interactions also remain highly valued, ranking significantly alongside digital communication methods. This preference indicates that, despite the digital transformation in workplace communications, the value of direct, personal interaction remains high. Face-to-face meetings are likely preferred for their effectiveness in building trust, clarifying complex issues quickly, and fostering relationships, which are essential for successful collaboration in tender processes.

Chart 12 detailing the usage of various data-sharing platforms during the tender process for the N211 Wippolderlaan project indicates a clear preference for traditional communication methods. Email remains the most utilized platform with 25% usage, reinforcing its role as a trusted and effective medium for formal communication and document exchange in business environments. Face-to-face interactions are also highly favored, accounting for 22% of communications, which highlights the ongoing importance of personal interactions for building relationships and facilitating clear, direct discussions in project settings.

Phone communication follows closely at 21%, underscoring its relevance for quick decision-making and problem-solving discussions. Less traditional but increasingly popular, video/virtual calls were used 13% of the time, reflecting the growing reliance on digital tools for remote collaboration. Chat applications like Microsoft Teams were used in 8% of instances, which, while lower, still signifies an adoption of real-time messaging platforms for less formal or immediate exchanges. Interestingly, BIM/ACC tools were not utilized, indicating either a lack of requirement or integration within the tendering phase of this project.

5.4.2 Lessons Learned

In the survey, the responses indicate that the majority of respondents selected "No," marking a notable deviation from usual patterns seen in similar surveys as is shown in Chart 15. However, it's important to highlight that the two respondents who chose "Yes" applied their choice consistently throughout the entire tender phase. This approach represents a form of continuous learning and documentation, suggesting a strategic implementation of methodologies aimed at enhancing project outcomes through ongoing adaptation and record-keeping. Such practices are aligned with the principles discussed in the literature on project management and continuous improvement (Kerzner, 2017; Schindler & Eppler, 2003; Anbari et al., 2008; Duffield & Whitty,

2015). This continuous application suggests a commitment to leveraging structured methodologies to facilitate project success and efficiency, underlining the importance of systematic practices in managing complex projects. This kind of approach is crucial for capturing lessons learned and improving future tender processes, ensuring that they better meet stakeholder expectations and project requirements.

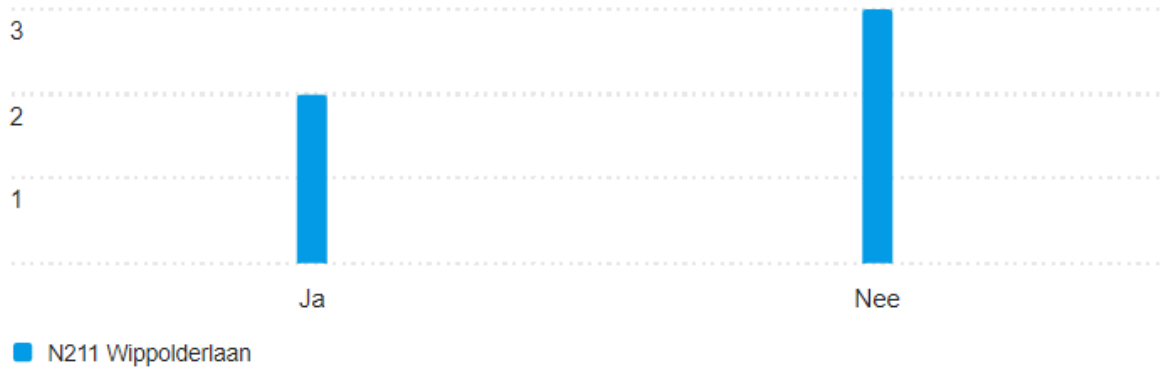


Chart 15: Lessons learned usage

Chart 16 depicting the most utilized tools by respondents for documenting or retrieving lessons learned during the project reveals a significant preference for options not listed among the standard choices. "None of the above options" stands out prominently, indicating that the most favored tools for managing lessons learned are not among those commonly recognized or predefined in the survey.

This preference suggests that respondents may be using alternative methods or tools that are more tailored to their specific needs or perhaps more innovative than the conventional options provided. It could also reflect a need for more diverse or flexible tools within the project management frameworks that are currently being employed. The minimal use of other listed tools further underlines this trend, pointing towards a potential gap in the effectiveness or suitability of traditional project management tools for capturing and accessing learned lessons in this context.

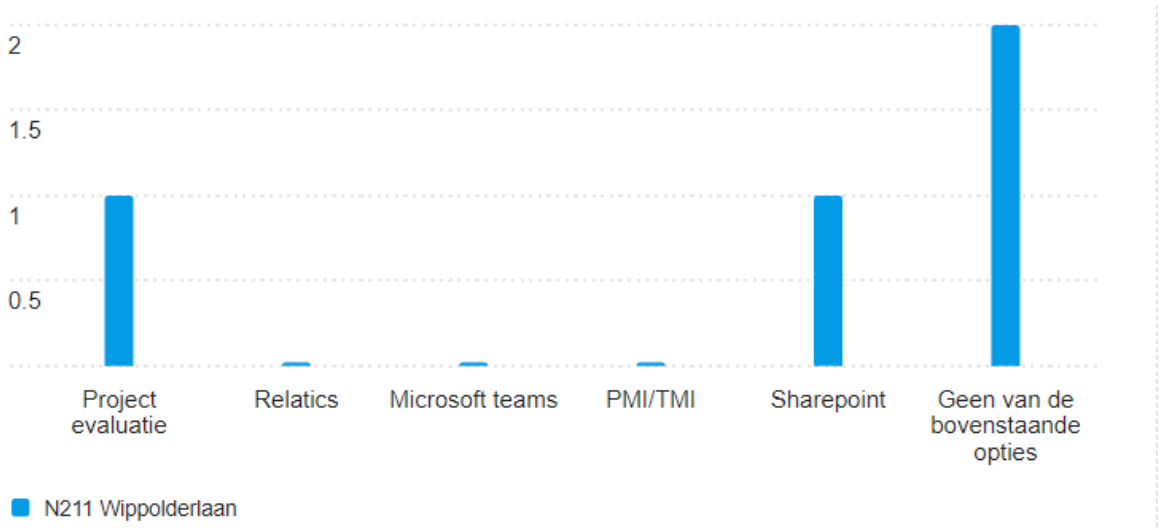


Chart 16: Tools division for lessons learned notation and reviewing

5.4.3 Analysis Network N211

Analyzing the network structure of the N211 project, detailed in the Appendix E, highlights the nuanced roles of specific nodes that are central to the project's operations and effectiveness. The roles examined include the Project Leader (B8), Calculator (A62), Tender Manager (B6), Traffic Advisor (A60), Procurement Manager (B7), and Legal Counsel (A50), each demonstrating unique centrality metrics that influence their interactions within the network. The project leader, B8, with the highest degree of connectivity, stands out as a central figure in coordinating activities and ensuring seamless communication across various sectors. This role's high betweenness centrality is pivotal in maintaining project coherence, acting as a main conduit for information flow. Conversely, A62, the calculator and the tender manager, B6, although serving in more specialized capacities, exhibit substantial integration within their functions. The calculator is notably involved in data analysis, impacting decisions with precision, while the tender manager connects various parts of the network, emphasizing their role in overseeing the tender process effectively. Similarly, the traffic advisor matches the project leader in terms of connectivity, highlighting their critical role in mediating traffic-related communications, essential for the operational success of the project. This role's extensive network presence underscores its importance in strategic traffic management.
The procurement manager demonstrates a balanced profile with efficient procurement operations, reflected by a moderate interconnection with other project areas, facilitating effective management of procurement-related tasks. Legal counsel, directly linked with multiple directors, emerges as a key player in weaving legal considerations into the strategic and operational fabric of the project. Their significant centrality metrics underscore a vital role in legal compliance and inter-departmental communication.

- Network Structure: The observed graph density of 7.8% in this network is the lowest among all the case studies reviewed. This low density indicates a significant level of isolation between departments or groups within the network. Such isolation can lead to communication inefficiencies, which may hinder effective collaboration and information sharing during the tendering process. The lack of interconnectivity could slow down decision-making processes and reduce the overall efficiency of the project.
- Clustering Coefficient: The average clustering coefficient for this project is 8.9%, which is also the lowest when compared to the coefficients in other case studies (where A = 21.5%, B = 20.9%). This suggests that, unlike other projects where groups or clusters are more interconnected, the N211 project features clusters that are not only smaller but also less connected to each other. The presence of tight-knit clusters with weak external links may lead to silos within the organization, where information is not adequately disseminated across different groups.
- Learning and Documentation: The survey results reveal a significant deviation from typical responses observed in other case studies. While the majority of respondents in this survey selected "No," indicating non-adoption of the proposed tools or methods, the two respondents who chose "Yes" applied their methods consistently throughout the tender phase. This suggests a systematic approach to continuous learning and documentation, highlighting a commitment to applying learned lessons and improving processes based on past experiences.
- Lowest Density in All Case Studies: This project has the lowest graph density recorded among all the case studies analyzed. This extreme result underscores the need for strategic

interventions to enhance connectivity and communication within the network. Enhancing these aspects could potentially alleviate the negative impacts of departmental isolation and improve the overall effectiveness and responsiveness of the tendering process.

5.4.4 Node type analysis

In this section on the N211 tender, I will examine the key gatekeepers and central figures within the network. Understanding these roles is essential for analyzing the dynamics and information flow throughout the tender process.

Gatekeepers

In the analysis of the N211 project, the identified gatekeepers include B22, B11, A60, B8, A62, A50, and B7 (Figure 36). Among these, A50, the legal counsel, stands out for its unique positioning within the network. A50 plays a crucial role by directly connecting with two different directors: the Director PMC (B35) and the Director of the Legal Division Netherlands (B36). This makes A50 particularly interesting as a node that bridges project management and top-level executive leadership, facilitating crucial communication between these two critical areas. Additionally, A50's position allows for the strategic alignment of legal strategies with the project's overall management objectives, ensuring that the project adheres to legal frameworks while also achieving business and operational goals. Furthermore, A50's involvement with both high-level directors and costing actors indicates a significant role in risk management, where legal considerations are integrated into financial planning and decision-making processes. These aspects highlight A50's pivotal role in maintaining the project's legal and financial integrity.

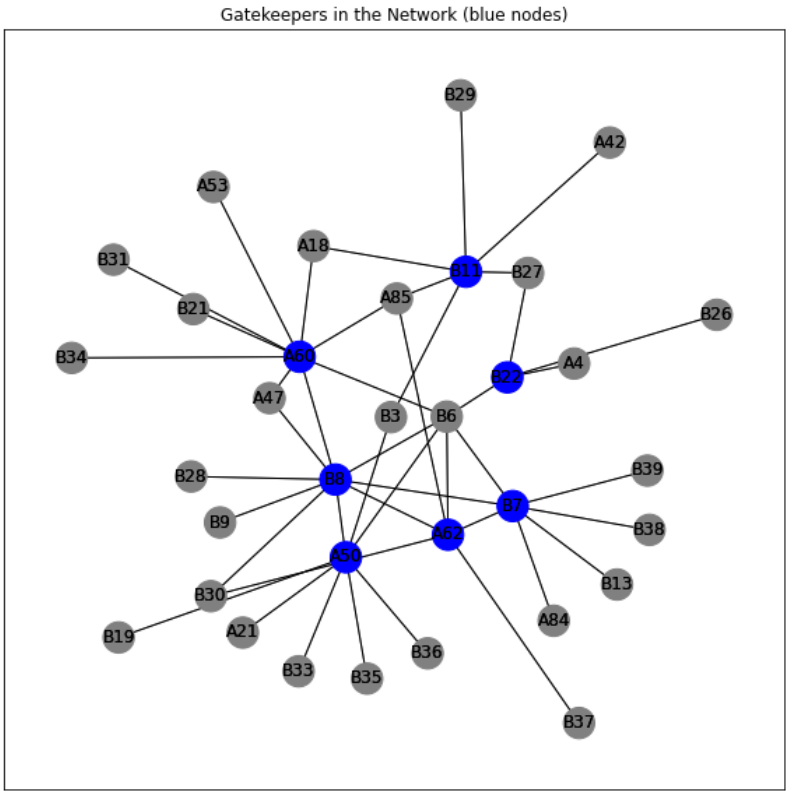


Figure 36: Gatekeepers N211 Wippolderlaan

Following the analysis of A50's crucial role within the N211 project network, Figure 37 will illustrate the impact on the network after the removal of A50. This figure will visually demonstrate the changes in connectivity and the potential isolation of certain nodes, highlighting the significant influence A50 has on maintaining the communication flow and structural integrity of the project network.

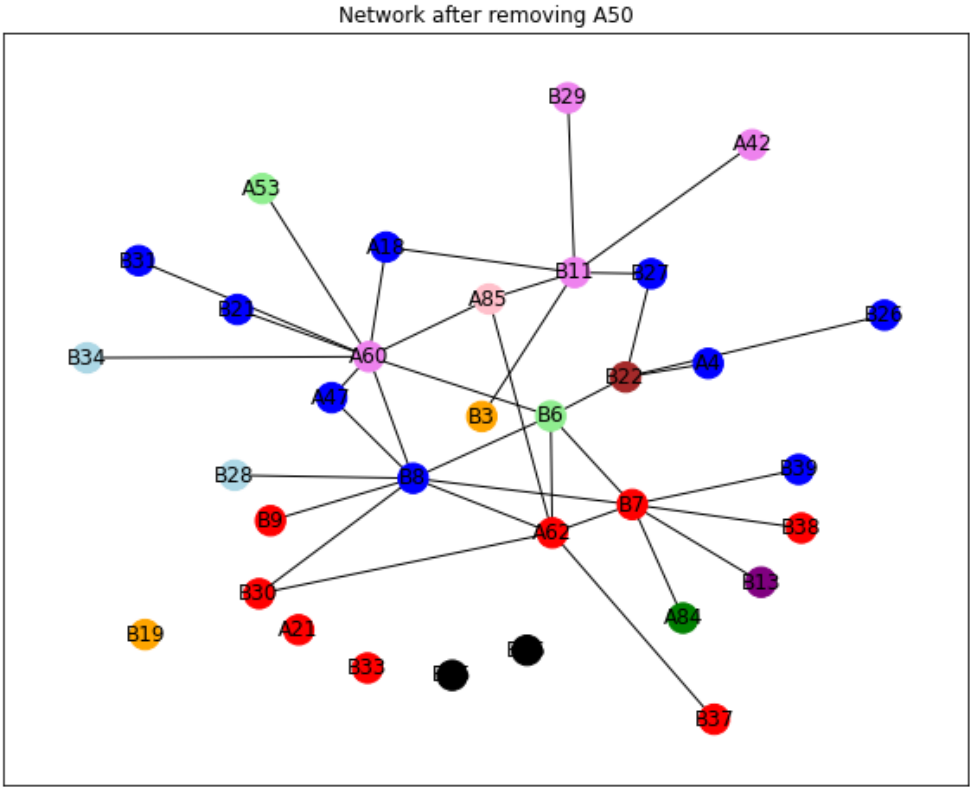


Figure 37: Network after removing A50

Central figures

In the N211 project network, B6, the Team Leader for Commerce, and B8, the Project Leader for Project Management, are key figures. B6 oversees the commercial aspects, ensuring financial and contractual objectives are met, while B8 drives the overall project management, coordinating teams to meet project goals. Their central roles are depicted in Figure 38, highlighting their importance in maintaining the network's effectiveness.

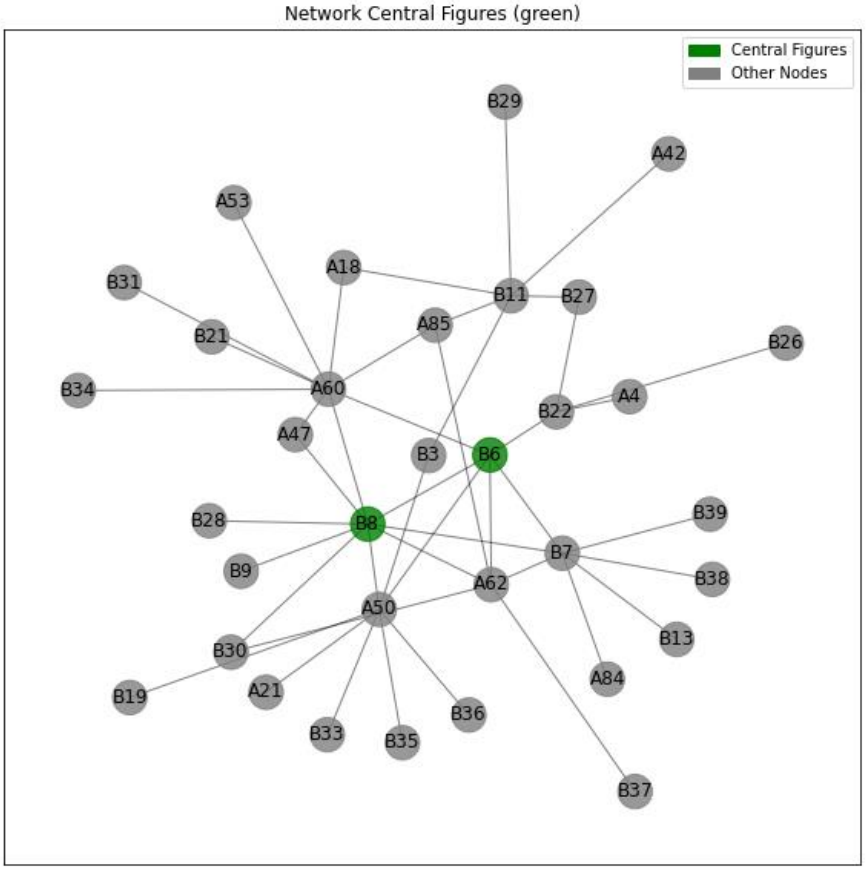


Figure 38: Central figures N211 Wippolderlaan

When B6, the Team Leader for Commerce, is removed from the network (Figure 39), there isn't a significant loss of data, but it does result in the Systems Engineer becoming poorly connected to the network. In this scenario, the Systems Engineer would only be able to share data with actors within the Project/Design Management group, limiting broader communication within the project.

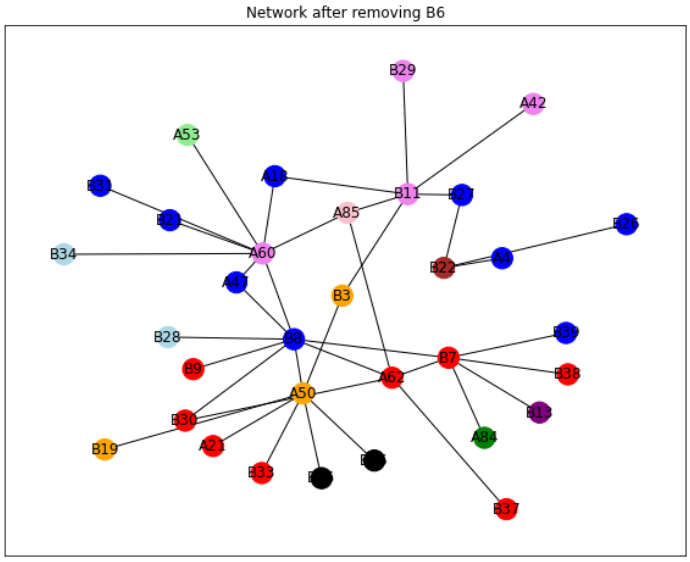


Figure 39: Network after removing B6

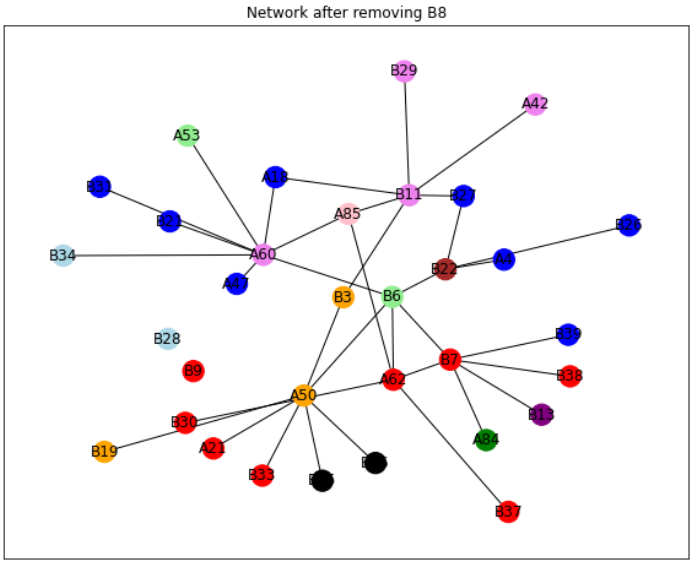


Figure 40: Network after removing B8

On the other hand, the removal of B8, the Project Leader for Project Management, as shown in Figure 40, leads to a more serious issue. This action causes certain nodes to become completely disconnected from the network, resulting in a significant loss of data and communication. The network's ability to share information effectively would be compromised, underscoring the critical role B8 plays in maintaining overall network connectivity.

5.5 Discussion

This chapter presents the findings and discussions based on the research into data sharing and lessons learned practices within Dutch construction companies during tender processes. 5.5.1 Cross-case Comparison compares various case studies, examining the tools used, key roles within the information flow, and the overall effectiveness of lessons learned practices across different organizations. 5.5.2 Impact of Organizational Structures and Network Dynamics explores how divisional structures and network configurations affect data sharing, with a focus on knowledge silos and the flow of information between departments. The analysis identifies both facilitating and hindering factors that influence the integration of lessons learned into future projects.

5.5.1 Cross-case comparison

This chapter will conduct a thorough comparative analysis across different case studies, focusing on how data sharing is managed and how 'lessons learned' are effectively managed and utilized within Dutch construction companies during tender processes. The analysis will delve into the similarities and differences in the practices and challenges associated with data sharing and lessons learned management across various organizational structures and network dynamics. The comparison will highlight how each case study addresses the flow of information and integrates learned lessons into their tendering strategies, emphasizing the methods used for capturing, documenting, and leveraging past experiences to enhance future tenders. This section aims to uncover the key factors that influence the effectiveness of knowledge management in these processes, providing insights into how different companies navigate the complexities of data sharing and learning from past projects. By examining these aspects across multiple cases,

this chapter seeks to illustrate the broader trends and pinpoint specific practices that either facilitate or impede the efficient management of lessons learned and data sharing in the context of tender processes. This will provide a comprehensive view of how knowledge is handled across projects and suggest ways in which these practices may be influenced by the organizational and network characteristics unique to each case.

Tools

By analyzing the tools used in mapping information flows during the tender process, shown in Chart 17. it is evident that different tools and practices reveal varying levels of effectiveness and integration. Email and SharePoint, commonly employed in Dutch construction companies, play a central role in communication and data storage, consistent with the literature. Ahmad & Bergsjö (2021) underscore the importance of Email due to its accessibility and widespread use, which aligns with the findings that Email is the most frequently used tool in these processes. However, this reliance on Email can pose challenges, such as fragmentation of information and limited real-time collaboration, as highlighted by Carrillo et al. (2013). This suggests that while Email serves an essential function, there is room for improvement through the adoption of more collaborative platforms to enhance the management and utilization of lessons learned.

Conversely, tools like Microsoft Teams, SharePoint and Relatics, though recognized in the literature for their potential in improving collaboration and project management (Carrillo et al., 2013), appear to be underutilized in the tender processes of the Dutch construction companies studied. This underutilization indicates a gap between the potential benefits of these tools and their actual application in practice. The literature suggests that the successful use of such tools depends on their proper integration and the willingness of teams to adopt them. This supports the observation that these tools have not yet become central in the processes analyzed, pointing to a need for better implementation strategies to improve the effectiveness of 'lessons learned' management.

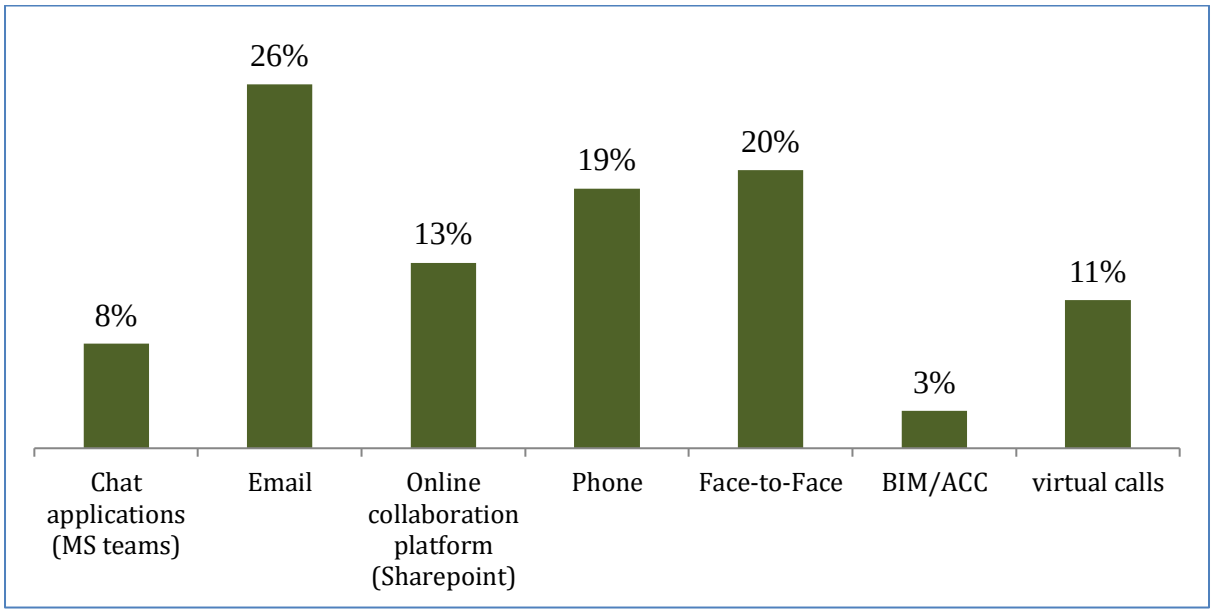


Chart 17: Tools frequence for data sharing

Nodes

By examining the central roles of key nodes within the tender process, such as Tender Managers and Project Management, it becomes clear that these positions are critical in managing information flows and ensuring effective communication within Dutch construction companies. The centrality of Tender Managers, as demonstrated by nodes like A11 and A46 in the case studies, is well-supported by the literature. Studies by Demirkesen & Ozorhon (2017) emphasize the strategic importance of these roles, particularly in their ability to influence network efficiency through their high betweenness centrality. This aligns with the observation that Tender Managers are pivotal in ensuring the smooth flow of information across various stakeholders during the tender process.

The roles of Project Management (A71) and Calculator (A66) are critical within the network, as they are central to coordinating project activities and ensuring coherence across various departments. The literature supports this view, with Schindler and Eppler (2003) emphasizing the importance of the Project Management function in aligning all aspects of a project with its overarching objectives. In the networks studied, node A71's centrality reflects its essential role in maintaining this alignment. Similarly, the Calculator, represented by node A66, plays a crucial role in providing accurate data analysis and financial planning, which are indispensable for informed decision-making throughout the project lifecycle.

However, the literature indicates that while these nodes are central to project coordination, there is a need for them to actively facilitate more integrated knowledge sharing across all departments, particularly with those that are less connected, such as sustainability and GIS (Schindler & Eppler, 2003). Comprehensive knowledge sharing is necessary to avoid missed opportunities that could arise from information silos (Schindler & Eppler, 2003). The risks associated with poor integration of specialized nodes, such as those focused on sustainability, into the central network are also highlighted in the literature (Bilal et al., 2016). The findings from the case studies suggest that the lower connectivity of these specialized nodes may indicate missed opportunities for incorporating broader insights that could enhance project outcomes. Therefore, improving the integration of A71 and A66 with these specialized nodes could lead to a more comprehensive and effective approach to project management, where diverse perspectives and information are better utilized to achieve holistic project success (Bilal et al., 2016).

Network statistics

The cross-case comparison reveals that low network densities, ranging from 7.8% to 10%, are associated with inefficiencies, communication bottlenecks, and the isolation of key departments. The lowest density observed (7.8%) underscores the risks identified in the literature, where sparse networks can result in slow information flow and underutilized connections (Demirkesen & Ozorhon, 2017). Additionally, low clustering coefficients across the cases suggest a lack of tightly-knit collaborative groups, potentially leading to isolated data silos and diminished teamwork effectiveness (Hossain & Wu, 2009). To address these challenges, the literature recommends increasing network density and enhancing the role of central nodes to foster better cross-departmental collaboration and reduce the risks of data silos, ultimately leading to more integrated and efficient project management (Bilal et al., 2016).

Lessons Learned Practices

The cross-case comparison of lessons learned across the three case studies reveals a consistent pattern of challenges in the application and integration of lessons learned during tender

processes. In all three cases, there is a noticeable inconsistency in how lessons learned are applied, despite their recognized importance in enhancing project outcomes. This inconsistency is particularly evident in the underutilization of collaborative tools like Relatics and PMI, which are noted in the literature as essential for effective knowledge sharing and reducing inefficiencies (Alreshidi et al., 2018).

In the N346 Schakel case, while "Project Evaluation" and SharePoint are the primary tools for capturing and reviewing lessons learned, the application of these lessons is sporadic. When applied, they have a tangible impact on technical challenges, particularly in the design and implementation of infrastructure elements such as roundabouts and crossings. This aligns with Schindler and Eppler's (2003) emphasis on the value of consistently applying lessons learned to address specific project issues. However, the underutilization of more collaborative tools suggests a gap in fully leveraging available resources to enhance project outcomes. Similarly, the DMS Prinses Alexiaviaduct case mirrors these challenges. Lessons learned are difficult to locate and are inconsistently applied, especially during critical stages like pre-qualification and initial startup. The continued reliance on "Project Evaluation" and SharePoint, alongside the underutilization of Relatics and Microsoft Teams, highlights a significant gap in the consistent application of lessons learned across different tender stages. This finding is consistent with literature that describes the fragmentation of knowledge and the persistence of data silos as barriers to effective project management (Bilal et al., 2016). Better integration of lessons learned tools, coupled with systematic approaches to knowledge management, is essential to overcoming these challenges (Carrillo et al., 2013). The N211 Wippolderlaan case stands out with the lowest network density (7.8%) and clustering coefficient (8.9%) among the cases, indicating significant isolation and the presence of silos within the organization. The inconsistent use of lessons learned is evident, with many respondents not engaging with the proposed tools and methodologies. However, those who do consistently apply lessons learned demonstrate a continuous learning approach that positively impacts project outcomes. The literature supports the view that low network density and clustering coefficients can hinder effective communication and the dissemination of lessons learned, underscoring the need for enhanced network connectivity and reduced silos to improve project management (Hossain & Wu, 2009; Bilal et al., 2016)

Across all cases, the inconsistent application of lessons learned emerges as a critical issue. The literature emphasizes the necessity of systematic processes to ensure that lessons learned are not only captured but also effectively integrated into future projects, a point underscored by the findings from these case studies (Schindler & Eppler, 2003). Additionally, the consistent use of "Project Evaluation" and SharePoint, coupled with the underutilization of collaborative tools like Relatics and Microsoft Teams, reflects a broader challenge in the integration of tools that facilitate real-time collaboration and reduce data silos (Carrillo et al., 2013; Alreshidi et al., 2018).

5.5.2 Impact of Organizational Structures and Network Dynamics on Data Sharing

This section will analyze how organizational structures and network dynamics influence data sharing during tender processes in Dutch construction companies. It will examine the role of different organizational designs and network configurations in facilitating or hindering effective data sharing, highlighting key differences observed across the case studies.

Divisional Structures and Knowledge Silos

Divisional structures, common in many construction companies, involve organizing the company into semi-autonomous units or divisions that focus on specific aspects of operations, such as project types or geographical areas (Mintzberg, 1980). While this structure allows for specialization and operational efficiency within each division, it also leads to the creation of knowledge silos. These silos result in significant communication barriers, as each division may prioritize its own objectives and processes over broader organizational goals. The literature underscores the impact of divisional structures on lessons learned management, highlighting how these silos hinder the effective sharing of knowledge across the organization (Ahmad & Bergsjö, 2021; Lesser & Fontaine, 2004). Specifically, the compartmentalization inherent in divisional setups complicates the flow of critical information, leading to fragmented decision-making processes and inefficiencies during tender processes. This structure not only disrupts the seamless exchange of data but also limits the organization's ability to leverage collective insights that could enhance project outcomes.

Network Dynamics and Their Effect on Data Sharing

The dynamics within these organizational networks further exacerbate the challenges posed by divisional structures. For instance, in cases where the network exhibits low graph density and clustering coefficients, such as in the N211 Wippolderlaan case study, there is a clear indication of fragmented communication and isolated knowledge pools. These network characteristics are symptomatic of an organization where divisions operate with minimal interconnection, leading to inefficient data sharing practices. Research supports this observation by emphasizing that low network density and poor connectivity hinder the dissemination of knowledge and create barriers to effective collaboration (Bilal et al., 2016; Hossain & Wu, 2009). In such environments, information flow is often restricted to tightly knit sub-groups within divisions, limiting the broader organizational integration necessary for comprehensive and cohesive project management.

The Role of Central Nodes in Facilitating Data Sharing

Despite these challenges, central nodes within the network, such as project managers or tender coordinators, play a crucial role in bridging the gaps between divisions. These individuals act as key communication hubs, facilitating the flow of information across different parts of the organization. However, the effectiveness of these central nodes is contingent on how well they are integrated into the overall organizational structure and their ability to navigate the complexities of divisional silos.

The literature suggests that enhancing the role and connectivity of these central nodes can significantly improve data sharing efficiency (Duffield & Whitty, 2015). By strategically positioning these nodes within the network and ensuring they are equipped with the necessary tools and authority, organizations can mitigate the negative effects of divisional structures and promote more effective knowledge transfer during tender processes.

Technological Integration and Organizational Culture

While collaborative management platforms are implemented across divisions in construction companies, their potential for effectively managing lessons learned is not yet fully realized. The lack of clarity on where critical information can be found often hampers the utilization of these

platforms for lessons learned. As Martínez-Rojas et al. (2016) emphasize, data technology can become ineffective if it is not accompanied by a standardization process. Without standardized procedures for capturing, storing, and retrieving lessons learned, it becomes challenging to monitor, control, and reuse project data effectively.

Organizational culture also significantly influences the effectiveness of data sharing. A culture that fosters open communication and collaboration can help mitigate some of the structural barriers posed by divisional setups. However, if the culture within an organization reinforces silos and discourages cross-divisional collaboration, it can exacerbate the challenges of utilizing lessons learned, even with advanced technological platforms in place (Carrillo et al., 2004). This disconnect highlights the need for both cultural and technological alignment to ensure that lessons learned are effectively integrated into ongoing and future projects.

6. Root Cause analysis

In this chapter, the RCA process is explored in detail. Section 6.1 outlines the setup of the in-depth interviews, explaining how they were designed to uncover the underlying causes of knowledge-sharing challenges within the tender processes. Sections 6.2, 6.3, and 6.4 focus on the specific RCAs of the individual tenders, analyzing the key factors that influenced the effectiveness of lessons learned in each case. In section 6.5, the total findings are synthesized, providing an overview of the common root causes across all tenders. Finally, section 6.6 presents the discussions, where the implications of these findings are examined and linked back to the broader research objectives. The elaboration of the interviews can be found in the Appendix F.

6.1 In-depth interviews

The interviewees were carefully selected based on their influence within tender processes, as identified through a SNA. This analysis enables the identification of significant players within the tender processes, specifically those who play a crucial role in the sharing of knowledge and information. By analyzing their positions and connections within the network, individuals were selected who have the most impact on the dissemination and application of lessons learned within the tenders. Focusing on these influential figures ensures that the interviews provide valuable and representative insights, which are essential for understanding the dynamics within the tenders. The nine statements that are discussed in the Case preparation (Ch. 4) are stated in Table 11. The are presented during the in-depth interviews to collect their root causes. The results of the interviews have been send back to the respondents to make sure that the results are correct.

Table 11: In-depth interview statements

#		Statements
1		Leadership drives the integration of lessons learned in tender processes.
2		The organization values bottom-up communication and takes input from all levels into account during the process.
3		It is clear where to find lessons learned reports of older tenders
4		Lessons learned during the tender process are easily communicated and accessible.
5		Standardized lessons learned documents would help streamline the sharing and application of knowledge
6		A reliable and impactful Lessons learned repository would enhance Lessons reporting
7		Lessons learned should be discussed more frequently during tender meetings.
8		Mentorship and incentives are key to fostering a proactive lessons learned culture.

9		Lessons learned documents are reliable sources of knowledge.

The criteria for the selection of the responders for the interviews are listed below:

- At least two nodes per tender
- At least in the five connections in their networks
- In the top 5 nodes with the most influence in the network
- Available to have a face to face interview for 60 minutes.
- No external nodes from the company
- At least 5 different roles

Table 12: Deatails of interviewee

#	Project	Code	Role
1	N211	B8	Project leader
2	N211	A50	Legal counsel
3	Alexia viaduct	A56	Civil contractor
4	Alexia viaduct	A46	Tender strategist
5	Alexia viaduct	A73	Tender manager
6	N346	A71	Project leader
7	N346	A17	Tender manager
8	N346	A66	Costing manager

Table 12 shows the nodes that contributed to the RCA. Each of these selected nodes plays a pivotal role within their respective tenders, providing a unique perspective on how lessons learned are shared and applied. By focusing on the key players within each tender, this approach allows for a detailed examination of the obstacles and enablers in the lessons learned process, ensuring that the most impactful factors are thoroughly analyzed and addressed in the RCA

6.2 N211

Two team members were interviewed for the N211 tender, one project leader (B8) and one legal counsel (A50). Both participants found the N211 project to be complex, requiring high levels of coordination. However, the lack of a formal process for applying lessons learned and sharing knowledge made it more difficult to manage effectively. Both relied heavily on informal communication, such as phone calls and emails, to navigate the project, expressing frustration that there wasn't a sufficient system in place to streamline knowledge-sharing. The RCA is shown in Table 13

Table 13: Root causes N211

Reading guide			
Agree with the statement and also applies to me in the tender (Enabling factor)	Disagree with the statement but applies to me in the tender (Enabling factor)	Agree with the statement but it does not apply to me in the tender (Limiting Factor)	Disagree with the statement and it does not apply to me in the tender (Limiting factor)

	1	2	3	4	5	6	7	8	9
B8	Process overview	Open communication	Fragmentation	Informal communication	No formal system	Fragmentation	Lack of outcomes.	Process improvement	Need for context
A50	Uniform leadership practices.	Formalized approach	Fragmentation	No structured communication	No structured communication	Engagement into daily practices	Prioritization	Recognition	No standardized documentation

Enabling factors

One of the key enabling factors identified by both participants in the N211 project is management's role in supporting the integration and use of lessons learned in the tender process, as outlined in Statement 1: *Management supports the integration and use of lessons learned in the tender process*. Both participants viewed this as an enabling factor that applied directly to the tender, but they approached it from slightly different perspectives.

Participant B8, who held a leadership position as a project manager, emphasized the importance of having a comprehensive process overview and how this helped drive the integration of lessons learned. In their view, the project leader's role is crucial in ensuring that lessons from previous experiences are effectively applied. B8 attributed this to the leader's ability to maintain a clear overview of the process, which allows them to guide the team and connect current activities with past lessons. This continuous oversight was seen as vital in stimulating the use of lessons learned, as it provided the project leader with the knowledge needed to steer the team effectively. The root cause identified here is process overview and stimulation. In contrast, Participant A50 approached leadership from the perspective of team involvement. A50 did not view leadership in the traditional sense but focused on the tender manager's ability to involve everyone in the process and keep them well-informed. For A50, this sense of involvement and access to relevant information was what truly mattered in applying lessons learned. The

participant noted that while the tender manager may not have exhibited typical leadership traits, their strength lay in engaging the team, which fostered a more collaborative environment. However, A50 also pointed out that there was no clear or uniform approach to leadership within the company. This lack of clarity in leadership styles and expectations made it more difficult to consistently integrate lessons learned across different tenders. The root cause identified here is team involvement.

Both participants acknowledged the importance of discussing lessons learned during the tender process, but their perspectives differed. B8 felt that while lessons are discussed regularly in formal and informal settings, the real challenge lies in making these discussions actionable and ensuring lessons are well-documented for future use. In contrast, A50 emphasized the need for more frequent reflection on successes and mistakes to drive continuous improvement and cross-departmental collaboration. Both responses point to the significance of not just having discussions but ensuring they lead to tangible outcomes and improvements. B8 and A50 disagree with the statement but acknowledge the role of mentorship during the tenders. B8 believes the issue lies in the lack of integration of lessons learned into daily workflows, making the process feel bureaucratic. A50, on the other hand, emphasizes the need for employees to see visible benefits from their contributions to feel motivated. Both agree that without proper structure or results, mentorship alone won't foster engagement.

Limiting factors

Both participants of the interview agreed that statement 3 about that It is clear where to find lessons learned reports of older tenders is a limiting factor. Both B8 and A50 agree that accessing lessons learned reports is a significant challenge in their organization, particularly for tenders. B8 highlights the fragmentation of these reports, noting that there is no well-defined, centralized location where they are consistently stored. This lack of structure forces them to rely on informal methods, such as reaching out to colleagues or relying on personal memory and experience. The issue becomes even more pressing when reports are needed to inform current tender strategies, but their scattered nature makes them practically inaccessible, reducing the effectiveness of lessons learned in improving processes or avoiding past mistakes. Similarly, A50 points to poor organization and unclear labeling on platforms like MS Teams and SharePoint. While A50 acknowledges that reports do exist and are stored digitally, finding them is often time-consuming and frustrating. The problem stems from how information is categorized and labeled, which may make sense to the person who originally set up the system but is not intuitive for others. This inconsistency creates barriers to accessing important information, especially when under time constraints during the tender process. Both B8 and A50 stress that these platforms are only as effective as the organizational structure that underpins them. Without a clear and consistent approach to organizing, labeling, and categorizing reports, employees struggle to locate the information they need.

Furthermore, statement 5 about standardization of lessons learned documentation is a limiting factor as well. For B8, the root cause of the issue with standardized documents is the lack of a formal system. While they agree that having standardized lessons learned documents would streamline knowledge-sharing and improve project performance, no such system is currently in place, making it difficult to access and apply this knowledge consistently. For A50, the problem stems from unclear documentation practices. The absence of a consistent approach leads to ambiguity, where different roles prioritize different aspects of lessons learned, making it harder

to effectively share and apply this knowledge across the organization. Both agree that a standardized system would significantly improve the process.

6.3 N346

For the N346 project, the interviews highlighted several interesting aspects. One key point is that the project is still ongoing, which adds a dynamic element to the analysis. The respondents mentioned the challenge of integrating lessons learned in real-time as the project progresses, rather than waiting until the project's completion. This reflects the necessity for continuous knowledge-sharing practices throughout the lifecycle of a project, rather than a retrospective approach. The results are shown in Table 14

Table 14: Root causes N346

Reading guide			
Agree with the statement and also applies to me in the tender (Enabling factor)	Disagree with the statement but applies to me in the tender (Enabling factor)	Agree with the statement but it does not apply to me in the tender (Limiting Factor)	Disagree with the statement and it does not apply to me in the tender (Limiting factor)

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
A71	Management enforcement	Informal communication	No centralized system	Easy request	Lack of context	No centralized system	No time	Consistent approach	Trust
A66	Reliance on personal systems	Open communication	Desire for control	Informal communication	No management enforcement	Underdeveloped database.	Prioritization	Consistent approach	Trust

Enabling factors

In the analysis of this tender process, the most frequently identified enabling factors are a consistent approach and trust. A consistent approach ensures uniform handling of lessons learned across the organization, facilitating easy understanding and implementation of insights from past projects. This uniformity is crucial for building a structured framework that supports continuous improvement and effective decision-making in future projects. Similarly, trust within teams and across the organization enhances open communication and the free exchange of information, which is vital for leveraging lessons learned effectively. When team members trust each other and the processes in place, they are more likely to share valuable experiences and insights, fostering a collaborative environment.

activities like ensuring the reliability of lessons learned, alongside mentorship and incentives, are vital for enhancing the integration of lessons learned. Reliability ensures that the lessons are accurate and trustworthy, while mentorship guides the application of these insights and incentives motivate engagement with the process, collectively improving project outcomes.

Despite these positive attributes, the responses from the two participants indicated a degree of skepticism or critical perspective regarding the implementation or impact of these enabling factors on project outcomes. This suggests that while the factors are recognized for their potential benefits, there may be underlying challenges or inconsistencies affecting their practical application, which could compromise the effectiveness of the lessons learned processes within the organization.

Limiting factors

In the analysis of the tender N346, several limiting factors have been identified that hinder the effective integration of lessons learned. These include a reliance on informal communication methods and the absence of a centralized system for accessing lessons learned documents. The informal communication can lead to inconsistencies in how lessons are transmitted and assimilated across the team, potentially causing important insights to be overlooked or misinterpreted. Without a centralized system, team members face challenges in quickly accessing necessary information, which can delay the application of valuable insights to current projects.

Furthermore, there are critical areas where improvements are needed but currently lacking. The tender process lacks standardized documentation for lessons learned, which would help ensure that all insights are captured in a uniform manner, making them easier to understand and apply. Additionally, there is no reliable repository where these lessons are stored, which would serve as a dependable source for retrieving past knowledge. Establishing such a repository would enhance the trustworthiness and usability of the information, supporting better decision-making based on accumulated experiences.

6.4 Alexia viaduct tender

This analysis delves into the key factors that influenced the knowledge-sharing process and the application of lessons learned. During the initial phase of the tender, an expert from Havenbedrijf Rotterdam was brought in to provide insights based on previous projects. This early involvement aimed to align the team's approach with the client's expectations and to mitigate potential risks. The following analysis will explore the underlying causes that impacted the integration of lessons learned, highlighting both the enabling and limiting factors (Table 15) that shaped the tender process. By embedding this knowledge from the start, the team was better equipped to anticipate challenges and apply past experiences effectively. The following analysis will dive deeper into the root causes that either enhanced or hindered the integration of lessons learned during the Alexia Viaduct tender.

Table 15: Root causes Alexia viaduct

Reading guide			
Agree with the statement and also applies to me in the tender (Enabling factor)	Disagree with the statement but applies to me in the tender (Enabling factor)	Agree with the statement but it does not apply to me in the tender (Limiting Factor)	Disagree with the statement and it does not apply to me in the tender (Limiting factor)

	1	2	3	4	5	6	7	8	9
A56	Prioritization	Open Communication	No Centralized system	Fragmentation	Inconsistent implement-ation	Underdeveloped database.	Structured discussions	Active learning	Fragmentation
A46	Recognition	Stimulation	No initiative	Prioritization	No initiative.	Inconsistent implementation	No time	Process improvement	Consistent approach
A73	Prioritization	Open communication	Fragmentation	Informal communication	No initiative	Fragmentation	Formalized approach	Active learning	Need for context

Enabling factors

The analysis of root causes within the tender process revealed several key enabling factors for effective management of lessons learned. Foremost among these was the prioritization of integrating lessons into current projects. This prioritization ensured that lessons were not merely recorded but actively applied to enhance project execution and outcomes. Additionally, open communication stood out as a critical factor. It facilitated a transparent exchange of information and experiences across project teams, which was essential for real-time problem solving and adapting to project dynamics. Active learning was also identified as a vital component. It involved a continuous and proactive engagement of team members in reflecting upon and learning from ongoing activities. This approach not only captured tacit knowledge effectively but also encouraged its dissemination within the team, thereby improving collective understanding and performance.

Building on this foundation, the practices outlined in Statements 1 and 2 further promote the effective utilization of lessons learned. The active engagement of management in integrating these lessons and the emphasis on inclusive, bottom-up communication ensure that lessons are not only captured but also effectively applied across projects. This fosters a culture of continuous improvement and learning, crucial for the success of tender processes.

Limiting factors

In the analysis of tender processes, three primary limiting factors were identified: No Initiative, Fragmentation, and Inconsistent Implementation. No Initiative reflects a lack of proactive engagement with lessons learned, leading to missed opportunities as valuable insights remain unexploited. Fragmentation occurs due to siloed management and dissemination of knowledge within the organization, causing isolated pockets of knowledge that are inaccessible across different teams or departments. Inconsistent Implementation involves varied effectiveness in applying lessons learned across projects, stemming from a lack of standardized processes and clear responsibilities. This inconsistency undermines the reliability of and trust in the lessons learned process, impacting the overall effectiveness of integrating these lessons into future projects. In tender processes, the absence of standardized documents and a reliable repository for lessons learned significantly hampers effective knowledge management. Standardized documents would ensure clarity and consistency in capturing and sharing lessons, while a central repository would provide easy access to these valuable insights. Without these tools, organizations struggle to apply past lessons effectively, limiting their ability to leverage these experiences for continuous improvement and more successful project outcomes.

6.5 Total Findings

After conducting a RCA across three different cases, it's important to consolidate these findings to better understand common behaviors and the origin of problems within the tender processes. This synthesis will help identify which practices are already effective in encouraging the use of lessons learned and which areas consistently pose challenges. The aim here is not to prematurely suggest enhancements but to provide a clear view of the dynamics and procedural elements that influence the success or failure of integrating lessons learned. This understanding can serve as a foundation for further investigation or future interventions tailored to address the specific issues identified in the tender processes. Chart 18 Showcases the difference in enabling and limiting factors.

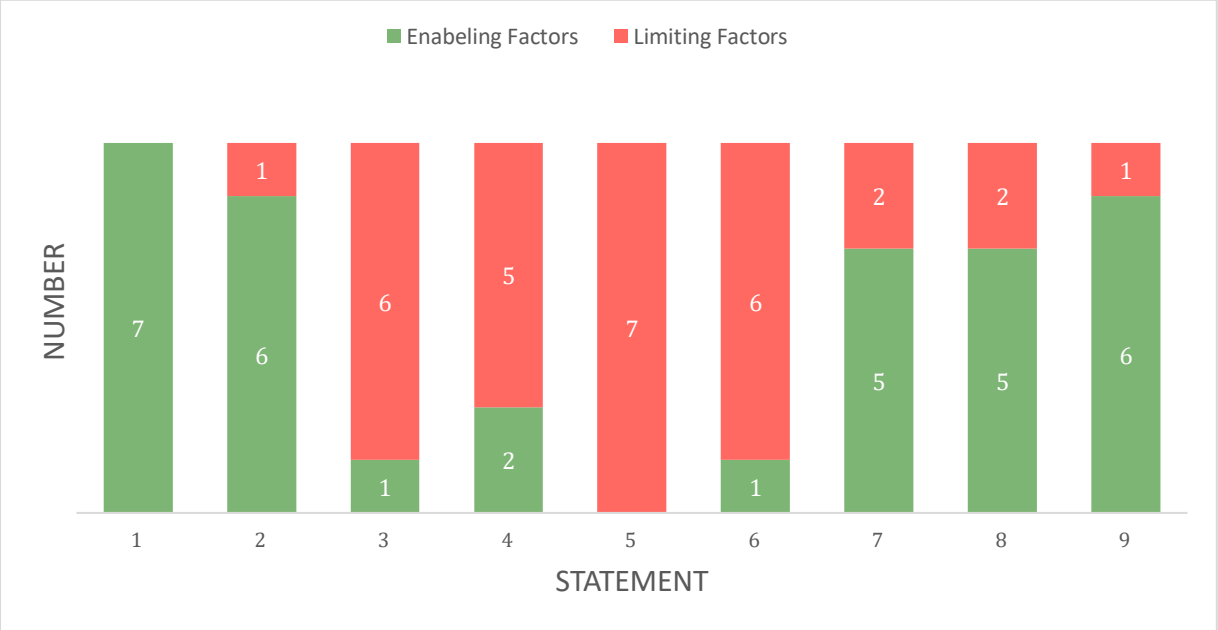


Chart 18: Difference in Enabling and limiting factors

6.5.1 Enabling factors

Chart 18 is depicting the distribution between enabling and limiting factors across various statements about lessons learned in tender processes reveals an almost equal balance between the two. This close distribution could indicate that while there are robust mechanisms in place to support the integration and utilization of lessons learned, there are also substantial challenges that limit their effectiveness. The presence of both enabling and limiting factors in such proximity may suggest areas where improvements could further enhance the effectiveness of lessons learned processes.

Statement 1, which emphasizes management's role in driving the integration of lessons learned, is universally recognized as an enabling factor. This consensus highlights the critical role of leadership and structured management support in facilitating the effective use of lessons learned within tenders. Following closely, the reliability of lessons learned documentation is also highly regarded, with a general trust among team members that the documents are accurate and dependable, forming a trusted foundation for decision-making and strategy development.

Additionally, there is significant support for the idea that lessons learned should be discussed more frequently during meetings, suggesting a need to regularly integrate past insights into current project deliberations. Moreover, the positive effects of mentorship and incentives are acknowledged as beneficial, enhancing engagement and the overall impact of lessons learned.
These insights indicate that while the framework for managing lessons learned is well-established, bolstering regular discussions and formal recognition of these practices through structured meetings and incentives could potentially improve the effectiveness of lessons learned in driving project success.

6.5.2 Limiting factors

In the analysis of limiting factors within tender processes, several key issues have emerged that hinder the effective integration and application of lessons learned. One prominent issue is the lack of standardization in the documentation of lessons learned. While there is consensus among respondents that their current processes lack a standardized format, most acknowledge that such standardization would greatly streamline and clarify the sharing and application of knowledge.
Additionally, there is considerable uncertainty about where to find lessons learned documents, indicating a gap in the organizational structure for effective knowledge management. The need for a clear and reliable repository where these documents are easily accessible was frequently highlighted, yet such a system is notably absent in current practices. This absence complicates the retrieval of valuable information and hinders the learning process from past projects.

Furthermore, the communication of lessons learned during the tender process is often inadequate, with much of the knowledge transfer relying on informal communication and implicit knowledge sharing. This reliance on informal methods can lead to inconsistencies and the potential loss of crucial insights, as it does not ensure that all team members have the same understanding or access to the lessons learned

In addition to these factors, statements 4, 5, and 6 (Chart 19) were initially viewed as limiting factors. Most respondents agree that these processes would enhance the integration of lessons learned if properly implemented, but the fact remains that these methods are not currently in place. This is evident from the dominance of orange in the chart, symbolizing that while respondents recognize the potential benefits, these actions have not yet been incorporated into practice. Thus, the lack of proper execution makes them limiting factors in the present system.

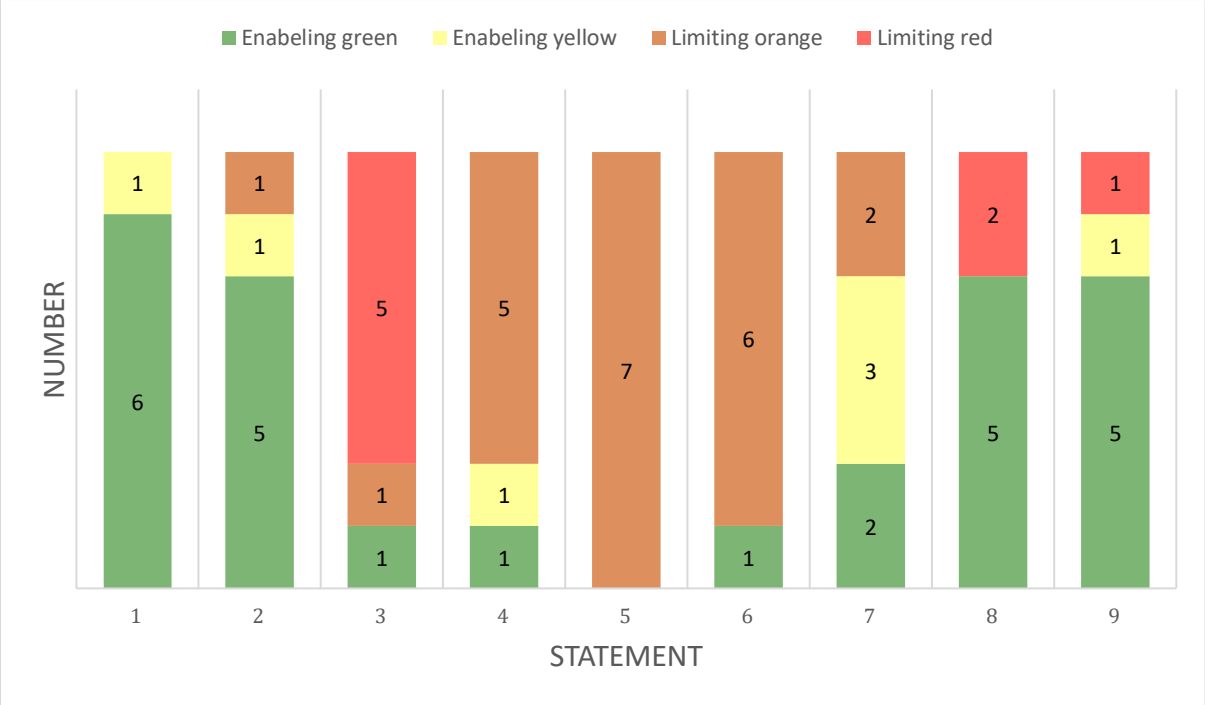


Chart 19: Difference in Enabling and limiting factors (2)

These points will be further analyzed in the synthesis section, where the relationship between these limiting factors and the overall effectiveness of lessons learned will be explored in greater depth, as illustrated in the corresponding chart.

6.5.3 Analysis: Enhancing lessons learned

Through a detailed examination of both enabling and limiting factors, we identify key practices and obstacles that significantly influence the effectiveness of lessons learned. This analysis sets the stage for understanding how these factors interact to shape outcomes and inform continuous improvement strategies. At the end of the chapter the most frequently mentioned enabling and limiting factors are detailed.

In synthesizing the insights from academic literature, the enhancement of lessons learned processes within tender management is underscored as a multi-faceted approach that integrates strategic prioritization, effective communication, consistency in practices, and the cultivation of trust. These components are not merely operational tactics but form the core framework within which lessons learned transform into actionable insights that propel organizational success and adaptability.

Prioritization, as emphasized by Milton (2012), is vital for enhancing decision-making and project outcomes by keeping lessons learned central to project planning. Duffield and Whitty (2015) also highlight the need for strategic use of lessons to prevent recurring errors and optimize project execution. Carrillo et al. (2004) stress the importance of open communication for effective knowledge dissemination across an organization, ensuring all stakeholders have access to insights from past experiences, which fosters a collaborative environment. Consistency

in managing lessons learned is critical, with Duffield and Whitty (2015) advocating for standardized processes that ensure lessons are easily accessible and applicable to future projects. Lastly, trust is fundamental to a productive learning environment, as noted by Edmondson (2004), creating a safe space for sharing successes and failures and fostering a culture of continuous learning and development.

The primary limiting factors in the integration of lessons learned are fragmentation, informal communication, lack of a centralized system, and insufficient initiative. Fragmentation, as discussed by Shokri-Ghasabeh & Chileshe (2014), creates silos within organizations, where knowledge and lessons are isolated, preventing cross-departmental learning. This lack of cohesion is compounded by informal communication structures, which Carrillo et al. (2004) argue hinder the formal documentation and dissemination of key insights across teams. Without a centralized system for storing and accessing lessons learned, as emphasized by Chen et al. (2021), organizations struggle to maintain a consistent and reliable repository of knowledge, leading to repeated mistakes and inefficiencies. Furthermore, the lack of initiative or ownership in managing lessons learned, highlighted by Milton (2020), results in a passive approach where knowledge is neither actively captured nor utilized, stifling potential improvements in future projects. These factors collectively obstruct the efficient implementation of lessons learned in tender processes.

The contrast between enabling and limiting factors in the integration of lessons learned reveals how the presence of strong enablers can significantly diminish the impact of obstacles. For instance, prioritization of lessons learned plays a crucial role in actively embedding past insights into tender processes. This strategic focus ensures that knowledge is applied consistently, counteracting the limiting factor of lack of initiative, where lessons are often ignored or underutilized (Milton, 2012; Duffield & Whitty, 2015). By making lessons learned a central component of project planning, organizations foster a proactive culture that values continuous improvement. Similarly, open communication fosters transparency and ensures that critical information is accessible across teams, which directly mitigates the challenges posed by informal communication. Informal knowledge exchanges, while flexible, often result in fragmented information and inconsistent application of lessons. A more formal and structured communication approach enhances clarity and consistency, as noted by Carrillo et al. (2004), thus preventing the isolation of key insights within silos. In the same vein, the use of a consistent approach to managing lessons learned creates a framework that ensures knowledge is captured, documented, and shared systematically across all projects. This consistent methodology directly addresses the issue of fragmentation, which typically results in isolated pockets of knowledge that fail to be disseminated organization-wide (Shokri-Ghasabeh & Chileshe, 2014). With a standardized approach, teams are better equipped to access relevant insights, reducing inefficiencies and the repetition of mistakes. Finally, the cultivation of trust within teams enhances collaboration and open dialogue, creating a supportive environment where individuals feel safe to share both successes and failures (Edmondson, 2004). This trust helps to overcome the limitations of a lack of centralized systems. In the absence of formalized data storage systems, trust encourages team members to actively share knowledge and insights through other means, ensuring that valuable lessons are not lost in the process (Chen et al., 2021).

Root causes Enabling factors

- Prioritization
- Open communication
- Consistent approach
- Trust

Root causes Limiting factors

- Fragmentation
- Informal communication
- No centralized system
- No initiative

In summary, the key to addressing the challenges identified in the lessons learned process lies in three practical strategies. First, the implementation of a centralized knowledge management system is crucial for mitigating fragmentation and ensuring that lessons are easily accessible to all stakeholders across projects (Chen et al., 2021). Second, establishing a formalized communication structure can standardize the sharing of insights, ensuring that valuable knowledge is consistently documented and disseminated, effectively addressing the limitations posed by informal communication (Carrillo et al., 2004). Finally, fostering a culture of active participation through incentivizing initiative will encourage greater ownership and engagement in the process, helping to ensure that lessons are captured and applied with greater rigor and commitment (Milton, 2020). These approaches, grounded in both literature and analysis, provide a clear path for improving the way lessons are integrated and applied within tender processes.

6.6 Discussion

This part of the discussion will focus on the key root causes of each tender and will look at the similarities and the differences between them. Tender N211 exhibits 10 out of 18 enabling factors, Alexia Viaduct shows 13 out of 27, and N346 also displays 10 out of 18 enabling factors. This data suggests that lessons learned are being used with both success and limitations across these projects. However, it would be premature to draw firm conclusions based solely on this data. To validate these findings, a comparison with the existing literature is necessary to ensure that these observations align with established theories and practices.

Statement 1, which discusses management's role in driving the integration of lessons learned into tender processes, is unanimously agreed upon across the cases. When analyzing the network graphs from the SNA, it becomes clear that management roles, such as tender managers and project leaders, consistently occupy central positions in these networks. This suggests that these leadership roles are pivotal not only in overseeing the tender process but also in ensuring that lessons learned are effectively integrated and applied throughout the projects. However, while all cases acknowledge the importance of management's involvement, the approaches taken by the tender managers and project leaders differ. The project leader in N211 emphasizes the importance of having a comprehensive process overview, using this to guide their team and actively apply past lessons. In contrast, the project leader in N346 focuses on the strategic value of lessons learned in decision-making and risk mitigation, viewing them as critical to improving the efficiency and outcomes of tenders. The tender manager of the alexiaviaduct, on the other hand, notes that while management should be responsible for integrating lessons, in practice, this is often left implicit. The process tends to rely more on individual initiative rather than a structured, management-driven effort, leading to inconsistencies in how lessons learned are applied.

Despite the variations in network densities and clustering coefficients across the different tenders, no significant difference is observed in the balance between enabling and limiting factors. In each case, the number of enabling and limiting factors is relatively similar, suggesting that the structural characteristics of these networks, such as density and clustering, do not appear to play a decisive role in the integration of lessons learned. This balance implies that the organic structure of the network, whether more centralized or distributed, does not substantially impact the documentation and sharing of lessons learned within the network. Therefore, it could be argued that the network's structure may not directly influence how effectively lessons learned are integrated into tender processes.

The literature supports the idea that network structure may not significantly influence the integration of lessons learned. For instance, divisional or siloed organizational structures tend to create isolated knowledge pools, making it challenging to standardize and share lessons across an entire organization (Ayodele & Kajimo-Shakantu, 2021). Similarly, without a centralized data management system, the flow of lessons learned can become fragmented, regardless of the network's density or clustering (Chen et al., 2021). This aligns with the observation that, despite differences in network structure, the number of enabling and limiting factors remains balanced across tenders, indicating that the organic nature of the network may not substantially affect how lessons are integrated or shared (Chen et al., 2021; Ayodele & Kajimo-Shakantu, 2021).

One of the key limiting factors identified in the analysis is the lack of standardization in lessons learned documentation. While many respondents agree that having a standardized format would greatly improve the sharing and application of knowledge, it remains something that is seldom implemented in practice. This gap can significantly limit the efficient sharing and application of knowledge across projects. Literature highlights the importance of a standardized framework for documenting lessons learned to ensure uniformity and accessibility across departments, thereby reducing errors and improving project outcomes (McClory et al., 2017; Williams, 2008). Implementing such a framework would provide consistency in how lessons are captured and interpreted, streamlining the dissemination of critical insights (El-Diraby et al., 2005). Encouragement from management is essential to institutionalize this practice, ensuring that the lessons learned process is not only implemented but also maintained rigorously across all levels of the organization (Iyer et al., 2009) .

6.7 Wrap-up

This chapter will summarize the key findings from the interviews conducted with seven employees, selected based on their different roles and important positions within the SNA. The chapter will provide a synthesis of both the enabling and limiting factors identified during the interviews, reflecting how the employees' central roles within the network influenced the integration of lessons learned across the tender processes. This will conclude the case study analysis and prepare for a deeper discussion in the following sections of the thesis. Table 16 presents the enabling factors, which demonstrate the key elements that contribute to the successful integration of lessons learned within tender processes. These factors highlight the importance of providing proper attention and consistent application of lessons, ensuring that they are effectively incorporated and understood by all relevant stakeholders. In contrast, Table 17 outlines the limiting factors, which reveal recurring challenges in the process. These challenges underscore issues related to disconnected processes, lack of structure, and insufficient

systems for managing lessons learned. The need for more structured and proactive approaches is evident to improve the overall effectiveness of lessons learned in tender operations.

Table 16: Root causes of enabling factors

Root causes of enabling factors	#	%
Prioritization	5	16%
Open communication	4	13%
Consistent approach	4	13%
Active learning	2	6%
Recognition	2	6%
Need for context	2	6%
Trust	2	6%
Decentralized department storage	2	6%
Structured discussions	1	3%
Actionable outcomes	1	3%
Uniform leadership practices.	1	3%
Formalized approach	1	3%
Stimulation	1	3%
Engagement into daily practices	1	3%
Management enforcement	1	3%
Easy request	1	3%
Process overview	1	3%

Table 17: Root causes Limiting factors

Root causes of limiting factors	#	%
Fragmentation	7	22%
Informal communication	6	19%
No centralized system	3	9%
No initiative	3	9%
Inconsistent implementation	2	6%
No time	2	6%
Process improvement	2	6%
Underdeveloped database.	2	6%
No formal system	2	6%
No standardized documentation	1	3%
Lack of context	1	3%
No management enforcement	1	3%

The comparison between the projects indicates that network density and clustering coefficients do not seem to significantly influence the integration of lessons learned. Despite variations in these structural aspects, there is no clear difference in the balance between enabling and limiting factors across the tenders. This suggests that the organic structure of the network, whether more centralized or distributed, does not substantially affect how lessons learned are documented and shared within the network. To explore what might influence the integration of lessons learned more effectively, it could be beneficial to investigate other factors, such as organizational culture, the presence of formalized systems for documenting knowledge, or leadership engagement. As noted in the literature, the implementation of standardized documentation frameworks and active management involvement are often crucial to ensuring the consistent application of lessons across projects (Williams, 2008; El-Diraby et al., 2005). By focusing on these internal organizational dynamics, further research could shed light on what truly drives the effective integration of lessons learned.

III Synthesis

7. Bridging the gap

This chapter is divided into three main sections: Section 7.1 presents the discussion, where the findings from the exploratory phase are compared with the results of the case studies, offering insights into the similarities and differences between theory and practice. Section 7.2 covers the validation of the results, while Section 7.3 delivers the conclusion, addressing the sub-questions and ultimately providing a well-supported answer to the main research question, bridging the gap between theoretical concepts and the real-world application of lessons learned in tender processes.

7.1 Discussion

In this section, the findings are compared and analyzed in light of the previous literature, confirming certain aspects while also revealing new insights. By contrasting the results from the exploration and case studies, the discussion highlights both the alignment with existing theories and the emergence of fresh perspectives that contribute to a deeper understanding of lessons learned in tender processes.

7.1.1 Findings

Table 18 below illustrates the alignment between root causes identified in the practical tender processes and the corresponding factors from the literature review. It provides a clear overview of how these factors, both enabling and limiting, influence the integration of lessons learned within a tender process. By connecting practical findings to theoretical insights, this table highlights the current practices that enhance or hinder the effective application of lessons learned.

Table 18: Comparing practical and theoretical factors

Root cause	Lessons learned factors from theory	En.%	Lim.%	Tot%
+ Prioritization + Management enforcement +Uniform practices. - No management enforcement	Top-Down Support for Prioritizing Lessons Learned Integration	21%	3%	12%
+ Consistent approach + Formalized approach - No formal system	Formalized Processes for Capturing and Applying Lessons Learned	16%	6%	11%
+ Open Communication + Easy request - Underdeveloped database	Use of digital platforms for knowledge sharing	14%	6%	10%
+ Stimulation	Motivation and Incentives to Encourage Participation in Lessons	9%	9%	9%

+ Recognition - No initiative				
+ Actionable outcomes - Inconsistent implementation	Monitoring and Adjustments to Refine Lessons Learned Processes	3%	6%	5%
+ Structured discussions - Informal communication	Encouraging Bottom-Up Communication to Capture Insights	3%	-	2%
+ Trust	Psychological Safety to Encourage Open Sharing of Insights	6%	-	3%
+ Active learning - Lack of process - No time	E-Learning Modules to Train Employees on Lessons Learned	6%	12%	9%
+ Decentralized department storage - No centralized system - Lack of context	Searchability and Accessibility of Lessons Learned	6%	12%	9%
+ Need for context - No standardized documentation - Informal communication	Effective Documentation Tools for Capturing Lessons Learned	6%	22%	14%
+ Process overview + Engagement into daily practices - Fragmentation	Integration of Lessons Learned into the Tender Lifecycle	6%	22%	14%

The top of the table showcases factors that currently enable the integration of lessons learned within the tender processes. The highest-rated enabler, "Top-Down Support for Prioritizing Lessons Learned Integration," highlights the importance of management prioritizing knowledge sharing and learning. When management actively emphasizes the use of previous project knowledge and encourages documenting new insights, lessons learned are more effectively utilized. This ensures that valuable insights from past experiences are applied to ongoing projects, improving project outcomes and increasing the attention paid to documenting new knowledge (Duffield & Whitty, 2015; Milton, 2012). Formalized Processes for Capturing and Applying Lessons Learned act as both enabling and limiting factors within organizations. On one hand, a consistent and formalized approach ensures that lessons learned are effectively captured, documented, and integrated into project practices, thereby fostering continuous improvement and knowledge retention (Drupsteen & Guldenmund, 2014; Duffield & Whitty, 2015). The consistent approach enables smoother transitions between projects and ensures that valuable insights are not lost (Kerzner, 2017). However, limitations arise due to a lack of a formal system and time constraints, which can hinder this process. The absence of a formalized system leads to fragmented knowledge management, making it difficult to ensure uniform application across departments (Wiewiora & Murphy, 2015). Additionally, time pressures, commonly cited in competitive tendering processes, often prevent employees from thoroughly engaging in lessons learned activities, further limiting the impact of these formalized processes (Levy, 2018; Shokri-Ghasabeh & Chileshe, 2014). The factor "Use of digital platforms for knowledge sharing" plays both an enabling and limiting role in the integration of lessons learned in tender processes. The enabling aspect is reflected through "Open Communication" and "Easy Request" systems, which

facilitate seamless sharing of information across teams, allowing for real-time access to lessons learned and quick requests for information (Chen et al., 2021). However, this factor is limited by the presence of an "Underdeveloped database," which hampers the effective utilization of digital platforms. Without a robust and well-maintained database, knowledge sharing becomes inconsistent, reducing the overall efficiency of digital tools (Martínez-Rojas et al., 2016).

To address the limiting position of "Integration of Lessons Learned into the Tender Lifecycle" in the table, the primary reason for its low ranking is the root cause of fragmentation. Fragmentation creates barriers in retrieving and utilizing data, making it difficult for teams to access lessons learned throughout the tender lifecycle. When data is scattered across different systems or departments, it becomes less accessible and inhibits the efficient use of valuable insights (Shokri-Ghasabeh & Chileshe, 2014). This severely limits the potential for lessons learned to be integrated effectively into ongoing projects. Improving the accessibility and searchability of this fragmented data can mitigate this issue, as suggested by Kerzner (2017). A unified system that consolidates lessons learned across all phases of the tender lifecycle can increase the likelihood of those lessons being applied consistently. On the other hand, enabling factors such as "Process Overview" and "Engagement into Daily Practices" offer potential for improvement. A clear process overview can help teams connect the relevant lessons learned at each stage of the tender process, fostering a more systematic approach to knowledge application (Carrillo et al., 2014). Additionally, integrating lessons learned into daily practices ensures that knowledge-sharing becomes a routine part of the workflow, rather than an isolated task, further encouraging the use of past insights (Milton, 2012). These enabling factors indicate that, by addressing fragmentation, organizations can enhance the integration of lessons learned throughout the tender lifecycle, leading to better project outcomes. The low ranking of "Effective Documentation Tools for Capturing Lessons Learned" is primarily influenced by limiting factors such as "No Standardized Documentation" and "Informal Communication". When documentation processes lack standardization, it becomes challenging to maintain consistency and accuracy in capturing lessons learned. This makes it difficult for teams to access and use valuable insights effectively, leading to fragmented knowledge sharing (Williams, 2008; Naot et al., 2004). Informal communication, , which has a notably high percentage as a limiting factor. bypasses formalized channels of knowledge sharing, resulting in important lessons being conveyed in unstructured or undocumented ways. While informal communication can foster immediate exchanges, it frequently lacks the rigor needed for organizational learning. This can lead to fragmented or incomplete records, making it difficult for other teams or future projects to access or apply these insights (Carrillo et al., 2004)

In the following section, it is discussed that certain factors have not been included in the table and further analysis. This is because these factors were only identified in the theoretical framework and were not mentioned by respondents during the practical RCA. As a result, while these factors are relevant according to the literature, they did not emerge as significant within the practical context of the studied tender processes. Therefore, they have been excluded from the core analysis to focus on factors that directly influence lessons learned integration in practice.

Factors:

1. Shared Learning Sessions for Collaborative Knowledge Exchange
2. Mentorship and Coaching to Reinforce Lessons Application
3. Continuous Improvement Cycles Driven by Lessons Learned
4. Data Analytics to Identify Trends in Lessons Learned
5. Fostering a Learning-Oriented Culture for Knowledge Integration
6. Active Involvement of Management in Promoting Lessons Learned
7. Ongoing Training Programs for Lessons Learned Best Practices
8. Interdepartmental Communication for Cross-Project Learning

It is important to note, however, that while these factors were not highlighted by the respondents involved in the tender processes, their significance cannot be overlooked. These elements, as identified in the literature, remain crucial for the effective integration of lessons learned. The fact that they were not acknowledged by practitioners suggests a gap between theory and practice. This lack of recognition may indicate that these factors are either underutilized or not prioritized in day-to-day operations, despite their potential to improve knowledge sharing and application in tender processes.

7.1.1.1 Critical questions:

In the course of conducting this thesis, several critical questions emerged regarding the processes and content of the research itself. These questions serve as reflections on the approach taken, the methodology used, and the overall scope of the work. Addressing these questions was crucial to ensuring the thoroughness of the study and identifying any knowledge gaps that could impact the validity of the conclusions.

1. *How useful was the SNA for the research on how Lessons learned is imbedded in data sharing behavior?*

During the analysis, a critical question arose regarding the adequacy of SNA a method for capturing the true dynamics of knowledge sharing within tender operations. While SNA successfully highlighted key actors and communication paths, there was concern about whether this approach could sufficiently reflect the nuanced, real-life complexities of data exchange in tender processes. Additionally, doubts emerged around the ability of SNA to fully capture the role of informal communication channels and whether it could represent the true depth of lessons learned integration. Despite these concerns, it became clear that SNA remained a valuable tool in understanding the broader structural aspects of knowledge sharing, offering significant insights into how lessons learned flow within the organization and identifying areas for improvement.

2. *How did the RCA contribute to the in depth understanding on how lessons learned is used in tender processes?*

The RCA provided an in-depth understanding of how lessons learned are utilized in tender processes by systematically identifying the underlying factors that either enable or hinder their integration. Through RCA, it became clear which practical issues, such as fragmentation, informal communication, and lack of a centralized system, prevent the effective use of lessons learned. Additionally, the RCA highlighted enablers like prioritization and open communication, offering

concrete insights into how organizations can improve knowledge retention and application in future tenders. This analysis allowed for a more comprehensive view of the practical challenges faced and the solutions that could be implemented to address them.

3. *To what extent do the findings align with the broader organizational objectives of the tender processes, and how can these insights be practically applied?*

This question was crucial in ensuring that the research findings were not just theoretical but had practical relevance to the organization. By aligning the lessons learned with broader organizational objectives, the goal was to improve decision-making and optimize tender processes in a way that supports long-term success. Additionally, the insights needed to be adaptable to real-world conditions, ensuring that they could be seamlessly integrated into existing workflows and support the company's strategic priorities for continuous improvement.

4. *How comprehensive is the scope of identified enabling and limiting factors, and are there other, perhaps overlooked, organizational aspects that may impact the integration of lessons learned?*

This question underscores the practical implications of the research. The ultimate goal of the study was not only to identify gaps in the lessons learned process but also to provide actionable insights that can improve tender practices. It was necessary to reflect on whether the findings were applicable in real-world settings and aligned with the strategic goals of the organization.

7.1.1.2 Limitations of the research

The limitations of this research arise from the scope, time constraints, and the specific methods employed. Due to the focused nature of the study on tender processes and the timeframe available for data collection, certain aspects of knowledge sharing and lessons learned could not be explored in full depth. Additionally, the chosen methodologies, while effective for the research objectives, may limit the generalizability of the findings across all organizational contexts.

- **Technology focus:** While the research emphasizes the importance of digital tools for knowledge sharing, this focus limits the scope of the study. Technology alone cannot address the cultural and human factors influencing knowledge-sharing behaviors within the organization. The research does not fully explore how employees adopt and engage with these tools or the potential resistance to change, which are significant aspects of successful knowledge sharing. This limits the understanding of how technology interacts with organizational culture and human behavior in facilitating lessons learned.
- **Respondents of the survey:** One limitation of the survey data is that respondents worked on two of the three case studies, meaning that insights from the third case are underrepresented. Additionally, many respondents had experience with multiple tenders, but the survey did not capture their influence across different networks outside of the specific cases studied. This limits the ability to understand their broader impact on knowledge sharing within the organization. Furthermore, some key employees had left the organization, making it difficult to fully map the knowledge-sharing dynamics, as their insights and influence were missing from the analysis.
- **Complexity of real-life knowledge sharing:** SNA provides a snapshot of knowledge-sharing pathways, offering a static view of the network at a particular point in time. However, the dynamics of real-life knowledge sharing are far more fluid. Knowledge flows can change

rapidly due to evolving project demands, personnel changes, or emerging challenges. The static nature of SNA means it cannot capture the shifting context or the temporal aspects of how knowledge is shared and applied throughout the lifecycle of a project. This limits the analysis by not accounting for the dynamic, ever-changing nature of knowledge-sharing behaviors in real-world scenarios.

- **Dependence on data availability and accuracy:** SNA heavily relies on the completeness and accuracy of the data collected. If certain employees (nodes) do not participate in the survey or provide incomplete responses, the analysis may not accurately reflect the full scope of the knowledge-sharing network. Missing or inaccurate data can lead to skewed interpretations, where the centrality and influence of specific individuals in the network may be under- or over-estimated. This limits the reliability of conclusions drawn about knowledge-sharing dynamics, potentially overlooking key influencers or knowledge silos within the organization.
- **Network statistics:** Although the research uses network statistics to define central nodes and identify data silos, the full potential of these statistics has not been explored. For example, while the centrality of nodes is highlighted, further analysis could have provided insights into subgroups, bridges, or key connectors within the network. The limitations in utilizing these advanced metrics mean that some important dynamics, such as the influence of peripheral nodes or potential knowledge brokers, may not have been fully examined, leaving gaps in understanding how knowledge truly flows through the network.
- **Project type:** The research focuses solely on the tender phase of projects, which limits the generalizability of the findings. While the tender phase is crucial for project initiation, many of the most significant knowledge-sharing challenges occur during the execution phase of a project. Since the study does not address knowledge sharing during execution, it misses out on insights related to the most critical stage for applying lessons learned and resolving issues that emerge during project implementation. This leaves a gap in understanding how lessons learned during tendering are applied, transferred, or adjusted in the later stages of project development.
- **Subjectivity in Identifying Root Causes:** RCA relies on qualitative input from employees, which can introduce subjectivity into the identification of root causes. The perspectives of individuals may be influenced by personal experiences, biases, or incomplete knowledge of the broader organizational processes. This means that the identified root causes may not always represent the most objective or comprehensive factors contributing to the issues. Moreover, RCA typically focuses on past problems rather than predicting future ones, potentially limiting its scope when trying to address more complex, evolving organizational challenges.
- **Conceptual Design of the GIS Application:** While the GIS application concept highlights potential functionalities aimed at enhancing knowledge sharing and the integration of lessons learned, a fully comprehensive design addressing all specific requirements has not yet been developed or implemented. As a result, the real-world effectiveness of the application in an operational environment remains untested, and its features may need adaptation to align with the existing system's unique data structures and workflows. Future research should focus on incorporating this conceptual design into the company’s actual GIS portal to evaluate its practical performance and pinpoint areas for refinement.

7.2 Validation of the results

This section provides an overview of the validation process, where key findings and proposed solutions were reviewed by four experts. The validation involved discussions on the research results, the roadmap for improving lessons learned documentation, and the design of a knowledge-sharing tool. The experts' feedback helped refine the methodology and provided insights into the practical implementation of the proposed strategies. The following subsections cover the validation process, feedback on the results and roadmap, and the design of the knowledge-sharing tool.

7.2.1 Overview validation process

To validate the findings of this research, one-on-one discussions were conducted with four key experts within the organization: the Director of PMC, the Director of Commerce, the Design Manager, and the Knowledge Manager. These experts were chosen for their strategic roles in the tender processes and their broad influence within the company. Each expert was presented with a detailed PowerPoint presentation that outlined the research approach, the identified root causes, and the proposed solutions.

The presentation included a roadmap, showed in Figure 41, aimed at improving the documentation, searchability, and application of lessons learned to enhance organizational learning. Additionally, a conceptual design for a knowledge-sharing tool, featuring a GIS portal for uploading and accessing documents, was introduced. The discussions were interactive, allowing the experts to provide real-time feedback, ask questions, and offer suggestions during the presentation. This engagement was crucial for refining both the research methodology and the proposed strategies. For reference, the slides from the presentation, as well as screenshots of the knowledge-sharing tool design, can be found in the Appendix G. These materials provide a comprehensive visual overview of the validated concepts and tools.

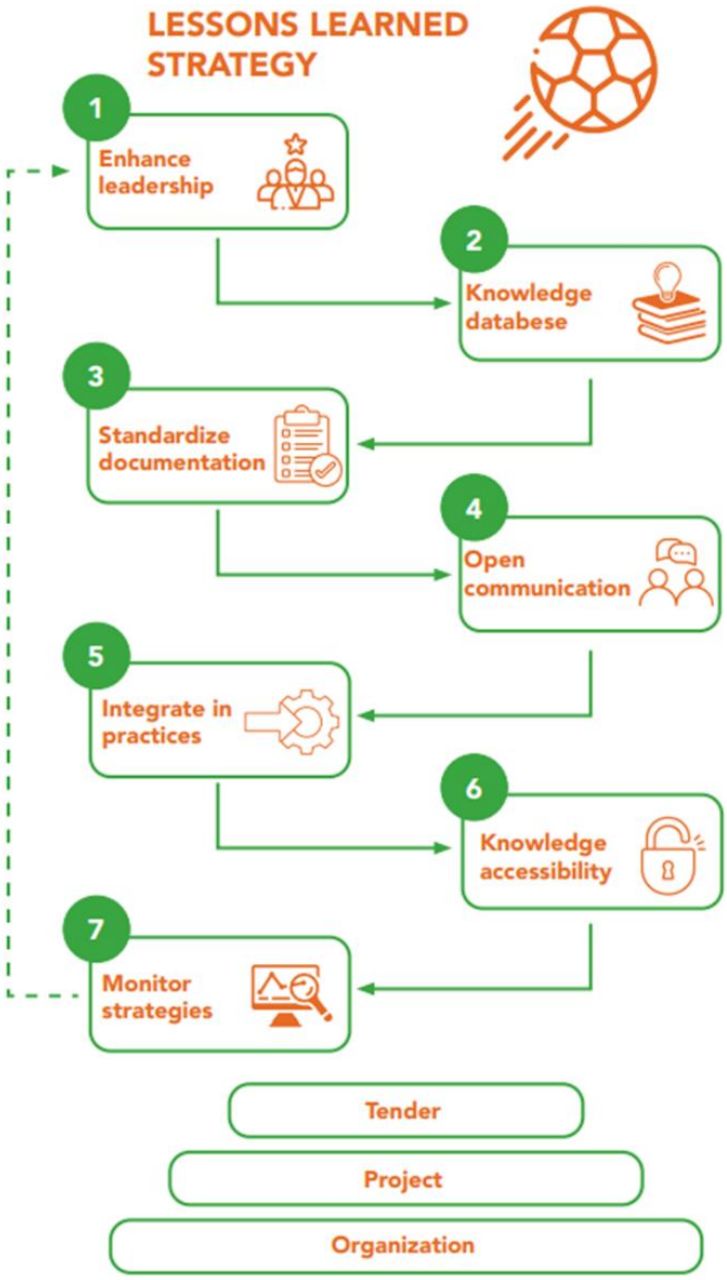


Figure 41: Road map

During the validation process, a PowerPoint presentation was used to outline the research methodology, key findings, and root causes related to lessons learned and knowledge sharing in tender processes. The presentation began by explaining how the research was structured, from exploratory interviews to surveys and case studies, all of which were essential in identifying the primary barriers to effective knowledge documentation and sharing within the organization.

The experts were guided through the root causes identified in the research, particularly the inconsistencies in the use of digital tools, the lack of standardized processes for documenting lessons learned, and the cultural resistance to knowledge sharing. The methodology focused on how these factors were analyzed in-depth, emphasizing the importance of improving access to lessons learned and integrating them more effectively into daily practices. The experts were invited to evaluate the research methodology and its relevance to the identified challenges. Their

feedback centered on the practical application of the findings and the proposed solutions, ensuring that the results accurately reflected real-world conditions in tender processes. Their responses validated the research approach, while also highlighting areas where further refinement was needed.

7.2.2 Feedback on results and Roadmap

The experts provided feedback on both the roadmap and proposed strategies for improving lessons learned documentation, search functionality, and overall knowledge-sharing processes. Across the discussions, a few critical areas of improvement and agreement emerged.

1. Leadership and Management's Role
The Director of PMC and Director of Commerce agreed on the crucial role of leadership in promoting the use of lessons learned, but they differed in their emphasis. The Director of PMC was surprised that bottom-up communication did not play a larger role in the findings, stressing that while leadership drives the process, employees need to feel empowered to share insights without fear of judgment. He emphasized that management should work on fostering a culture where people feel comfortable contributing knowledge and asking questions freely. In contrast, the Director of Commerce felt that leadership already played a key role but recognized room for improvement, especially in promoting the systems in place more effectively.

2. System Enhancements Over New Platforms
There was consensus across the experts, including the Design Manager, that introducing new databases or systems was unnecessary. Instead, they favored improving the functionality and visibility of existing systems. The Director of Commerce emphasized that the company already has enough databases and tools for knowledge sharing but suggested that employees often overlook them due to a lack of proper communication or awareness. The Design Manager added that while the systems are there, they are often underutilized because people are unsure of how to use them or lack the appropriate context when accessing information. He suggested that improving the user experience and offering clearer guidelines would make the existing tools more effective.

3. Cultural and Generational Differences
The Commerce Director also raised the issue of generational differences in communication styles. Older employees tend to favor traditional methods like phone calls and face-to-face meetings, whereas younger employees are more comfortable with digital platforms such as Microsoft Teams and SharePoint. This generational divide influences how knowledge is shared, and the roadmap should account for these differences by ensuring that both types of communication are accommodated. The Design Manager also mentioned that these differences can contribute to information fragmentation because employees might not understand how or where to document information digitally, especially if they are not familiar with the systems in place.

4. Ownership and Context
A key challenge identified by both the Director of PMC and the Design Manager was the lack of clear ownership of knowledge documents. Without a designated person responsible for maintaining and updating lessons learned, the documents tend to become outdated or ignored.

This lack of ownership hinders effective knowledge sharing across projects. The Director of Commerce also highlighted the importance of context in ensuring the correct application of lessons learned. He stressed that merely having the documents available in a database is not enough, there needs to be direct contact with the person who documented the lesson to ensure that the knowledge is correctly applied in a new context. Otherwise, there is a risk that lessons learned will be misunderstood or misapplied, which can lead to mistakes or inefficiencies.

5. Human Factor and Tools

Throughout the feedback, it was clear that tools alone are not enough to solve the knowledge-sharing challenges. The Director of PMC emphasized that the human factor, specifically, employees' willingness to share and seek knowledge, is the most significant barrier. He advocated for a cultural shift, where employees feel safe and encouraged to contribute their insights without fear of judgment. The Design Manager echoed these sentiments, emphasizing that lessons learned need to be practically applied and should reflect actual project outcomes. He recommended more interactive ways to document and share insights, such as integrating tools like GIS for easier visualization and understanding.

6. Road map

During the validation of the roadmap, a proposal was presented that highlighted the factors deemed to have the greatest impact on the use of lessons learned. Initially, the plan focused on directly addressing these specific factors. However, feedback suggested that the roadmap should remain flexible, allowing management to determine which factors should be prioritized. Additionally, it was recommended that practical measures be developed for the factors identified in Table X, enabling them to be applied as needed based on management's strategic decisions.

In conclusion, the feedback highlighted a balanced approach that focuses on improving existing systems and promoting a cultural shift towards open communication and ownership of knowledge. The experts generally agreed with the strategy presented in the roadmap but emphasized the need for continuous refinement, especially in ensuring that the systems and processes are widely adopted and understood across different levels of the organization.

7.2.3 Design of GIS Application

A key aspect of the validation process was the presentation of a potential knowledge-sharing tool designed to address the challenges identified in the research, screen shots of this tools are placed in Appendix H. This tool features a GIS portal that facilitates the visualization and access to knowledge documents, aiming to make the search for lessons learned more intuitive and accessible across different projects and departments.

The design includes two main components:

1. **A project filter system** that allows users to search for projects based on several parameters such as project type, document type, year, and department. This ensures that relevant knowledge documents can be easily located, improving the efficiency of the knowledge-sharing process.
2. **A document upload and categorization system** that ensures all knowledge documents are properly categorized with critical metadata such as project phase, key lessons,

contributing departments, and impact level. This system is designed to maintain a centralized, easily searchable repository of knowledge documents.

The Design Manager was particularly supportive of the GIS interface, which he felt added a valuable visual element to the process, making it easier to locate and interact with knowledge documents. However, he expressed concerns about whether the tool would be actively used unless it was fully integrated into the team's daily workflows. He emphasized the need to incentivize users to engage with the system, recommending that structured project reviews and regular reminders about the tool be implemented to improve usage rates. Similarly, the Commerce Director acknowledged the value of the GIS portal and the document categorization features but stressed the importance of context in ensuring that the lessons captured were applied correctly. He was concerned that without direct communication between teams, the knowledge documented in the system might be misinterpreted. To mitigate this, he suggested that the tool should include communication features, such as comments or direct links, allowing users to provide additional insights or clarifications on the lessons. The Knowledge Manager reinforced the importance of ownership and accountability within the system. He pointed out that simply uploading documents would not ensure their active use. There needs to be clear responsibility for maintaining and updating these knowledge documents, and accountability for ensuring that they are applied across projects. Without this, valuable lessons could be left unused, diminishing the effectiveness of the system.

Further insights were provided during the validation session regarding potential improvements to the existing GIS system with the GIS specialist, particularly around the integration with other platforms. One significant enhancement discussed was the integration of GIS with a DMS, which would allow documents to be visually linked to geographic locations within the GIS interface. This integration improves document accessibility by making it easier to retrieve relevant project information based on geographic context. Such a system could be particularly beneficial during the project phase when continuous reference to tender documents is often necessary. Another improvement centered on the visual coupling of documents to geographic locations. By linking documents such as lessons learned, best practices, and project reports directly to specific areas on the GIS map, users gain an additional layer of visibility and control over project information. This enables more effective validation of decisions and promises made during the tender phase as the project progresses. In addition, the document upload process was highlighted as an area for enhancement. By implementing a hierarchical structure or "decomposition" for categorizing and uploading documents, such as through a system like an MBSE, users can maintain a structured and organized system. This structured approach is key to preventing unorganized data accumulation and ensuring that documents are uploaded consistently and easily retrievable. Lastly, it was noted that while GIS itself serves primarily as a visualization tool rather than a storage system, its strength lies in its ability to offer a clear and navigable visual interface for accessing project documents. Documents remain stored in the DMS but can be visualized and accessed within GIS via simple URL links. This creates a seamless integration between document storage and visualization, facilitating more intuitive navigation through project data.

Operational, technical and strategic relevance

During the validation process, it was highlighted that the GIS tool could serve at multiple levels: operational, technical, and strategic.

Operational Level

At the operational level, the GIS application design can significantly enhance how project documents, particularly lessons learned, are accessed and utilized within the organization. By linking documents such as lessons learned reports to specific geographic locations, the application allows teams to visually navigate project data, making it easier to retrieve relevant information based on location, project phase, or document type. This spatial linkage enables more intuitive access to project knowledge, helping employees quickly find and apply lessons to ongoing or future projects, thereby streamlining workflows and reducing redundancy.

One of the key operational challenges that the GIS application design addresses is the lack of data continuity when transitioning from the tender phase to the execution phase of a project. Often, valuable knowledge and insights gathered during the tender stage are fragmented or lost, resulting in inefficiencies as teams move into the execution stage. By ensuring that data is seamlessly transferred across project phases, the GIS application design will act as a bridge, maintaining the flow of crucial information throughout the entire project lifecycle. This will ensure that lessons learned and project insights are consistently available for real-time application, eliminating the common issue of data loss during project handovers. Furthermore, the metadata filtering functionality allows users to search based on project phase, document type, or geographic location, making it easier to pinpoint specific knowledge relevant to their current tasks.

Additionally, the design includes a feature that will guide users to an upload page, where they can contribute documents such as lessons learned or project-specific data. Upon upload, these documents will be automatically structured with essential metadata such as project phase, geographic location, involved departments, and document type. This structured approach ensures that documents are not only stored but are also accessible and categorized in a way that facilitates future retrieval and application in real-time project work.

Technical Level

From a technical perspective, the GIS application design serves as a visual interface, integrating with an existing DMS for document storage and MBSE for structured project data. Rather than storing documents, the GIS application provides an intuitive, map-based interface for users to navigate and access documents by associating them with specific geographic locations.

The integration between a DMS, MBSE, and the GIS application is essential to ensure seamless data flow. DMS manages the storage and tagging of documents, while MBSE ensures the structured project data is consistently organized. The GIS application design enhances this by linking documents to geographical points, enabling users to access relevant project data based on location.

A critical aspect is ensuring synchronization between these platforms. When documents are uploaded to a DMS, the associated metadata, such as geographic location or project phase, must be automatically integrated into the GIS application. This synchronization enables real-time interaction with project data on the

Strategic Level

At the strategic level, the GIS application design has the potential to significantly enhance the organization's knowledge management framework by centralizing lessons learned across departments. This centralization supports a culture of continuous improvement, where insights gained from previous projects are easily accessible and can directly inform future projects and decision-making processes.

In addition to meeting current knowledge-sharing needs, the GIS application can serve as the foundation for more advanced, data-driven decision-making systems. By capturing structured data, the application enables the use of predictive analytics and AI-driven tools to analyze past project performance, forecast risks, and optimize resource allocation. The consistent tagging of documents with metadata such as geographic location, project phase, and key lessons ensures that information is both accessible and strategically valuable.

For example, data collected during the tender phase can seamlessly transition into the project phase, providing decision-makers with a complete overview of project-related risks, lessons, and opportunities from the beginning. This approach ensures that lessons learned are integrated into strategic planning, risk management, and long-term decision-making processes, making the GIS application a key tool in supporting the organization's strategic goals.

By positioning the **GIS application design** as an essential part of a company's knowledge infrastructure, the organization not only addresses current challenges but also prepares for future advancements. This includes the integration of machine learning algorithms and other tools that can analyze historical data to improve project outcomes and long-term strategies.

7.3 Conclusion

In this concluding chapter, the four research questions posed at the outset of this study will be addressed in detail, alongside the main research question. By analyzing the findings from the case studies, surveys, and interviews, this section will synthesize the insights gained throughout the research and provide a comprehensive response to the core issues related to knowledge sharing and lessons learned in tender processes. These answers will form the basis for the final conclusions and recommendations.

7.3.1 Research questions

This section provides answers to the four research questions that guided the study. Each question will be addressed based on the findings, offering insights into how lessons learned are used and shared within tender processes.

Q1 **How do data sharing practices within a tender organization influence the movement of lessons learned during tender processes?**

Within tender organizations, data sharing practices significantly impact the movement and integration of lessons learned across projects. This relationship operates on several key dimensions: the technological infrastructure in place, organizational culture, the structured vs. informal nature of data sharing, and the role of leadership in fostering a collaborative knowledge-sharing environment. Here's an in-depth analysis:

1. Technological Infrastructure and Digital Platforms

The availability and use of effective data-sharing technologies within tender organizations play a crucial role in determining how lessons learned are captured and transferred. According to the literature, organizations with robust digital platforms, such as Common Data Environments, enable smoother and more efficient access to shared knowledge. These platforms reduce data fragmentation by centralizing information from various departments, allowing employees from different teams to tap into a collective pool of lessons learned. Centralized platforms ensure that all stakeholders have access to key insights and project experiences in real-time, allowing lessons learned to be applied continuously across projects (Ayodele & Kajimo-Shakantu, 2021).

However, when digital platforms are underdeveloped, or fragmented, data becomes siloed in isolated departments, limiting the effectiveness of knowledge transfer. Fragmentation, as discussed in the literature, often results in inefficiencies in retrieving and utilizing data during the tender process. Teams are left with incomplete or inaccessible lessons learned, which hinders the integration of valuable insights into future projects (Kerzner, 2017). For lessons learned to move fluidly across an organization, data-sharing systems must be unified, with easily searchable and accessible repositories of knowledge.

2. Structured vs. Informal Communication Channels

Data sharing within tender organizations can occur through both structured and informal channels, each impacting the movement of lessons learned differently. Structured communication ensures that valuable insights are captured systematically, documented, and made available to all relevant teams. This practice is more effective for long-term retention and application of lessons learned, as it formalizes the process of documenting and sharing critical project knowledge (Milton, 2012). Formalized discussions, often embedded in project review sessions or team debriefings, help create a standardized approach to capturing lessons learned, reducing the chance that important insights are overlooked or forgotten (Carrillo et al., 2004).

Conversely, informal communication, while beneficial for fostering immediate knowledge transfer between individuals, often lacks the structure needed to maintain consistency across projects. Informal channels, such as verbal exchanges or ad-hoc emails, may lead to the loss of critical insights as they are not systematically captured or shared. This is particularly problematic in large organizations where information needs to be disseminated across different teams and departments to be effective. Informal communication, when relied upon too heavily, can thus limit the organization's ability to integrate lessons learned into future tender processes (Shokri-Ghasabeh & Chileshe, 2014).

3. Cultural Factors and Organizational Support

The culture within a tender organization, particularly its emphasis on collaboration and openness, profoundly shapes the way data is shared and, consequently, how lessons learned are integrated into the workflow. When an organization fosters a learning-oriented culture, where open communication is encouraged and knowledge-sharing is seen as a collective responsibility, lessons learned tend to move more freely across departments. This environment empowers employees to actively engage in both the sharing and application of insights from past projects. Leadership support for such a culture is also critical; when management prioritizes lessons learned and promotes an open exchange of knowledge, it signals to employees that these practices are vital for the organization's success (Carrillo et al., 2004).

On the other hand, organizations that lack this cultural support may see fragmented data sharing practices, with employees hesitant to share insights openly. If lessons learned are not incentivized or encouraged by leadership, knowledge-sharing may be sporadic and limited to specific teams, preventing the organization from fully benefiting from its collective experience. A lack of top-down support for lessons learned integration results in missed opportunities to apply valuable insights in future tender processes, stifling continuous improvement efforts (Duffield & Whitty, 2015).

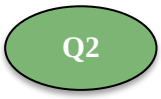
4. Leadership and Strategic Direction

Leadership's role in guiding data sharing practices is central to the effectiveness of lessons learned during tender processes. When leadership actively promotes the integration of lessons learned, they help institutionalize knowledge-sharing practices that allow for continuous improvement. Leaders who prioritize the use of past project insights ensure that teams remain focused on applying lessons to enhance decision-making, risk management, and project outcomes. By embedding these practices into the tender lifecycle, leaders can create a culture where knowledge-sharing is not just encouraged but expected (Edmondson, 2004).

Without top-down support, however, the application of lessons learned may be inconsistent. Teams may lack the strategic direction needed to prioritize lessons learned, and as a result, the movement of insights across projects becomes inefficient. Leadership-driven initiatives, such as structured debriefs or digital platforms for knowledge sharing, are crucial to formalizing the process and ensuring that lessons learned are captured systematically and applied effectively in future tenders (Kerzner, 2017).

5. Impact on Lessons Learned Movement

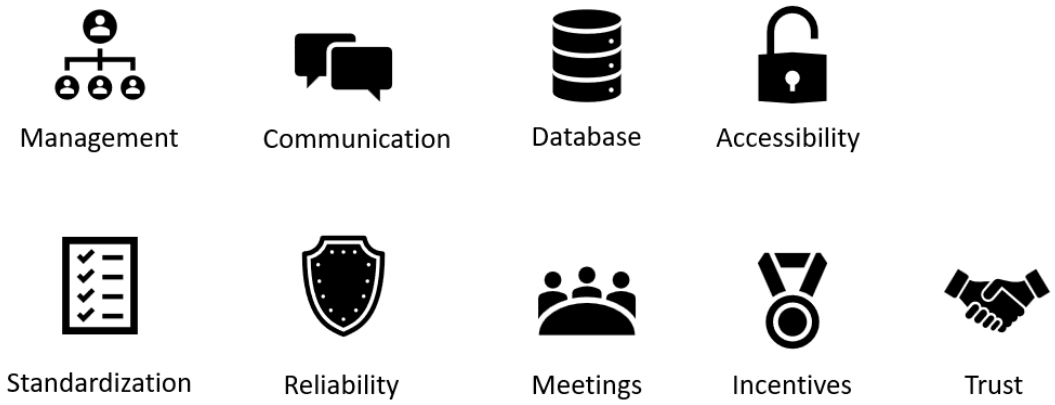
Data sharing practices within tender organizations often suffer from fragmentation, where data is stored in silos across departments, as noted in the thesis. These silos limit the free flow of information, preventing the systematic capture and application of lessons learned. Fragmented communication networks within divisions create inefficiencies, causing lessons from one project to remain unshared or underutilized in other projects. Ultimately, data-sharing practices directly influence how lessons learned are captured, stored, and applied throughout the tender process. When data-sharing systems are robust, supported by a collaborative culture and strong leadership, lessons learned can move seamlessly across the organization, enhancing project outcomes and promoting continuous learning. Conversely, when data-sharing practices are fragmented or informal, the movement of lessons learned becomes inefficient, limiting their impact on future tender processes. The interplay between formal data-sharing practices, cultural support, and leadership involvement ultimately determines the effectiveness of lessons learned integration.



What are the factors that influence the integration of lessons learned in tender processes, according to theory?

In the literature review, a total of 19 factors were identified as influential to the incorporation of lessons learned within tender processes. These factors represent a broad spectrum of organizational practices, tools, and cultural elements that either enable or limit the effective use

of lessons learned. These factors are detailed in Appendix A. To better analyze these influences, these factors were organized into a qualitative factor grid. This grid was organized along two axes: "Individual-Collective" and "Technology-People." These axes represent the spectrum between factors that either focus on individual or collective actions, and those that are driven by technological tools or human interactions. Here they were grouped into overarching themes or statements that align with common organizational practices. These grouped statements will form the basis for further analysis, specifically through a RCA aimed at understanding the practical enablers and barriers to integrating lessons learned in tender processes. The image below represents these 19 identified factors in the form of icons. These icons visually encapsulate the core concepts from the literature and serve to facilitate their interpretation during subsequent stages of analysis.



Q3 **What are the representations of intra-organizational data sharing within tender processes in practice?**

The network visualizations of the tenders N346, Alexia viaduct, and N211 provide valuable insights into the flow of data within these projects. These visualizations reveal the structure of the data-sharing networks, allowing for the identification of central figures based on their number of connections and influence within the network. By analyzing these networks, it becomes evident which individuals play key roles in facilitating the integration and dissemination of lessons learned, highlighting the importance of those with significant connectivity and influence in the organizational structure.

The network analyses of the N346, Alexia viaduct, and N211 tenders reveal several commonalities regarding data-sharing practices and key nodes that influence the flow of information. All three cases highlight moderate network connectivity, with each node typically connected to a few others. This pattern suggests that while communication is functional, there is room for greater collaboration and integration across departments.
In terms of central figures, the tender managers consistently emerge as pivotal nodes across all networks. These individuals serve as primary communication hubs, ensuring that information flows smoothly between different project participants. Their central roles emphasize the

importance of project leaders in maintaining the cohesion of the network and ensuring that valuable insights, such as lessons learned, are effectively distributed.
Additionally, clustering tendencies within the networks suggest the formation of smaller, tightly-knit groups. These clusters, while beneficial for focused collaboration, may also indicate the presence of data silos that could hinder broader knowledge sharing. Overcoming such silos would be essential for improving the overall efficiency of data exchange and lessons learned integration within the tender processes.

The most significant differences between the networks lie in the levels of fragmentation and connectivity. Alexia viaduct has a more connected network with moderate fragmentation, allowing for better distribution of lessons learned across departments. In contrast, N346 exhibits higher fragmentation despite having a similar network density, with certain teams operating in silos that limit cross-team knowledge sharing. The N211 project stands out with the highest fragmentation and lowest network density, which severely hampers communication and the effective application of lessons learned due to isolated departments and minimal cross-team interactions.

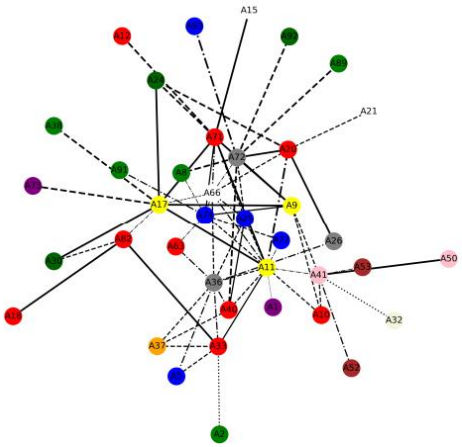


Figure 42: Network N346

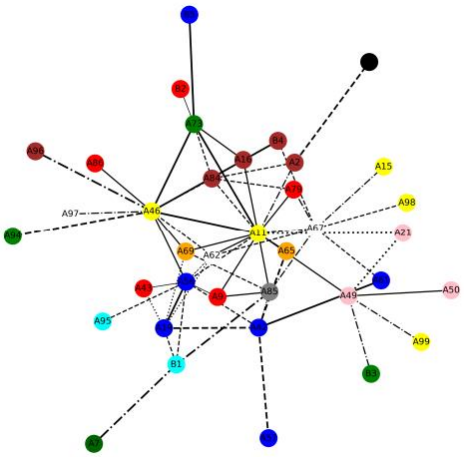


Figure 43: Network Alexia viaduct

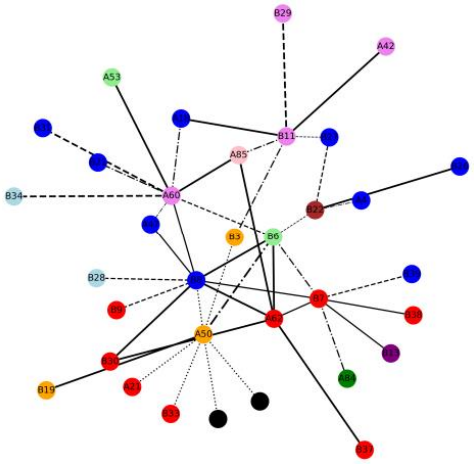


Figure 44: Network N211

Q4

What are the enabling and limiting factors that influence the integration of lessons learned into organizational tender processes within the studied projects?

The RCA conducted through interviews with seven employees, who played key roles in the data sharing networks of various tenders, provided crucial insights into the enabling and limiting factors that influence the integration of lessons learned in organizational tender processes. By focusing on individuals with significant impact within the data-sharing networks, the study identified both strengths and weaknesses in how lessons learned are currently utilized. By analyzing the key themes from these discussions, it became clear which practices are driving knowledge-sharing success and which obstacles are hindering the effective use of past insights in tender processes. Among the enabling factors, prioritization, open communication, and a

consistent approach were the most frequently cited as contributing positively to the integration of lessons learned. Prioritization emphasizes the importance of making lessons learned a higher priority within processes, encouraging teams to actively use them to inform decisions and prevent repeating past mistakes. Open communication fosters transparency across departments, ensuring that employees can freely share experiences and insights, which promotes collaboration and makes knowledge more accessible. Lastly, a consistent approach guarantees that the capture and application of lessons learned follow a standardized process, ensuring that valuable insights are systematically documented and applied in future projects.

The RCA identified limiting factors that hinder the integration of lessons learned in tender processes. Fragmentation leads to isolated data-sharing practices, where valuable lessons are often lost or remain inaccessible, hindering the organization's ability to apply insights consistently across projects. This lack of cohesion results in inefficiencies and missed opportunities for improving tender processes. Similarly, informal communication, while beneficial for quick exchanges, lacks the necessary structure to systematically capture and disseminate lessons learned. As a result, important insights are confined to small groups rather than benefiting the entire organization. Compounding these challenges is the absence of a centralized system for managing lessons learned, which makes storing, retrieving, and applying knowledge difficult. Without a unified platform, teams struggle to access relevant information, leading to repeated mistakes and inefficiencies throughout the tender process.

Root causes Enabling factors

- Prioritization
- Open communication
- Consistent approach
- Trust
- Active learning

Root causes Limiting factors

- Fragmentation
- Informal communication
- No centralized system
- No initiative
- No time

RQ

How can the integration, capturing of lessons learned be enhanced within tender processes in construction organizations?

At the outset, it was emphasized that processes benefit greatly from the better incorporation of lessons learned, ultimately enhancing operational efficiency. By systematically applying lessons from past projects, organizations can streamline workflows, reduce errors, and optimize resource usage. After analyzing the SNA and gathering insights from personnel on lessons learned documentation and sharing practices, it becomes clear that improving these areas enhances knowledge retention. This in turn leads to more effective use of that knowledge in making better-informed decisions. The combined perspectives from SNA and employee feedback suggest that prioritizing lessons learned not only strengthens organizational memory but also enables teams to apply insights strategically, fostering continuous improvement in tender processes.

To foster effective organizational learning, construction companies must rethink how they approach the integration of lessons learned within their tender processes. While tender managers often face numerous operational demands, it remains crucial that they take the lead in prioritizing lessons learned from the very start of a tender process. The role of tender managers is not only

to oversee project delivery but also to empower employees to take initiative in applying and documenting knowledge. This top-down support ensures that lessons learned become a fundamental part of the workflow, encouraging employees at all levels to actively engage with and contribute to knowledge sharing. By embedding this culture early in the tender process, organizations can enhance the flow of valuable insights, streamline knowledge retention, and improve overall decision-making. Addressing the root causes that limit this integration, and recognizing the importance of managerial support, is key to building more efficient and knowledge-driven tender processes.. These factors are:

- Top-Down Support for Prioritizing Lessons Learned Integration
- Integration of Lessons Learned into the Tender Lifecycle
- Effective Documentation Tools for Capturing Lessons Learned
- Formalized Processes for Capturing and Applying Lessons Learned
- Use of digital platforms for knowledge sharing

The integration of lessons learned into the tender lifecycle is crucial for maintaining an overarching view of the process, enabling teams to engage with past insights as part of their daily practices. However, this potential is hindered by fragmented data and documentation, making it difficult to consistently access and apply valuable knowledge. Effective documentation tools, while providing much-needed context, are similarly challenged by a lack of standardized formats and the prevalence of informal communication, which weakens the structure needed for proper knowledge retention. Formalized processes could offer a consistent framework for capturing and applying lessons, ensuring that insights are regularly integrated into tender processes. Yet, without a formal system in place to guide these efforts, lessons learned risk being inconsistently applied. Digital platforms hold promise by fostering open communication and allowing for clear tracking of knowledge use, but their impact is limited by an underdeveloped database, preventing effective knowledge sharing and integration. These combined factors underscore the challenges in fully embedding lessons learned into tender operations.

The factors and root causes identified through this research offer valuable insights into improving strategies for capturing and utilizing lessons learned within tender processes. By addressing these elements, organizations can develop more effective systems for knowledge retention and application, enhancing overall project outcomes. The following steps outline a strategic approach to incorporating these lessons learned into the tender lifecycle, ensuring that key insights are systematically captured and applied throughout the organization.

1. **Determine which factors to address**: The first step is identifying the specific factors that need improvement based on the lessons learned. Management can choose which factors are most critical to the organization or project. These factors are kept open for decision by leadership, ensuring flexibility in prioritizing issues that have the most significant impact.
2. **Decide on the necessary measures**: Once the factors are determined, the next step is deciding what actions or measures should be implemented to address those issues. These measures are practical, based on identified factors, and ensure that each factor has a clear plan for resolution.
3. **Consult tender managers**: Tender managers play a key role in the process, as they provide insights into the practical implications of these measures and help shape their

implementation within the tender phase. This ensures the measures are aligned with project goals and operational realities.

4. **Establish ownership of documents**: To ensure accountability, clear ownership of the lessons learned documents must be established. This step involves assigning responsibility to specific individuals or teams to maintain and update the documentation, ensuring that lessons learned are applied and not forgotten.
5. **Implement and integrate measures**: The agreed-upon measures are put into action, and integrated into the tender and project workflows. This ensures that lessons learned are actively used in decision-making processes and are effectively embedded within ongoing operations.
6. **Monitor effectiveness**: After implementing the measures, the process is monitored to determine how effective the changes are. This step ensures that progress is tracked and adjustments are made where necessary to improve the outcomes.
7. **Review and improve the strategy**: Finally, the effectiveness of the entire strategy is reviewed, and improvements are made based on the results. This ongoing process of refinement ensures that lessons learned are continuously integrated and that the strategy evolves to meet changing project and organizational needs.

Building on the strategy of developing a centralized system for documenting lessons learned, the creation of a structured GIS application is a critical step toward reducing fragmentation and enhancing knowledge sharing within tender processes. By implementing a standardized platform, organizations can streamline the documentation and retrieval of past project insights, ensuring that valuable lessons are applied effectively across future tenders. This approach focuses on creating an intuitive, easily accessible, and user-friendly system designed to cater to the diverse needs of employees across various departments.

Advanced search and filtering capabilities

One of the key features of the structured database is its advanced search and filtering capabilities. Employees will be able to search for lessons learned based on specific keywords, categories, or detailed filters such as the type of project, the phase of the tender process, or the nature of the challenges encountered. Additionally, this search functionality will be linked to a project database that integrates with the GIS application. This integration allows users to filter documents not only based on traditional metadata but also by geographic locations, project sites, and other spatial criteria. By visually linking lessons learned to specific projects and their locations on a map, users can quickly identify relevant knowledge tied to specific regions or project phases. This ensures that valuable insights are not lost in the vast amount of organizational data, and it enhances accessibility to the lessons learned by combining geographic and traditional search filters.

Categorization and metadata integration

Each lesson within the database will be categorized systematically, making it easier to navigate and apply. The system will provide detailed metadata for each lesson, including information such as the project background, a summary of the problem, the steps taken to resolve it, and the results. Furthermore, this metadata will be linked to the project database, allowing documents to be categorized based on geographic information through the GIS system. For instance, users will be able to tag documents with locations such as project sites, specific regions, or even critical infrastructure components, enhancing the ability to retrieve documents based on location-

specific needs. By combining project-based metadata with geographic location tags, the system ensures that lessons are not only captured comprehensively but also presented in a way that facilitates quick understanding and practical application.

This geographic linkage further encourages users to draw parallels and apply insights from one project to another, especially when similar challenges are encountered in different geographic regions or project phases. This provides a more holistic understanding of the data, enriching both the technical and contextual dimensions of lessons learned.

Seamless integration with existing systems

Crucially, the GIS application design integrates with an existing DMS and MBSE. This ensures that project data and documents are managed effectively while being accessible through a visual interface. The DMS acts as the primary storage system, the MBSE structures project data, and the GIS application links this data to specific geographic locations, allowing for real-time access to critical knowledge across departments. This integration eliminates the silos that currently exist, ensuring that lessons learned are not lost during transitions between tender and project phases.

Collaboration features and interactive knowledge sharing

The GIS application will support real-time collaboration, enabling employees to engage with and contribute to lessons learned through interactive features such as comments, discussions, and file uploads. This collaborative environment fosters cross-departmental communication and promotes a continuous learning culture, encouraging employees at all levels to share and apply project insights actively. By allowing users to provide feedback and share their experiences, the platform ensures that the knowledge remains dynamic and up-to-date, further enriching the learning process.

Embedding Lessons Learned into the Tender Lifecycle

The GIS application will align lessons learned with each phase of the tender lifecycle, providing employees with relevant insights exactly when needed, whether during the planning, execution, or closure stages. By embedding lessons learned into the workflow, the application makes it easier for employees to engage with past knowledge, improving both the efficiency and outcomes of the tender process. Real-time knowledge transfer is enhanced by linking documents from the tender phase to the execution phase, ensuring that no valuable information is lost during project transitions.

Facilitating structured document upload and retrieval

The GIS application will offer a streamlined process for uploading and categorizing project documents. This process will include fields for essential metadata such as project name, geographic location, project phase, and document type. Once uploaded, these documents will be structured within the platform, allowing users to filter and search through a well-organized repository. The integration of this functionality ensures that project teams can access and contribute knowledge efficiently, reducing redundancy and improving overall knowledge management.

Prototype for Knowledge Sharing application

a prototype website was developed to function as an application for locating and uploading project knowledge documents. This platform includes a GIS-based portal where users can filter

projects by location, type, and other criteria, making it easier to locate relevant documents. Additionally, the site allows users to upload files directly, contributing to a centralized knowledge repository. Metadata linked to geographical coordinates is incorporated to display how location-based data could be managed within a DMS, providing users with contextual location-based insights. This tool is designed to facilitate real-time access to lessons learned, ensuring that critical insights are easily available to all team members. A detailed layout of the tool, including metadata integration and the geographical display within a DMS framework, can be found in Appendix H

8. Take aways

Chapter 8 provides a summary of the key findings and their connections. Section 8.1 focuses on lessons learned strategies, outlining strategies to improve the lessons-learned process based on the analysis. In 8.2, suggestions for further research are presented to expand and deepen the current findings. Section 8.3 offers a reflection on the past seven months, highlighting the learning experiences and personal growth.

8.1 Strategies for lessons learned

Table 19 outlines the enabling and limiting factors related to the lessons-learned process, accompanied by the corresponding practical measures. Additionally, Figure 45 presents a roadmap that a company can utilize to assess which factors warrant higher priority, based on the prevailing circumstances and the specific needs of departments or teams. This structured approach allows for targeted decision-making, ensuring that the most impactful actions are prioritized for optimal outcomes.

Table 19: Measures for lessons learned

Root cause	Lessons learned factors from theory	En.%	Lim.%	Tot%
+ Prioritization + Management enforcement +Uniform practices. - No management enforcement	Top-Down Support for Prioritizing Organizational learning	21%	3%	12%
Measures • Ensure that top management actively commits to prioritizing lessons learned by embedding this into the company's strategic goals. • Introduce a system where management is responsible for ensuring lessons learned are captured and integrated • Ensure that management is held accountable by embedding lessons learned responsibilities into their leadership roles.				
+ Consistent approach + Formalized approach - No formal system	Formalized processes for capturing and applying lessons	16%	6%	11%
Measures • Develop and implement a formal workflow that details the steps and responsibilities for capturing, reviewing, and integrating lessons learned into future projects. • Establish formal guidelines that dictate how lessons learned should be captured, reviewed, and applied across all projects. And who is responsible				
+ Open Communication + Easy request - Underdeveloped database	Use of digital platforms for knowledge sharing	14%	6%	10%
Measures • Promote the use of existing or newly introduced digital collaboration tools to encourage real-time, open communication.				

• Address the underdeveloped database by investing in a centralized, well-structured digital repository for lessons learned.				
+ Stimulation + Recognition - No initiative	Motivation and Incentives to Encourage Participation in Lessons	9%	9%	9%
Measure: • Promote a culture where active participation in lessons learned is a routine part of the project lifecycle. • Introduce a formal recognition program that highlights employees or teams who actively participate in lessons learned. • Let employees know when a report of theirs is used during other projects. • Leaders and project managers should lead by example, initiating lessons learned sessions at key project milestones and encouraging their teams to contribute.				
+ Active learning - Lack of process - No time	E-Learning modules to train employees on organizational learning	6%	12%	9%
Measure: • E-Learning modules can be designed to fit into employees' schedules, ensuring that learning happens progressively and continuously, rather than as one-off training sessions. • This process should be clearly defined within the organization's workflows and integrated into both the project lifecycle and employee training modules.				
+ Structured discussions - Informal communication	Encouraging Bottom-Up Communication to Capture Insights	3%	-	2%
Measure: • During structured discussions, team members can systematically review what went well, what didn't, and what lessons can be applied to future projects.				
+ Trust	Psychological Safety to Encourage Open Sharing of Insights	6%	-	3%
Measures: • Encourage leadership to create an environment where employees feel safe to share both successes and failures without fear of blame. • Foster enthusiasm by recognizing and celebrating employees who actively contribute their experiences, motivating others to be more open and engaged in sharing their insights with colleagues.				
+ Actionable outcomes - Inconsistent implementation	Monitoring and Adjustments to Refine Lessons Learned Processes	3%	6%	5%
Measures: • Each lesson should be linked to specific actions, and these actions should be monitored to assess their effectiveness. By ensuring that lessons are actionable and measurable • .Regular feedback loops and performance reviews can help identify gaps in implementation and provide teams with opportunities to make necessary adjustments				
+ Decentralized department storage - No centralized system - Lack of context	Searchability and Accessibility of Lessons Learned	6%	12%	9%
Measures: • Enhance the centralized knowledge system's functionality and user-friendliness to meet departmental needs.				

• Include project context, challenges, outcomes, and document owner contact details with each lesson captured.				
+ Need for context - No standardized documentation - Informal communication	Effective Documentation Tools for Capturing Lessons Learned	6%	22%	14%
Measures: • Ensure that all lessons learned are captured with detailed contextual information, including project background, challenges, and resolutions. • Develop standardized templates for documenting lessons learned to ensure that the format is consistent across all projects and departments.				
+ Process overview + Engagement into practices - Fragmentation Measures: • Create checkpoints during key phases (e.g., planning, execution, and post-project reviews) where teams actively reflect on previous lessons and document new insights. This systematic approach ensures that lessons learned are not just stored but actively applied throughout the lifecycle of each tender. • Ensure that a predetermined centralized database is used for storing and accessing lessons learned. • Clearly assign responsibility for ownership and maintenance. This ensures that lessons learned are stored consistently, easily searchable, and accessible across departments, preventing silos and enhancing the application of insights throughout the tender lifecycle.	Integration of Lessons Learned into the Tender Lifecycle	6%	22%	14%

This section outnes strategies developed based on the identified root causes, focusing on how to address them effectively. It includes a detailed discussion of lessons-learned strategies at both the tender and organizational levels, offering practical solutions to improve knowledge sharing and the application of insights across projects.

8.1.1 Quick wins on tender level

This subsection discusses the quick wins that can be gained at the tender level. By repeating these actions consistently, teams can quickly enhance knowledge sharing.

1. Use of digital knowledge sharing
   - Promote the use of existing or newly introduced digital collaboration tools to encourage real-time, open communication.
   - Address the underdeveloped database by investing in a centralized, well-structured digital repository for lessons learned.
2. Top-Down support for prioritizing organizational learning
   - Ensure that top management actively commits to prioritizing lessons learned by embedding this into the company's strategic goals.
   - Introduce a system where management is responsible for ensuring lessons learned are captured and integrated
   - Ensure that management is held accountable by embedding lessons learned responsibilities into their leadership roles.
3. Searchability and accessibility of lessons learned

- Enhance the centralized knowledge system's functionality and user-friendliness to meet departmental needs.
- Include project context, challenges, outcomes, and document owner contact details with each lesson captured.

To promote effective data sharing at the tender level, it's crucial to start strong from the project kickoff. Tender managers should reference lessons or knowledge from past projects, encouraging the team to actively seek out relevant knowledge from the company's database. Clearly identifying where knowledge documents are stored and making the database accessible from the outset ensures everyone is aligned. Digital knowledge sharing is key, and real-time collaboration should be encouraged through the use of existing digital platforms. Highlighting the value of contributing and accessing these platforms will foster a culture where sharing knowledge digitally is both expected and appreciated. For example, at the beginning of a tender, a tender manager could bring in an expert to provide insights on potential errors or challenges that could arise, based on similar projects in the past. This proactive approach sets the stage for smoother project execution and stronger knowledge integration.

8.1.2 Long term strategy on organizational level

This subsection covers long-term strategies for sustainable knowledge sharing. It emphasizes building structured processes, integrating lessons learned into the tender lifecycle, and fostering continuous improvement.

1. Formalized processes for capturing and applying lessons
   - Develop and implement a formal workflow that details the steps and responsibilities for capturing, reviewing, and integrating lessons learned into future projects.
   - Establish formal guidelines that dictate how lessons learned should be captured, reviewed, and applied across all projects. And who is responsible
2. E-Learning modules to train employees on organizational learning
   - E-Learning modules can be designed to fit into employees' schedules, ensuring that learning happens progressively and continuously, rather than as one-off training sessions.
   - This process should be clearly defined within the organization's workflows and integrated into both the project lifecycle and employee training modules.
3. Integration of Lessons Learned into the Tender Lifecycle
   - Create checkpoints during key phases to reflect on past lessons and document new insights, ensuring their application in the tender lifecycle.
   - Assign ownership and maintenance to ensure lessons are consistently stored, searchable, and accessible, preventing silos and enhancing application across the tender lifecycle.
   - Ensure that a predetermined centralized database is used for storing and accessing lessons learned.

At the organizational level, long-term strategies focus on how knowledge is managed and applied after a tender is completed. To ensure that lessons learned are effectively utilized, it is essential to assign ownership of knowledge documents. A designated individual or team should be responsible for maintaining and updating these documents to keep them relevant and accessible. Without clear ownership, valuable lessons can be forgotten, limiting their impact on future projects. Ownership also helps prevent fragmentation of information, ensuring lessons are

available across departments. Additionally, creating checkpoints during key phases of projects allows teams to reflect on past lessons and document new insights, ensuring their continued application throughout the tender lifecycle. Regular training must also be provided to ensure responsible parties understand how to manage, update, and share this knowledge, fostering continuous improvement across the organization.

8.1.3 Organizational learning mindset on organizational level

This subsection will explain the activities that can be done to change mindsets of employees on the benefits of organizational learning.

1. Motivation and incentives to encourage participation in Lessons Learned
- Promote a culture where active participation in lessons learned is a routine part of the project lifecycle.
- Introduce a formal recognition program that highlights employees or teams who actively participate in lessons learned.
- Let employees know when a report of theirs is used during other projects.
- Leaders and project managers should lead by example, initiating lessons learned sessions at key project milestones and encouraging their teams to contribute.

2. Psychological safety to encourage open sharing of insights
- Encourage leadership to create an environment where employees feel safe to share both successes and failures without fear of blame.
- Foster enthusiasm by recognizing and celebrating employees who actively contribute their experiences, motivating others to be more open and engaged in sharing their insights with colleagues.

3. Encouraging Bottom-Up communication to capture insights
- During structured discussions, team members can systematically review what went well, what didn't, and what lessons can be applied to future projects.

At the organizational level, fostering a learning mindset ensures lessons learned are actively captured, shared, and applied. Currently, the mentality often focuses on avoiding or hiding mistakes, as people feel vulnerable acknowledging errors, which hampers knowledge sharing. To overcome this, motivation and incentives are key, promoting a culture where participation is routine and recognized, with leaders setting the example. Informing employees when their reports are used fosters ownership and encourages more openness. Psychological safety is crucial, creating an environment where sharing both successes and failures is normal, without fear of blame. This shift helps make learning from mistakes and successes a natural part of the organization. Bottom-up communication through structured discussions allows insights from all levels, ensuring continuous improvement and creating a learning organization where knowledge contributes to future success.

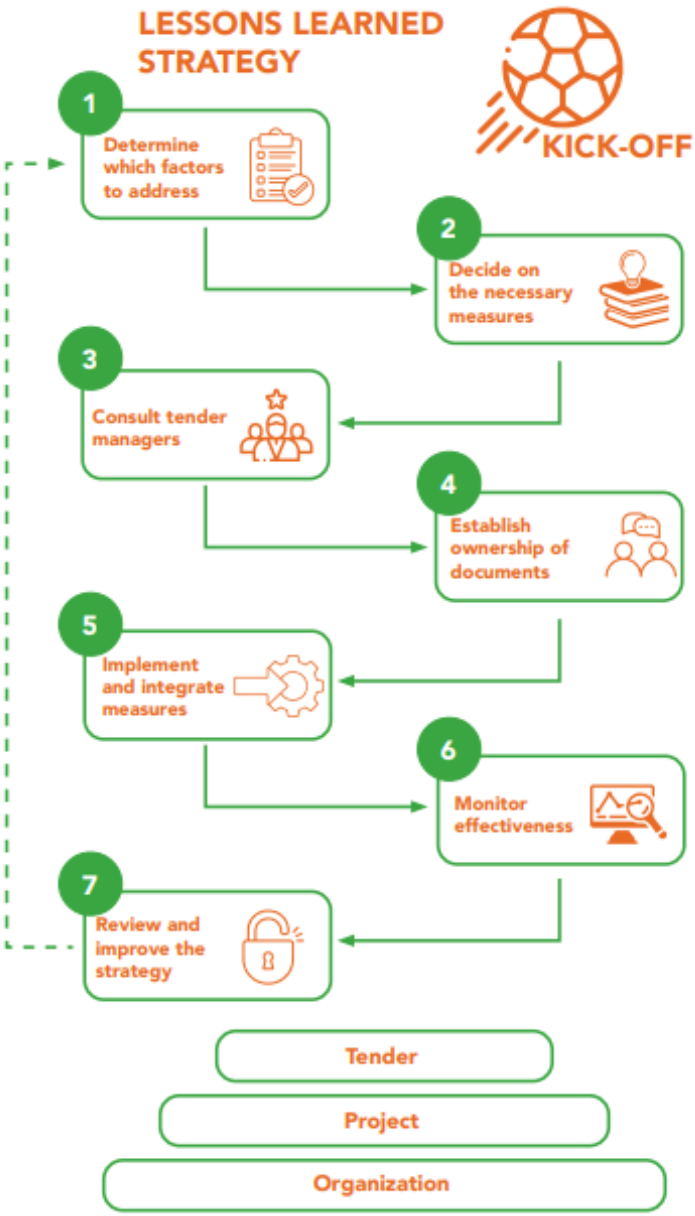


Figure 45: Road map

8.2 Strategies GIS-application

To improve the integration and utilization of lessons learned within tender processes, this research suggests the following key strategies, with a particular emphasis on the development and implementation of a GIS-based knowledge-sharing application.

1. **Implementation of a GIS-based Knowledge Application for data visualized data navigation**: The strategy for the GIS application focuses on creating a visual navigation interface that will transform how project locations and associated documents, such as lessons learned, and project data, are accessed within our organization. The planned GIS map interface will allow users to locate specific projects and instantly access relevant documents simply by clicking on the project's location. This functionality aims to make the system a

valuable tool for navigating and managing project knowledge, enhancing its usability beyond geographic information alone. To ensure efficient document access, the strategy includes integrating comprehensive metadata and filtering capabilities. Users will be able to search for documents by project phase, document type, department, and location. This structured approach is intended to eliminate the need to sift through unstructured data, offering a highly organized and visually accessible platform that enables team members to locate and retrieve information quickly and intuitively. The GIS application will be designed with ease of use as a priority, so that even those with minimal training can navigate the system effectively. By focusing on an intuitive interface, the goal is to encourage regular usage among employees, making critical project data readily accessible. The application will also provide geographic context for each document by visualizing project information on a map, helping users understand both where projects are located and how to access related information seamlessly.

2. **Upload function and document organization** : The strategy for designing the upload function within the GIS application centers on streamlining document organization and retrieval through the use of structured metadata. The design requires users to input key information fields, such as project name, geographic location, document type, involved departments, project phase, and other relevant details, when uploading documents. This metadata-driven approach aims to ensure that documents are systematically stored in a DMS and MBSE, making structured data quick and efficient to locate. To facilitate ease of use, the strategy includes the development of an intuitive, guided upload form that walks users through the metadata entry process step-by-step. By requiring essential details such as project phase and geographic location, users contribute to both the future accessibility and relevance of stored documents. This structured approach to data storage is intended to provide immediate context for each document, visually linking project data and knowledge to specific locations on the GIS map. This design strategy seeks to balance structured data management with user-friendliness, ensuring that documents are consistently organized and easy to retrieve. The result is an efficient system that enhances knowledge management across the organization, allowing employees to filter and access relevant information with minimal effort and maximum context.
3. **Optimized Data flow and synchronization:** The strategy for synchronizing MBSE, DMS, and GIS focuses on enhancing data and document management by leveraging the unique capabilities of each platform. In this setup, the DMS acts as the central repository, where documents are stored with structured metadata that captures essential relationships, such as author, location, and project information. The MBSE is designed to inherit this folder structure and metadata from the DMS, thereby preserving critical project relationships while allowing GIS to manage the visual representation of project data.
    a. **Linking Geographic Locations to Documents**: Once the tender phase is complete, structured project data from the DMS, can be associated with specific geographic locations within GIS. This approach creates a direct, intuitive connection between project data and its real-world location, allowing users to access relevant project information based on geographic context.
    b. **Benefit**: This integrated data flow between MBSE, DMS, and GIS offers a cohesive solution that combines data and document management with geographic context. The resulting system enables location-based access to documents, making it easier for users to interact with data that is both contextually rich and geographically grounded.

4. **Scalability and flexibility**: To ensure the GIS application's long-term relevance and adaptability, it should be designed with scalability and flexibility in mind. A future-oriented structure will enable the organization to add new document types and expand datasets as needed, supporting growth and evolving requirements. Additionally, the application should maintain flexibility for potential integration with advanced technologies, such as AI and predictive analytics, allowing it to support more complex decision-making processes like risk management in the future. This scalable and flexible setup will ensure the GIS application remains an invaluable tool, capable of evolving alongside the organization's needs and technological advancements, facilitating both current functionality and future growth.
5. **Operational Improvements**: To ensure seamless data transfer and continuity from the tender to the project phase, the GIS application should be designed to retain and make accessible all critical information gathered during the tender. By implementing a system that allows data from the tender phase to remain up-to-date and accessible throughout project execution, essential insights and project knowledge are preserved and remain readily available. This minimizes data loss at critical transition points, ensuring that valuable lessons are actively applied during the project phase. In addition, the GIS application should provide a visually intuitive interface that connects project locations directly to related documents. This visual navigation enables project teams to quickly retrieve relevant information, such as lessons learned or project-specific documents, without unnecessary searching. By organizing and linking documents to specific locations, the application will make project knowledge directly accessible, facilitating streamlined day-to-day operations and supporting informed decision-making. This approach reduces inefficiencies, prevents redundant work, and equips teams with necessary project insights at all stages. By actively bridging the gap between tender and execution phases and enhancing document accessibility, the GIS application becomes an essential tool in ensuring continuity and optimizing workflows.
6. **Ownership and Accountability:** To ensure the GIS application remains a reliable and valuable knowledge-sharing platform, a structured approach to document ownership and accountability is essential. First, specific team members or departments should be assigned responsibility for maintaining and updating particular documents. This assignment will help maintain data quality and ensure that knowledge remains current and relevant across project stages. In addition to ownership, setting user access and permission guidelines will standardize document handling and help prevent unauthorized access or changes. By implementing clear access rights, only designated users can interact with specific document types, ensuring adherence to data integrity standards. Assigning document ownership not only supports the upkeep of information but also encourages a culture of responsibility. When users are accountable for the accuracy and relevance of documents, they are more likely to engage actively in keeping knowledge up-to-date and shared effectively within the organization. This structured approach to ownership and access enhances the GIS application's role as a dynamic and dependable knowledge platform, fostering a shared commitment to data quality and continuous improvement.
7. **Training and Incentives for User Adoption:** To ensure effective use of the GIS application, a structured training program will be essential to help users become proficient with the system and its workflows. These sessions will cover key functionalities such as metadata entry, filter application, and document navigation, empowering users to integrate the GIS application seamlessly into their daily work. Additionally, targeted communication campaigns will raise awareness of the application's benefits, ensuring that all team members

involved in tender processes understand its advantages and practical applications. An incentive system can further support this integration by rewarding consistent use. By linking engagement with the application to performance metrics, such as recognizing departments that contribute high-value lessons learned, the organization can foster a culture where knowledge sharing becomes routine. This combined approach of training and incentives will not only encourage active participation but also ensure that the GIS application becomes a central, user-friendly tool for improving knowledge sharing across projects.

To conclude, the proposed GIS application design not only aims to enhance the systematic management of lessons learned but also prioritizes usability and relevance across all organizational levels. This strategy emphasizes structured metadata, intuitive visual navigation, and integration with existing systems, ensuring seamless access to project insights. By linking project documents to geographical locations and facilitating real-time data transfer between tender and project phases, the application provides immediate context and accessibility for users engaged in various project stages. Importantly, targeted training and communication initiatives will ensure that all team members are aware of the application's capabilities, encouraging its use as a routine tool within tender processes. As the organization grows, this scalable and adaptable tool can expand alongside it, supporting the broader goals of continuous learning, collaboration, and informed decision-making across the company.

8.3 Further research

In this section, I discuss areas that require further research. Due to the scope of this thesis, certain aspects could not be explored in depth, leaving several elements that warrant additional investigation. Further research in these areas could provide valuable insights into organizational learning, specifically within the context of knowledge sharing and lessons learned. These topics offer opportunities for future students to build on this study and expand understanding in this field.

- **Lessons learned beyond the tender process:** While this study focuses on the tender process, exploring knowledge-sharing strategies at the broader project level could yield valuable insights. Project teams operate in diverse environments with varying timelines and challenges, and understanding how lessons learned can be applied in these contexts is essential. Further research could uncover how knowledge sharing can be optimized beyond tender-specific scenarios, contributing to more holistic organizational learning.
- **Exploring incentive structures:** Incentive structures are a critical factor in encouraging participation in lessons learned, but the most effective strategies remain unclear. Further research could examine different types of incentives, both financial and non-financial, and their impact on motivating employees to contribute to knowledge-sharing initiatives. Understanding which incentives work best can help organizations build stronger, more active learning cultures.
- **Knowledge sharing in hierarchical organizations:** Hierarchical structures often create barriers to open communication and knowledge sharing, with employees sometimes reluctant to share insights due to power dynamics or fear of repercussions. Investigating how to foster a culture of open knowledge sharing within hierarchical organizations would be

valuable. Research into how incentives, leadership, and structured communication can break down these barriers could help make lessons learned processes more inclusive and effective.

- **Real-time learning tools: The future of knowledge capture:** Real-time learning tools present a significant opportunity to capture insights as they occur, rather than waiting until the end of a project. This could enhance the relevance and applicability of lessons learned. However, more research is needed to understand how these tools can be effectively integrated into day-to-day workflows and how they impact knowledge retention. Developing real-time learning tools tailored to specific organizational needs could revolutionize how knowledge is captured and applied.
- **Validation system:** Ensuring that lessons learned are accurate and applicable is crucial for effective knowledge sharing. A formal validation system could improve the reliability of shared insights, ensuring that only relevant and useful knowledge is circulated. Further research could explore how to design a validation system that balances thoroughness with efficiency, preventing bottlenecks while maintaining the quality of knowledge shared across projects.
- **Ownership of knowledge documents:** Ownership of knowledge documents is essential to maintaining and updating lessons learned, ensuring they remain relevant over time. However, the question of who should take ownership, whether individuals, teams, or departments, requires further exploration. Research into the impact of assigning ownership on the effectiveness of knowledge-sharing systems could provide insights into creating sustainable, long-term practices for maintaining lessons learned.
- **Standardization of documentation practices:** Inconsistent documentation can limit the effectiveness of knowledge sharing. By standardizing the way lessons are captured and shared, organizations can ensure that insights are easily transferable and accessible across teams. Further research could explore how standardization of documentation practices impacts knowledge-sharing efficiency and whether it leads to greater adoption and application of lessons learned in different departments.
- **Systems integration:** For future research, investigate the most effective methods for integrating a DMS, MSBE and GIS. This exploration could provide valuable insights into the technical and operational synergies between these systems, offering a framework that enhances data coherence, accessibility, and contextualization across project phases. Such research could also address potential challenges in metadata standardization, system compatibility, and data flow optimization, ultimately contributing to more streamlined and efficient knowledge-sharing practices.
- **Implementation of GIS-Based Knowledge application:** While this thesis has proposed a GIS-based knowledge application, the actual implementation and integration of this system into existing workflows within the organization is still hypothetical. Further research could explore how to practically implement such a portal, measure its effectiveness, and assess user adoption and satisfaction within a real-world context. Understanding the technical and cultural challenges involved in integrating the GIS portal into existing knowledge management systems like a DMS and MBSE would provide valuable insights for future deployment.

8.4 Reflection

In this reflection, the outcomes of the thesis are analyzed in two parts. Section 8.3.1 focuses on the product, discussing the overall contribution of the research, the strengths and weaknesses of the final thesis, and its alignment with the initial objectives. Section 8.3.2 delves into the process, reflecting on the challenges encountered during the research and the steps taken to overcome them. This section also highlights the personal growth and learning outcomes from conducting the research.

8.3.1 Product

The aim of my thesis was to explore how lessons learned and knowledge sharing function within tender processes, identifying the root causes that hinder effective exchange and organizational learning. My research provides new insights into the structural and cultural barriers that limit these processes, and it proposes practical solutions, including a centralized knowledge-sharing tool to improve accessibility and engagement. Overall, the thesis contributes valuable knowledge to the field of organizational learning, particularly in the construction industry.
I believe I largely met the objectives I set at the start. The root causes of ineffective knowledge sharing, such as inconsistent use of tools and lack of engagement, were clearly identified, and the findings offer practical recommendations for improvement. While the results align with my initial expectations, the scope of the research limited some areas, particularly around fully exploring human and cultural barriers to knowledge sharing.
The strengths of the thesis lie in its comprehensive research approach, combining a SNA and a RCA, and qualitative and quantitative methods. The creation of a knowledge-sharing tool prototype also adds a practical dimension. However, weaknesses include limitations in data scope and challenges in obtaining consistent responses during interviews. More depth could have been added to certain areas, particularly regarding cultural resistance to knowledge sharing. Overall, the research provides a solid foundation for further exploration and practical application.

8.3.2 Process

At the beginning of my research, I faced a major challenge that led to a significant shift in focus. Originally, the research was centered on the use of ontologies in tenders and how they could improve processes. However, during the initial kick-off, I realized I wasn't comfortable with the topic and didn't feel confident in pursuing it further. This led me to completely rethink the research direction, ultimately shifting the focus to lessons learned and knowledge sharing within tender processes. While this was a daunting adjustment, it proved to be a more fitting and engaging topic, aligning with my strengths and interests. This thesis process has been a significant period of personal growth. Through the challenges I faced, I discovered strengths in perseverance, adaptability, and problem-solving. Having to pivot my entire research direction early on was not easy, but it taught me the importance of flexibility in research. I also developed greater attention to detail, particularly when working with complex data sets and integrating feedback from various experts. These skills are invaluable and will guide me in future work, where I plan to apply them to problem-solving and project management in more dynamic environments.

In terms of future implications, this experience has shaped my approach to both research and professional projects. The lessons I've learned about the importance of adaptability, clear communication, and robust data analysis will be central to how I approach future complex systems or data-sharing initiatives. Moving forward, the strategy outlined in my thesis can be tested in real-world applications to see its effectiveness. Additionally, the implementation of the knowledge-sharing tool should be refined to ensure it aligns with existing systems, creating a cohesive and integrated platform for knowledge management within organizations. This further development would not only validate my research but also provide a practical foundation for improving lessons learned processes across future tenders.

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Appendix

Appendix A

1. Searchability and Accessibility
The accessibility and searchability of "lessons learned" are critical for their effective application within an organization. Williams (2008) and El-Diraby et al. (2005) emphasize that well-documented lessons only become valuable when they are easily accessible and searchable by those who need them. Koenig & Srikantaiah (2004) add that a clear structure and indexing in knowledge management systems ensure that these lessons can be retrieved at the right time, leading to improved decision-making and project outcomes.

2. Shared Learning Sessions
Shared learning sessions, as described by Kotnour (2000), play a vital role in fostering collective learning within organizations. Maya et al. (2005) and Duffield & Whitty (2015) support this by highlighting the importance of regular meetings where teams can share their experiences and insights. These sessions not only facilitate knowledge transfer but also enhance collaboration and openness between different departments and teams, leading to more effective application of "lessons learned."

3. Digital Platforms
Digital platforms such as SharePoint have become indispensable for effectively capturing and retrieving "lessons learned," as evidenced by the case study of the N346 project. McClory et al. (2017) and Tserng & Lin (2004) emphasize how these platforms help standardize documentation processes, thereby increasing the consistency and accessibility of knowledge resources. This contributes to improved knowledge management, enabling lessons from the past to be easily applied to future projects.

4. Mentorship and Coaching
Mentorship and coaching play a key role in effectively transferring "lessons learned" within organizations. Weber et al. (2000) and Carrillo et al. (2013) demonstrate that experienced employees, through coaching, can share valuable insights with less experienced colleagues, leading to enhanced knowledge transfer. De Long & Fahey (2000) add that mentorship not only contributes to individual development but also to embedding learned lessons in the organization’s culture.

5. Top-Down Support
Effective top-down support is essential for the success of systems aimed at capturing and sharing "lessons learned." Shokri-Ghasabeh & Chileshe (2014) highlight the importance of clear guidelines and management support to prevent fragmentation of the process. Davenport & Prusak (1998) and Milton (2020) further argue that leadership is not only responsible for establishing such systems but also for promoting a culture where knowledge sharing is valued and encouraged.

6. Bottom-up Communication
Open communication across different levels within an organization is vital for successfully capturing and implementing "lessons learned." Dave & Koskela (2009) and Drupsteen & Guldenmund (2014) stress the importance of formal processes that incorporate input from all organizational levels. Bresnen et al. (2022) and Mason & Pauleen (2003) add that when bottom-up communication is valued, it not only contributes to capturing valuable insights but also fosters a culture of collective learning that benefits the entire organization.

7. E-Learning Modules for Lessons Learned
E-learning modules are an effective means of training individuals in specific "lessons learned," enhancing their knowledge and skills for future projects. Fong & Yip (2006) emphasize how these modules, by integrating lessons from previous projects, can be tailored to improve personal skills. Weber et al. (2000) and Martínez-Rojas et al. (2016) support this by highlighting the importance of continuous training through digital means to optimize the application of learned lessons.

8. Formalized Processes
Formalized processes are essential for ensuring consistency and thoroughness in documenting and evaluating "lessons learned." Drupsteen & Guldenmund (2014) point out the necessity of standardized procedures to ensure that lessons are documented uniformly. Kerzner (2017) and Wiewiora & Murphy (2015) further emphasize that such formal processes contribute to creating a structured approach to knowledge management, which in turn leads to improved organizational performance.

9. Continuous Improvement Cycles
Integrating continuous improvement cycles into an organization’s processes is crucial for effectively applying "lessons learned." Duffield & Whitty (2015) and Williams (2008) emphasize that ongoing documentation and feedback loops are critical for organizational learning. Newell & Edelman (2008) add that a culture of continuous improvement not only enhances the application of learned lessons but also contributes to the overall efficiency and effectiveness of project management.

10. Data Analytics
Data analytics plays an increasingly important role in identifying patterns and trends in past projects, which can help synthesize and apply "lessons learned." Eken et al. (2020) and Firestone & McElroy (2012) emphasize how data analytics tools can translate large amounts of project data into actionable insights. Martínez-Rojas et al. (2016) add that these tools are essential for improving knowledge management by identifying recurring errors and best practices.

11. Learning-Oriented Culture
A culture focused on learning and continuous improvement is essential for the effectiveness of "lessons learned." Carrillo et al. (2013) and Duffield & Whitty (2015) highlight that a supportive, learning-oriented culture is crucial for the success of knowledge management initiatives. Naot et al. (2004) further add that such a culture encourages employees to actively participate in knowledge-sharing processes and to apply learned lessons in their daily work.

12. Integration into Project Lifecycle
Integrating "lessons learned" into every phase of the project lifecycle is critical for continuous improvement and achieving organizational goals. Abbas et al. (2021) and McClory et al. (2017) note that early identification and application of learned lessons can significantly improve overall project performance. Brouwer (2011) further emphasizes that integrating these lessons into the project lifecycle ensures that learning is an ongoing process, leading to better outcomes.

13. Involvement of Management
Involving management in the "lessons learned" process is critical for ensuring that insights are effectively integrated into strategic planning and decision-making. Fong & Yip (2006) highlight the importance of management participation, noting that it helps to align lessons learned with organizational goals. Shokri-Ghasabeh & Chileshe (2014) further emphasize that management's involvement ensures that the process is taken seriously and that the necessary resources are allocated. Le et al. (2017) add that when management is actively engaged, it fosters a culture where continuous learning is valued and integrated into the core business processes.

14. Effective Documentation Tools
The use of effective documentation tools is essential for capturing and sharing "lessons learned" within an organization. McClory et al. (2017) discuss how standardized documentation approaches contribute to improved knowledge management by ensuring that lessons are systematically recorded and easily retrievable. Milton (2020) supports this by highlighting the importance of using appropriate tools to maintain the integrity and accessibility of documented lessons. Wiewiora & Murphy (2015) add that effective documentation tools help prevent the loss of valuable insights and ensure that lessons are applied consistently across the organization.

15. Motivation and Incentives
Motivation and incentives at the individual level are crucial for encouraging active participation in the "lessons learned" process. Carrillo et al. (2004) and Kelly et al. (2017) argue that recognition, rewards, and opportunities for career advancement significantly enhance employee engagement in documenting and sharing lessons. Bresnen et al. (2022) further emphasize that when individuals are motivated by clear incentives, they are more likely to contribute valuable insights, which in turn strengthens the overall effectiveness of the lessons learned process. Levy (2018) also highlights the role of incentives in fostering a culture of continuous improvement and active learning.

16. Ongoing Training Programs
Ongoing training programs are vital for developing the skills necessary to effectively capture and apply "lessons learned" within an organization. Fong & Yip (2006) discuss the importance of continuous training in ensuring that employees remain competent in knowledge management practices. Rhodes & Dawson (2013) add that regular training helps to reinforce the importance of documenting and sharing lessons, thereby embedding these practices into the organizational culture. Kerzner (2017) further supports this by noting that ongoing training contributes to the long-term sustainability of knowledge management initiatives, ensuring that the organization continues to benefit from lessons learned over time.

17. Psychological Safety

Creating an environment of psychological safety is essential for encouraging employees to openly share their mistakes and the lessons they've learned. Rhodes & Dawson (2013) emphasize that when employees feel safe from judgment or reprisal, they are more likely to contribute valuable insights that can benefit the entire organization. Edmondson (2004) highlights the role of psychological safety in fostering a learning-oriented culture where mistakes are viewed as opportunities for growth rather than failures. Duffield & Whitty (2015) add that psychological safety is a key factor in promoting transparency and openness, which are crucial for the effective application of "lessons learned."

18. Interdepartmental Communication

Effective interdepartmental communication is vital for the successful implementation of "lessons learned" across different areas of an organization. Dave & Koskela (2009) point out that collaboration between departments helps to prevent the formation of silos and ensures that valuable insights are shared widely. Ayodele & Kajimo-Shakantu (2021) further emphasize the importance of cross-functional communication in enhancing the relevance and applicability of lessons learned. Milton (2020) adds that when departments communicate effectively, it creates a more cohesive learning environment, allowing the organization to leverage collective knowledge to improve overall performance.

19. Monitoring and Adjustments

Regular monitoring and adjustments are necessary to ensure that "lessons learned" are effectively integrated into future projects and continue to provide value. Drupsteen & Guldenmund (2014) discuss how ongoing evaluation of lessons learned helps to refine and adapt processes to changing circumstances. Levy (2018) supports this by highlighting the importance of continuous feedback loops that allow organizations to measure the impact of applied lessons and make necessary adjustments. Julian (2008) further adds that consistent monitoring ensures that lessons learned remain relevant and are applied in ways that contribute to organizational growth and success.

Appendix B

The purpose of the appendix is to gain insights into the gaps and deficiencies in the lessons learned processes and organizational learning within the tender process of Dutch construction companies. By examining communication barriers, the use of digital tools, and the organizational structures that influence knowledge sharing, the interviews aim to uncover the key factors that hinder effective knowledge transfer. To narrow the scope, the focus is placed on specific roles involved in the tender process and their direct experiences with lessons learned and communication practices. The emphasis is on how these individuals navigate challenges related to fragmented data and the integration of lessons into ongoing and future projects. The study is limited to Dutch construction companies and primarily investigates internal knowledge-sharing dynamics.

B1 Questions Interviews

Questions

1. **Experiences with Communication**: Can you describe how communication between different departments is managed during the tender process? Which key nodes (individuals or departments) are crucial for the flow of information?
2. **Digital Tools**: What specific digital communication technologies or software platforms have been introduced to improve the tender process? What are the benefits and challenges of these technologies?
3. **Barriers to Effective Communication**: What are the most common obstacles you encounter when it comes to communication between departments during the tender process?
4. **Impact of Organizational Structure**: To what extent does your company's organizational structure influence the efficiency of communication during the tender process? Are there specific departments or roles that are essential for overcoming communication barriers?
5. **Strategies for Improvement**: What strategies would you recommend to improve communication between departments during the tender process?
6. **Analysis of Change and Resistance**: Can you describe a situation where resistance to new communication technologies or processes posed a challenge? How was this dealt with within the project teams?
7. **Feedback Processes**: How is feedback on communication processes collected and integrated into future tender plans and strategies within your organization?
8. **Future of Digital Tools**: How do you see the future of digitalization in the tender process? Are there specific technologies or tools you would like to see implemented?

Question 1

Similarities:

1. **Focus on Project Structure and Planning:**
    - The BIM specialist, Planning Manager, Tender Manager, and Expert in Digital Transformation all emphasize the importance of good project structure and planning. Each of them highlights the necessity to clearly define and manage information, such as budgets and schedules, throughout the project.
    - The Planning Manager and Tender Manager mention their reliance on detailed meeting structures and communication platforms to enhance execution.

- The Tender Manager, Planning Manager, and Expert in Digital Transformation emphasize the importance of standardization in processes, whether in estimation, planning, or data exchange between projects.

Differences:

1. **Involvement and Specialization:**
   - The Tender Manager specifically discusses his role in managing complex commercial activities for large tenders.
   - The Planning Manager focuses on project meetings and obtaining workable files from the client.
   - The BIM Specialist talks about starting with a blank slate for each project, regardless of the tender phase's progress.
   - The Expert in Digital Transformation focuses on creating a unified system for project information that promotes efficient communication and integration across departments.
2. **Challenges and Solutions:**
   - The Tender Manager and Expert in Digital Transformation discuss the challenges of standardization across diverse projects and the need for flexibility to meet project-specific requirements.
   - The Planning Manager and BIM Specialist describe more technical aspects of project management, such as providing detailed project documentation and managing client expectations.

Conclusion: While all respondents recognize the importance of structured planning and communication, their approaches differ significantly depending on their specific roles and responsibilities within the projects. The emphasis lies on a combination of flexibility and standardization to meet both internal and client-specific requirements, illustrating how diversity in expertise and functions affects project execution.

Question 2

Similarities:

1. **Recognition of Benefits:**
   - All respondents acknowledge the benefits of digital communication technologies in improving efficiency, transparency, and collaboration within the tender process.
   - Technologies such as SharePoint and Relatics are mentioned by several respondents as important tools that enhance document management and communication between teams.
2. **Implementation Challenges:**
   - All four respondents highlight challenges in implementing new systems, particularly resistance to change and the need for training to increase user comfort with new technologies.

Differences:

1. **Specific Tools and Applications:**
   - The Tender Manager and Planning Manager mention more traditional project management tools like SharePoint, while the BIM Specialist emphasizes advanced platforms like Autodesk Construction Cloud for model management,

and the Expert in Digital Transformation focuses on implementing a general object-type library for standardization.
    - The BIM Specialist and Expert in Digital Transformation explore more advanced and customized digital solutions tailored to their project needs, while the Tender Manager and Planning Manager discuss more general and widely applicable tools.
2. **Future Vision and Strategy:**
    - The Planning Manager and Tender Manager seem more focused on the immediate benefits and practical implementation of technologies, while the BIM Specialist and Expert in Digital Transformation take a more strategic approach, with attention to the future direction of digitalization and its broader impact on the organization.

Conclusion: This analysis provides insight into how each respondent views the role of digital technologies within the tender process, ranging from direct operational improvements to long-term strategic integration.

Question 3

Similarities: All respondents emphasize the presence of communication barriers that affect efficiency during the tender process:

- Lack of direct communication is often mentioned, leading to delays and misunderstandings between departments.
- Resistance to change in communication technologies is a common theme, with older employees sometimes struggling to adopt new systems.

Differences: The specific obstacles mentioned by the different respondents provide insight into the various challenges within their respective roles:

- The Tender Manager mentions inconsistencies in the use of communication tools across departments, leading to inefficiency.
- The Planning Manager identifies the segmentation of communication channels as a major barrier, limiting the streamlining of the communication process.
- The BIM Specialist talks about information silos and the complexity of projects that hinder effective communication, especially for teams not physically together.
- The Expert in Digital Transformation points to the challenges of different interpretations of shared data between departments with varying technical backgrounds, leading to inconsistencies in project execution.

Conclusion: The core issue lies in the integration and uniformity of communication processes across departments, with technological solutions such as standardized communication platforms and targeted training being crucial to overcoming these barriers. Each respondent highlights specific aspects of these communication issues from their role, demonstrating that solutions need to be tailored to the specific needs and cultures within the company's departments.

Question 4

Similarities:

1. **Importance of Clearly Defined Roles:**
    - All respondents emphasize the importance of clearly defined roles within the tender process to facilitate communication.
    - Key roles such as Integrated Design Manager and Project Manager are repeatedly mentioned as essential for streamlining communication.
2. **Need for Regular Coordination Meetings:**
    - Regular meetings between key figures in the process are seen as crucial by both the BIM Specialist and Expert in Digital Transformation to keep communication efficient.

Differences:

1. **Perception of Organizational Influence:**
    - The Tender Manager and Planning Manager note that the organizational structure can sometimes be restrictive due to the reliance on key figures, which can create bottlenecks.
    - The BIM Specialist views the structure more as a facilitator, depending on how well the organization is aligned with the process.
    - The Expert in Digital Transformation focuses on the challenges arising from diverse technical backgrounds and the need for different types of communication.
2. **Specific Departments and Roles:**
    - The BIM Specialist highlights the role of the Integrated Design Manager as crucial for bridging communication barriers.
    - The Expert in Digital Transformation points out the diversity in communication needs between technical teams and management teams, making communication more complex.
3. **Training and Education:**
    - The BIM Specialist emphasizes the importance of training and education for using digital tools and communication techniques to ensure competency in the process.
    - The Expert in Digital Transformation underscores that a lack of uniform communication standards and jargon creates communication barriers, necessitating tailored training needs.

Question 5

Similarities:

1. **Adoption of New Technologies:**
    - All respondents emphasize the importance of introducing new digital tools and platforms to improve communication. Tools such as SharePoint and Relatics are specifically mentioned as helping streamline processes and improve efficiency.
2. **Training and Education:**
    - Several respondents mention that adequate training and education are essential to making employees comfortable with new technologies, contributing to more effective communication.
3. **Regular Evaluations and Feedback:**

- Collecting feedback and regularly evaluating communication processes are considered crucial for continuously improving communication.

Differences:

1. **Specific Implementation Strategies:**
   - The Tender Manager and Planning Manager emphasize the need for structured communication channels and direct interactions through regular meetings and integral teams.
   - The BIM Specialist focuses more on the role of the Integrated Design Manager as a crucial link for bridging communication barriers.
   - The Expert in Digital Transformation discusses the implementation of an object-type library to standardize and make information accessible to different teams, which was a point of contention among various stakeholders.
2. **Focus on Organizational Structure:**
   - The BIM Specialist and Expert in Digital Transformation mention that the organizational structure needs to be adjusted to overcome communication barriers, while the Tender Manager and Planning Manager place more emphasis on technological solutions and team dynamics.
3. **Approach to Resistance to Change:**
   - The Expert in Digital Transformation and BIM Specialist discuss the importance of managing resistance to new processes and technologies, with the Expert focusing specifically on training staff to support these changes.

Question 6

Similarities:

1. **Acceptance and Resistance:**
   - All respondents mention that resistance to new technologies often stems from uncertainty and comfort with old methods.
   - The BIM Specialist and Expert in Digital Transformation describe situations where older employees were more resistant due to uncertainty about new technologies like BIM and standardized project information.
   - The Planning Manager and Tender Manager note that initial discomfort in learning new technologies is a common obstacle.
2. **Management and Training:**
   - All respondents acknowledge the importance of education and guidance in overcoming resistance. Training and open communication are seen as essential for promoting acceptance.
   - The Tender Manager, Planning Manager, and BIM Specialist stress the importance of training to clarify the benefits of new technologies.
   - The Expert in Digital Transformation specifically mentions targeted communication and training strategies to promote acceptance.

Differences:

1. **Generational Differences:**
   - The way generational differences are experienced and addressed varies.
   - The BIM Specialist and Expert in Digital Transformation describe clearer challenges with older employees adapting, while the Tender Manager and Planning Manager focus more on general resistance without specifying demographic characteristics.

2. **Technological Implementation:**
    - The nature of the technologies and the specific resistances experienced also differ.
    - The Planning Manager and Tender Manager seem more focused on communication and information management systems like SharePoint, while the BIM Specialist and Expert in Digital Transformation discuss BIM and standardized data libraries, reflecting different levels of technological integration within their organizations.

Question 7

Similarities:

1. **Systematic Feedback Collection:**
    - All respondents emphasize the importance of systematic feedback collection, with feedback gathered through formal evaluations after each tender process (Tender Manager, Planning Manager, BIM Specialist) and through organized teams addressing specific challenges (Planning Manager).
2. **Integration of Feedback:**
    - Feedback is integrated into the planning of future projects, with processes and communication strategies adjusted based on collected feedback (Tender Manager, Planning Manager, BIM Specialist, Expert in Digital Transformation).
3. **Role of Leadership:**
    - The importance of leadership involvement in the feedback process is acknowledged, with leaders taking an active role in recognizing and responding to feedback to drive improvements (Planning Manager, Expert in Digital Transformation).

Differences:

1. **Focus on Training and Education:**
    - The BIM Specialist and Expert in Digital Transformation strongly emphasize the need for training and education to ensure that all participants can use the new systems effectively and understand the benefits of changes.
2. **Technological Support:**
    - The BIM Specialist discusses the use of advanced digital platforms to improve the efficiency of communication processes, while the Expert in Digital Transformation focuses on creating robust training and support programs that parallel technological rollouts.
3. **Feedback Loops and Open Communication:**
    - The Planning Manager highlights the importance of creating and maintaining feedback loops and keeping communication channels open within the organization, which is less explicitly mentioned by the others.

Question 8

Similarities:

1. **Increasing Integration of Digitalization:**
    - The Tender Manager, Planning Manager, BIM Specialist, and Expert in Digital Transformation all expect digitalization to continue growing within the tender

process. They agree that technologies are being employed to improve efficiency and accuracy.

2. **Importance of Training and Development:**
    - There is a general consensus among the respondents about the need for continuous training and professional development to equip employees with the skills needed to use new technologies effectively.

Differences:

1. **Specific Technologies and Tools:**
    - The Tender Manager and Planning Manager emphasize the potential need for advanced data analysis tools and collaborative platforms that enable team members to collaborate more seamlessly, regardless of their physical location.
    - The BIM Specialist and Expert in Digital Transformation place more emphasis on the integration of AI and automation, particularly in data analysis and decision-making processes.
2. **Balance Between Technology and Human Interaction:**
    - Respondents like the BIM Specialist emphasize that, despite technological advancements, human creativity, intuition, and decision-making remain essential components that cannot be fully replaced by machines.
    - The Planning Manager and Expert in Digital Transformation may highlight the importance of balancing the use of technology with maintaining human interaction within the team and with clients.

Conclusion: Opinions on the future of digitalization in the tender process show both similarities in the expectation of increasing digitalization and differences in the specific technologies respondents hope to see, as well as the role of human interaction in the process. All respondents value both technological integration and the irreplaceable value of human skills, suggesting that a careful balance is needed to maximize the benefits of both. They are cautiously optimistic and advocate for a measured and thoughtful implementation of new technologies, with adequate attention given to training and maintaining human interaction within the tender process.

Appendix C

Introduction

Thank you for taking approximately 10 minutes to participate in this survey. Your input is

invaluable and directly supports my thesis on the impact of data sharing within BAM on risk awareness during the tender phase.

This survey aims to gain insight into data-sharing behaviors at BAM, creating a robust dataset that enables analyses of data usage and interaction within the company. Upon completion of this study, participants will have the opportunity to receive personal feedback on their role within the data-sharing network.

Survey Objectives
This research utilizes social network analysis to map and investigate data-sharing networks within your organization. The goal is to identify patterns of data sharing among employees and examine how these behaviors influence risk awareness within BAM. A select group of participants may also be invited for follow-up interviews to explore the qualitative aspects of the study in greater detail.

Your Consent
By participating, you will be asked to share information about colleagues with whom you regularly exchange data, including names and other relevant details. Please note that all personal identification data will be anonymized with unique codes once the data collection phase is complete.

Best regards,

Job Rijpma

Introductie

Bedankt dat u ongeveer 10 minuten uittrekt om deel te nemen aan deze enquête. Uw input is van onschatbare waarde en ondersteunt direct mijn scriptie over de impact van gegevensdeling binnen BAM op risicobewustzijn tijdens de aanbestedingsfase.
Deze enquête is bedoeld om inzicht te krijgen in de gedragingen rondom gegevensdeling bij BAM, waardoor een robuuste dataset wordt gecreëerd die analyses van gegevensgebruik en interactie binnen het bedrijf mogelijk maakt. Na afronding van deze studie hebben deelnemers de mogelijkheid om persoonlijke feedback te ontvangen over hun rol binnen het netwerk van gegevensdeling.

Doelstellingen van de enquête

Dit onderzoek maakt gebruik van sociale netwerkanalyse om de netwerken van gegevensdeling binnen uw organisatie in kaart te brengen en te onderzoeken. Het doel is om patronen van gegevensdeling tussen medewerkers te identificeren en te onderzoeken hoe deze gedragingen het risicobewustzijn binnen BAM beïnvloeden. Een selecte groep deelnemers kan ook worden uitgenodigd voor vervolginterviews om dieper in te gaan op de kwalitatieve aspecten van de studie.

Uw toestemming

Door deel te nemen, wordt u gevraagd informatie te delen over collega's met wie u regelmatig gegevens uitwisselt, inclusief namen en andere relevante gegevens. Let op, alle persoonlijke identificatiegegevens worden geanonimiseerd met unieke codes zodra de fase van gegevensverzameling is afgerond.

Met vriendelijke groeten
Job Rijpma

Q1

Skip to

End of Survey if Ik kies ervoor om NIET deel... Is Selected

Selecteer uw antwoord

- Ik kies ervoor om deel te nemen en geef toestemming aan de onderzoeker om mijn antwoorden te analyseren
- Ik kies ervoor om NIET deel te nemen aan dit onderzoek

Page Break

Q2

Wat is uw naam

Q3

Bij welke Tender was u het meest betrokken?

- Prinses Alexiaviaduct
- N346
- N211 Wippolderlaan

Q4

Wat was uw rol in deze Tender

Q5

Onder welke categorie valt volgens u uw rol tijdens deze tender

- Project / Design Management
- Project assistant
- Engineering
- Tender management
- Contracting
- Modeling / BIM
- Costing
- Planning
- Construction management
- Systems engineer
- GIS
- Duurzaamheid
- Anders

Q2

Identificeer de mensen met wie u het meeste contact heeft gehad binnen BAM als het gaat om het delen van gegevens die relevant zijn voor de ${q://QID19/ChoiceGroup/SelectedChoices} aanbesteding. Dit kunnen mensen binnen en buiten uw aanbestedingsteam zijn. Deel minimaal VIJF personen, maar bij voorkeur zoveel mogelijk tot TIEN.

	Volledige naam	Rol	Afdeling	Business unit/ Bedrijf
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Q3

Geef voor elke door u geïdentificeerde persoon aan hoe vaak u gegevens hebt gedeeld met die persoon, met u als gegevens ONTVANGER van de geïdentificeerde persoon.

	Af en Toe	Elke maand	Elke week	Meerdere keren per week
${q://QID2/ChoiceTextEntryValue/1/1}	○	○	○	○
${q://QID2/ChoiceTextEntryValue/2/1}	○	○	○	○
${q://QID2/ChoiceTextEntryValue/3/1}	○	○	○	○
${q://QID2/ChoiceTextEntryValue/4/1}	○	○	○	○
${q://QID2/ChoiceTextEntryValue/5/1}	○	○	○	○
${q://QID2/ChoiceTextEntryValue/6/1}	○	○	○	○
${q://QID2/ChoiceTextEntryValue/7/1}	○	○	○	○
${q://QID2/ChoiceTextEntryValue/8/1}	○	○	○	○
${q://QID2/ChoiceTextEntryValue/9/1}	○	○	○	○
${q://QID2/ChoiceTextEntryValue/10/1}	○	○	○	○

Q4

Geef voor elke door u geïdentificeerde persoon aan hoe vaak u gegevens hebt gedeeld met die persoon, met u als VERZENDER van de gegevens van de geïdentificeerde persoon.

	Af en Toe	Elke maand	Elke week	Meerdere keren per week
${q://QID2/ChoiceTextEntryValue/1/1}	○	○	○	○
${q://QID2/ChoiceTextEntryValue/2/1}	○	○	○	○
${q://QID2/ChoiceTextEntryValue/3/1}	○	○	○	○
${q://QID2/ChoiceTextEntryValue/4/1}	○	○	○	○
${q://QID2/ChoiceTextEntryValue/5/1}	○	○	○	○
${q://QID2/ChoiceTextEntryValue/6/1}	○	○	○	○
${q://QID2/ChoiceTextEntryValue/7/1}	○	○	○	○
${q://QID2/ChoiceTextEntryValue/8/1}	○	○	○	○
${q://QID2/ChoiceTextEntryValue/9/1}	○	○	○	○
${q://QID2/ChoiceTextEntryValue/10/1}	○	○	○	○

Q5

Op wie vertrouwde u het vaakst als u snel gegevens nodig had?

Page Break

Q6

Geef voor elke persoon die u heeft geïdentificeerd de waarde aan van de gegevens die u ONTVANGT van hen bij het helpen bij het uitvoeren van uw werk (dus u als gegevens ONTVANGER)

	Laag	Gemiddeld	Hoog	Heel hoog
${q://QID2/ChoiceTextEntryValue/1/1}	○	○	○	○
${q://QID2/ChoiceTextEntryValue/2/1}	○	○	○	○
${q://QID2/ChoiceTextEntryValue/3/1}	○	○	○	○
${q://QID2/ChoiceTextEntryValue/4/1}	○	○	○	○
${q://QID2/ChoiceTextEntryValue/5/1}	○	○	○	○
${q://QID2/ChoiceTextEntryValue/6/1}	○	○	○	○
${q://QID2/ChoiceTextEntryValue/7/1}	○	○	○	○
${q://QID2/ChoiceTextEntryValue/8/1}	○	○	○	○
${q://QID2/ChoiceTextEntryValue/9/1}	○	○	○	○
${q://QID2/ChoiceTextEntryValue/10/1}	○	○	○	○

Q8

Tot wie wendde u zich het vaakst voordat u een belangrijke beslissing nam voor uw werk?

Q9

Geef voor elke persoon die u heeft geïdentificeerd de waarde aan van de gegevens die u ONTVANGT van hen bij het helpen bij het uitvoeren van uw werk (dus u als gegevens ONTVANGER)

	Chat applications (MS teams)	Email	BIM/ACC	Online collaboration platform (Sharepoint)	Phone	Face-to-Face	Video/Virtual calls
${q://QID2/ChoiceTextEntryValue/1/1}	☐	☐	☐	☐	☐	☐	☐
${q://QID2/ChoiceTextEntryValue/2/1}	☐	☐	☐	☐	☐	☐	☐
${q://QID2/ChoiceTextEntryValue/3/1}	☐	☐	☐	☐	☐	☐	☐
${q://QID2/ChoiceTextEntryValue/4/1}	☐	☐	☐	☐	☐	☐	☐
${q://QID2/ChoiceTextEntryValue/5/1}	☐	☐	☐	☐	☐	☐	☐
${q://QID2/ChoiceTextEntryValue/6/1}	☐	☐	☐	☐	☐	☐	☐
${q://QID2/ChoiceTextEntryValue/7/1}	☐	☐	☐	☐	☐	☐	☐
${q://QID2/ChoiceTextEntryValue/8/1}	☐	☐	☐	☐	☐	☐	☐
${q://QID2/ChoiceTextEntryValue/9/1}	☐	☐	☐	☐	☐	☐	☐
${q://QID2/ChoiceTextEntryValue/10/1}	☐	☐	☐	☐	☐	☐	☐

Q10

Geef voor elke persoon die u heeft geïdentificeerd aan welke tool u heeft gebruikt om gegevens met u te delen als AFZENDER naar de geïdentificeerde persoon (u kunt meer opties selecteren).

	Chat applications (MS teams)	Email	BIM/ACC	Online collaboration platform (Sharepoint)	Phone	Face-to-Face	Video/Virtual calls
${q://QID2/ChoiceTextEntryValue/1/1}	☐	☐	☐	☐	☐	☐	☐
${q://QID2/ChoiceTextEntryValue/2/1}	☐	☐	☐	☐	☐	☐	☐
${q://QID2/ChoiceTextEntryValue/3/1}	☐	☐	☐	☐	☐	☐	☐
${q://QID2/ChoiceTextEntryValue/4/1}	☐	☐	☐	☐	☐	☐	☐
${q://QID2/ChoiceTextEntryValue/5/1}	☐	☐	☐	☐	☐	☐	☐
${q://QID2/ChoiceTextEntryValue/6/1}	☐	☐	☐	☐	☐	☐	☐
${q://QID2/ChoiceTextEntryValue/7/1}	☐	☐	☐	☐	☐	☐	☐
${q://QID2/ChoiceTextEntryValue/8/1}	☐	☐	☐	☐	☐	☐	☐
${q://QID2/ChoiceTextEntryValue/9/1}	☐	☐	☐	☐	☐	☐	☐
${q://QID2/ChoiceTextEntryValue/10/1}	☐	☐	☐	☐	☐	☐	☐

Q11

Welke tool gebruikt u het liefst als u gegevens met anderen deelt?

- ○ Chat applications (MS teams)
- ○ Email
- ○ BIM/ACC
- ○ Online Collaboration platform (Sharepoint)
- ○ Phone
- ○ Face-to-Face
- ○ Video/virtual calls

Q12

Met wie ging data delen het meest moeizaam?

Q13

En wat was de reden hiervoor volgens u?

Page Break

Q14

Heeft u tijdens de aanbesteding van ${q://QID19/ChoiceGroup/SelectedChoices} Lessons learned opgezocht van soortgelijke projecten om van de ervaringen te leren en daar rekening mee te houden?

- ○ Ja
- ○ Nee

Q15

Zo ja, in welke fase

Q16

Tijdens het opstellen of vinden van bepaalde lessons learned, heb je dan gebruik gemaakt van bepaalde tools?

- [ ] Project evaluatie
- [ ] Relatics
- [ ] Microsoft teams
- [ ] PMI/TMI
- [ ] Sharepoint
- [ ] Geen van de bovenstaande opties

Deel 2 Demografische details

Q22

Wat is uw geslacht?

- ○ Man
- ○ Vrouw
- ○ Niet-binair/derde geslacht
- ○ Ik zeg dat liever niet

Q23

Wat is uw leeftijd?

- ○ Onder 25
- ○ 25-34
- ○ 35-44
- ○ 45-54
- ○ 55-65
- ○ Meer dan 65

Q24

Hoeveel jaar werkt u al voor BAM?

- ○ < 1 jaar
- ○ 1-4
- ○ 5-9
- ○ 10-19
- ○ 20-29
- ○ 30-40
- ○ 40 jaar >

Q25

Bij hoeveel tenders bent u betrokken geweest in de afgelopen 5 jaar?

- ○ 1
- ○ 2-4
- ○ 5 - 10
- ○ 11- 14
- ○ 15>

Appendix D

Python code for graphs of the social network analysis:

```python
# -*- coding: utf-8 -*-
"""
Spyder Editor

This is a temporary script file.
"""
import pandas as pd
import networkx as nx
import matplotlib.pyplot as plt
from matplotlib.patches import Patch
import itertools
import community as community_louvain  # Zorg ervoor dat je python-louvain hebt geïnstalleerd
from networkx.algorithms.community import girvan_newman
import os

csv_path = r'C:\Users\job.rijpma\OneDrive - Royal BAM Group nv\Documenten\python\N211\CSV\N211 code 4.csv'
if os.path.exists(csv_path):
    print("Het bestand bestaat.")
else:
    print("Het bestand bestaat niet. Controleer het pad.")
df_X = pd.read_csv(csv_path)
```

```python
#%%
# Create the graph based on your data
G = nx.Graph()

# Stap 3: Definieer functies voor het toevoegen van nodes en edges aan de grafiek
def add_nodes_and_edges(row):
    G.add_node(row['source'], color=row['source_color'])
    G.add_node(row['target'], color=row['target_color'])
    G.add_edge(row['source'], row['target'], frequency=row['frequency'], weight=row['weight'])

df_X.apply(add_nodes_and_edges, axis=1)

 # Zet de seed voor reproduceerbare resultaten
  # Zet de seed voor reproduceerbare resultaten
partition = community_louvain.best_partition(G, random_state=42)

# Voeg de gemeenschap toe aan elke knoop
for node, community in partition.items():
    G.nodes[node]['community'] = community

# Bereken de posities voor de knopen met Kamada-Kawai layout
pos = nx.kamada_kawai_layout(G, scale=2)
# Bereken de posities voor de knopen met de gekozen layout (hier Kamada-Kawai)

# Vergroot de figuurafmetingkomn
plt.figure(figsize=(50, 50))   # Grootte van de figuur instellen

# Kleuren van de nodes bepalen
node_colors = [G.nodes[n]['color'] for n in G.nodes]
nx.draw_networkx_nodes(G, pos, node_color=node_colors, node_size=10000)

# Lijnenstijlen definiëren op basis van frequentie
edge_styles = {
    1: ('dotted', 6),  # stijl, dikte
    4: ('dashdot', 7 ),
    7: ('dashed', 8),
    10: ('solid', 9)  # iets dikker voor solid
}

# Tekenen van de edges met aangepaste stijlen en gewichten
for u, v, data in G.edges(data=True):
    frequency = data['frequency']
    weight = data['weight']
    style, width = edge_styles.get(frequency, ('solid', 2.0))  # Default to solid if no match
    nx.draw_networkx_edges(G, pos, edgelist=[(u, v)], style=style, edge_color='black', width=weight)

# Netwerk tekenen met labels
nx.draw_networkx_labels(G, pos, font_size=50)
```

```
# Legenda voorbereiden
legend_colors = [
    'blue', 'lightblue', 'violet', 'lightgreen', 'orange',
    'grey', 'red', 'pink', 'purple', 'brown', 'white',
    'green', 'yellow', 'black'
]
legend_labels = [
    "Project / Design Management",
    "Project assistant",
    "Engineering",
    "Tender Management",
    "Contracting",
    "Modeling / BIM",
    "Costing",
    "Planning",
    "Construction management",
    "Systems engineer",
    "GIS",
    "Duurzaamheid",
    "Risk management",
    "Director"
]
legend_patches = [Patch(color=color, label=label) for color, label in zip(legend_colors, legend_labels)]
plt.legend(handles=legend_patches, loc='upper left', bbox_to_anchor=(1, 1),
           fontsize=35,  # Gebruik een specifieke grootte of vergroot nog meer indien nodig
           handlelength=4,  # Maak de markers langer
           labelspacing=1.5,  # Vergroot de ruimte tussen labels
           borderpad=2,  # Vergroot de ruimte binnen de legenda
           borderaxespad=1,  # Vergroot de ruimte tussen legenda en plot
           title='Role Description')

# Plot weergeven
plt.show()
```

Code for including the frequency and weights to the edges

```
#%% variabelen
num_nodes = G.number_of_nodes()
num_edges = G.number_of_edges()
print(f"Aantal nodes: {num_nodes}")
print(f"Aantal verbindingen: {num_edges}")

density = nx.density(G)
print(f"\nDichtheid van het netwerk: {density}")

average_clustering = nx.average_clustering(G)
print(f"\nGemiddelde clustering coefficient: {average_clustering}")

# Bereken de gemiddelde degree
average_degree = sum(dict(G.degree()).values()) / num_nodes
print(f"\nGemiddelde degree: {average_degree}")

# Bereken de gemiddelde frequentie en gewicht
average_frequency = df_X['frequency'].mean()
max_frequency = df_X['frequency'].max()
average_weight = df_X['weight'].mean()
max_weight = df_X['weight'].max()
print(f"\nGemiddelde frequentie van data-uitwisseling: {average_frequency} / ({max_frequency})")
print(f"\nGemiddelde aangegeven waarde van data: {average_weight} / ({max_weight})")
stats = {
    'Component': ['Nodes', 'Edges', 'Graph density', 'Average clustering coefficient',
                  'Average degree', 'Average frequency of data exchange',
                  'Average indicated value of data'],
    'Statistic': [num_nodes, num_edges, f"{density:.3f} ({density*100:.1f}%)",
                  f"{average_clustering:.3f} ({average_clustering*100:.1f}%)",
                  average_degree, f"{average_frequency:.1f} / ({max_frequency})",
                  f"{average_weight:.1f} / ({max_weight})"]
}

stats_df = pd.DataFrame(stats)

# Specificeer het volledige pad waar je het CSV-bestand wilt opslaan
print(stats_df)
```

```python
#%%# Bereken en print statistieken
degree = dict(G.degree())
degree_centrality = nx.degree_centrality(G)
print("\nDegree Centrality:")
for node, centrality in degree_centrality.items():
    print(f"Node {node}: {centrality}")

# 2. Eccentricity
eccentricity = nx.eccentricity(G)
print("\nEccentricity:")
for node, ecc in eccentricity.items():
    print(f"Node {node}: {ecc}")

# 3. Closeness centrality
closeness_centrality = nx.closeness_centrality(G)
print("\nCloseness Centrality:")
for node, centrality in closeness_centrality.items():
    print(f"Node {node}: {centrality}")

# 4. Betweenness centrality
betweenness = nx.betweenness_centrality(G, weight='weight')
print("\nBetweenness Centrality:")
for node, centrality in betweenness.items():
    print(f"Node {node}: {centrality}")

# 5. Eigenvector centrality
eigenvector = nx.eigenvector_centrality(G, weight='weight')
print("\nEigenvector Centrality:")
for node, centrality in eigenvector.items():
    print(f"Node {node}: {centrality}")

# 6. Clustering coefficient
clustering_coefficient = nx.clustering(G)
print("\nClustering Coefficient:")
for node, coeff in clustering_coefficient.items():
    print(f"Node {node}: {coeff}")
```

```python
#%%
# Bereken de eigenvector centrality
eigenvector = nx.eigenvector_centrality(G, weight='weight')

# Controleer de normalisatie
sum_of_squares = sum([value**2 for value in eigenvector.values()])
print(f"Som van de kwadraten van eigenvector centrality: {sum_of_squares}")

# Tabel maken
data = {
    'Label': list(eigenvector.keys()),
    'Eigenvector centrality': [round(eigenvector[node], 3) for node in eigenvector.keys()]
}
df = pd.DataFrame(data)
print("\nTabel met eigenvector centrality:")
print(df)

# Print de som van de eigenvector centrality-waarden
print("\nSom van eigenvector centrality-waarden:")
print(sum(eigenvector.values()))
```

```python
#%% export excel file
    # Tabel maken
data = {
    'Label': list(degree.keys()),
    'Degree': list(degree.values()),
    'Degree centrality': [round(degree_centrality[node], 3) for node in degree.keys()],
    'Eccentricity': [eccentricity[node] for node in degree.keys()],
    'Closeness centrality': [round(closeness_centrality[node], 3) for node in degree.keys()],
    'Betweenness centrality': [round(betweenness[node], 3) for node in degree.keys()],
    'Eigenvector centrality': [round(eigenvector[node], 3) for node in degree.keys()],
    'Clustering coefficient': [round(clustering_coefficient[node], 3) for node in degree.keys()]
}

df = pd.DataFrame(data)

# Rangschik de DataFrame op basis van eigenvector centrality
df_sorted = df.sort_values(by='Eigenvector centrality', ascending=False)

# Sla de DataFrame op als een Excel-bestand
output_path =r'C:\Users\job.rijpma\OneDrive - Royal BAM Group nv\Documenten\python\N211\tabellen\variabelen 2.xlsx'
df_sorted.to_excel(output_path, index=False)
print(f"Tabel opgeslagen op: {output_path}")

# Print de gesorteerde DataFrame
print("\nTabel met netwerkanalyses (gesorteerd op eigenvector centrality):")
print(df_sorted)
```

```
#%%
# 7. Shortest path length
shortest_paths = dict(nx.all_pairs_dijkstra_path_length(G, weight='weight'))
print("\nShortest Paths Length:")
for source, paths in shortest_paths.items():
    print(f"Source {source}: {paths}")
```

```
#%%
source_node = 'A72'
target_node = 'A20'
if G.has_edge(source_node, target_node):
    weight = G[source_node][target_node]['weight']
    print(f"\nGewicht van de verbinding tussen {source_node} en {target_node}: {weight}")
else:
    print(f"\nEr is geen verbinding tussen {source_node} en {target_node}")
```

```
#%% identify gate keeper
def identify_gatekeepers(G):
    gatekeepers = []

    for node in G.nodes():
        G_copy = G.copy()
        G_copy.remove_node(node)

        # Check if removing the node disconnects any other nodes
        initial_components = list(nx.connected_components(G))
        new_components = list(nx.connected_components(G_copy))

        isolated_nodes = set()
        for component in new_components:
            if len(component) == 1:
                isolated_nodes.update(component)

        if isolated_nodes:
            gatekeepers.append(node)

    return gatekeepers

# Identify gatekeepers
gatekeepers = identify_gatekeepers(G)

# Color the nodes based on whether they are gatekeepers
node_colors = ['blue' if node in gatekeepers else 'grey' for node in G.nodes()]

# Plot the entire graph with labels and node colors
pos = nx.kamada_kawai_layout(G)
plt.figure(figsize=(10, 10))
nx.draw_networkx(G, pos=pos, node_color=node_colors, node_size=500, labels={node: node for node in G.nodes()}, with_labels=True)
nx.draw_networkx_edges(G, pos, width=1.0, alpha=0.5)
nx.draw_networkx_labels(G, pos, font_size=12)

plt.title("Gatekeepers in the Network (blue nodes)")
plt.show()
```

```
#%% identify central figures
betweenness_centrality = nx.betweenness_centrality(G, weight='weight')
eigenvector_centrality = nx.eigenvector_centrality(G, weight='weight')

# Define the thresholds
central_threshold_betweenness = 0.23
central_threshold_eigenvector = 0.4

# Identify central figures
central_figures = [node for node in G.nodes()
                   if betweenness_centrality[node] > central_threshold_betweenness and
                   eigenvector_centrality[node] > central_threshold_eigenvector]

# Create the layout
pos = nx.kamada_kawai_layout(G)

# Define colors for nodes
node_colors = ['green' if node in central_figures else 'gray' for node in G.nodes()]

# Draw the graph
plt.figure(figsize=(10, 10))
nx.draw_networkx_nodes(G, pos, node_color=node_colors, node_size=500, alpha=0.8)
nx.draw_networkx_edges(G, pos, width=1.0, alpha=0.5)
nx.draw_networkx_labels(G, pos, font_size=12)

# Add legend
central_patch = Patch(color='green', label='Central Figures')
other_patch = Patch(color='gray', label='Other Nodes')
plt.legend(handles=[central_patch, other_patch], loc='upper right')

plt.title("Network Central Figures (green)")
plt.show()
```

```
comp = girvan_newman(G)
limited = itertools.takewhile(lambda c: len(c) <= 10, comp)
silos = list(limited)

# Gebruik de eerste set van gemeenschappen (silos) voor visualisatie
silo_communities = silos[0]
community_map = {}
for i, community in enumerate(silo_communities):
    for node in community:
        community_map[node] = i
pos = nx.kamada_kawai_layout(G, scale=2)
```

```
#%% data silo
comp = girvan_newman(G)
limited = itertools.takewhile(lambda c: len(c) <= 10, comp)
silos = list(limited)

# Gebruik de eerste set van gemeenschappen (silos) voor visualisatie
silo_communities = silos[0]
community_map = {}
for i, community in enumerate(silo_communities):
    for node in community:
        community_map[node] = i

# Bereken de posities voor de knopen met Kamada-Kawai layout
pos = nx.kamada_kawai_layout(G, scale=2)

# Visualisatie van de gemeenschappen (silos) met Kamada-Kawai layout
plt.figure(figsize=(20, 20))

# Kleuren van de nodes bepalen: rood voor de nodes in de silo's, grijs voor de rest
node_colors = ['red' if community_map[n] == 0 else 'gray' for n in G.nodes]
nx.draw_networkx_nodes(G, pos, node_color=node_colors, node_size=800)

# Lijnenstijlen definiëren op basis van frequentie
edge_styles = {
    1: ('dotted', 1),  # stijl, dikte
    4: ('dashdot', 2),
    7: ('dashed', 3),
    10: ('solid', 4)  # iets dikker voor solid
}

# Edges tekenen met aangepaste stijlen en gewichten
for u, v, data in G.edges(data=True):
    frequency = data['frequency']
    weight = data['weight']
    style, width = edge_styles.get(frequency, ('solid', 0.5))  # Stel de standaard breedte in op 0.5
    nx.draw_networkx_edges(G, pos, edgelist=[(u, v)], style=style, edge_color='black', width=width * 1)

# Labels tekenen
nx.draw_networkx_labels(G, pos, font_size=12, font_color='black')

# Plot weergeven
plt.title('Data silo using Girvan-Newman method', fontsize=40)
```

Appendix E

The table displayed in the appendix represents key social network analysis (SNA) metrics derived from various nodes (individuals or departments, indicated by their labels such as A71, A11, A17, etc.). Each column reflects a different centrality measure, which helps to understand the role and influence of each node within the tender process network. Below is a brief explanation of each column:

1. **Label**: This column represents the identifier of each node (e.g., A71, A11), which could be a department, team, or individual within the network.
2. **Degree**: This metric refers to the number of direct connections a node has. A higher degree suggests that a node interacts with more entities, indicating a greater level of activity or communication.
3. **Degree Centrality**: This column measures the centrality of a node based on its number of connections relative to others in the network. Nodes with high degree centrality are likely to be important communicators, as they interact with many other nodes.
4. **Eccentricity**: Eccentricity measures how far a node is from the farthest node it is connected to. Nodes with low eccentricity are closer to all other nodes in the network, indicating better access to information across the network.
5. **Closeness Centrality**: This metric evaluates how close a node is to all other nodes in the network. Nodes with high closeness centrality can quickly interact or disseminate information to other nodes, making them effective coordinators within the network.
6. **Betweenness Centrality**: Betweenness centrality indicates how often a node acts as a bridge along the shortest path between two other nodes. Nodes with high betweenness centrality are critical for the flow of information, as they facilitate communication between otherwise disconnected parts of the network.
7. **Eigenvector Centrality**: This metric measures a node's influence based on how well-connected its neighbors are. A node with high eigenvector centrality is connected to other influential nodes, indicating a higher level of prestige or importance within the network.
8. **Clustering Coefficient**: The clustering coefficient measures how closely connected a node's neighbors are to each other. A high clustering coefficient indicates that a node's neighbors tend to interact frequently, forming tight-knit groups, whereas a low clustering coefficient may indicate a more distributed or isolated network.

The combination of these metrics provides a comprehensive overview of each node's role within the tender process network, highlighting key individuals or departments that facilitate communication and information flow. For example, nodes with high betweenness centrality act as crucial intermediaries, while those with high eigenvector centrality are influential due to their well-connected positions. Analyzing these metrics helps to identify potential bottlenecks, isolated departments, or opportunities to improve knowledge-sharing practices.

N346

Table 20: Statistics N346 network

Label	Degree	Degree centrality	Eccentricity	Closeness centrality	tweenness central	Eigenvector centrality	Clustering coefficient
A71	10	0,263	3	0,5	0,124	0,403	0,289
A11	13	0,342	3	0,567	0,378	0,388	0,192
A17	9	0,237	3	0,463	0,241	0,314	0,167
A72	10	0,263	4	0,452	0,155	0,299	0,133
A66	8	0,211	3	0,514	0,271	0,27	0,464
A9	6	0,158	4	0,469	0,016	0,257	0,267
A25	6	0,158	4	0,458	0,015	0,245	0,667
A20	6	0,158	4	0,437	0,058	0,233	0,133
A36	9	0,237	3	0,447	0,125	0,201	0,25
A24	3	0,079	4	0,376	0	0,19	0,333
A74	8	0,211	4	0,442	0,151	0,19	0,179
A40	5	0,132	4	0,437	0,012	0,187	0,5
A33	6	0,158	4	0,422	0,073	0,113	0,2
A10	3	0,079	4	0,409	0	0,103	0,667
A41	7	0,184	4	0,427	0,212	0,089	0,095
A15	1	0,026	4	0,336	0	0,081	0
A12	1	0,026	4	0,336	0	0,081	0
A8	2	0,053	5	0,349	0	0,075	0
A26	2	0,053	4	0,345	0	0,075	0
A30	2	0,053	4	0,336	0	0,071	1
A37	3	0,079	4	0,345	0,001	0,07	0,667
A75	1	0,026	4	0,319	0	0,063	0
A38	1	0,026	4	0,319	0	0,063	0
A82	4	0,105	4	0,362	0,07	0,06	0,167
A93	1	0,026	5	0,314	0	0,06	0
A89	1	0,026	5	0,314	0	0,06	0
A92	1	0,026	5	0,314	0	0,06	0
A77	2	0,053	4	0,384	0	0,058	1
A5	2	0,053	4	0,325	0	0,044	1
A63	2	0,053	4	0,349	0,01	0,043	0
A21	1	0,026	5	0,306	0	0,033	0
A1	1	0,026	4	0,365	0	0,031	0
A91	1	0,026	5	0,309	0	0,027	0
A50	1	0,026	5	0,302	0	0,018	0
A2	1	0,026	5	0,299	0	0,016	0
A18	1	0,026	5	0,268	0	0,012	0
A52	1	0,026	5	0,302	0	0,012	0
A32	1	0,026	5	0,302	0	0,012	0
A53	1	0,026	5	0,302	0	0,007	0

Alexia Viaduct

Table 21: Statistics Alexia viaduct network

Label	Degree	Degree centrality	Eccentricity	Closeness centrality	Betweenness centrality	Eigenvector centrality	Clustering coefficient
A11	15	0,417	3	0,61	0,474	0,493	0,171
A46	11	0,306	3	0,514	0,255	0,397	0,127
A73	6	0,167	4	0,439	0,11	0,276	0,333
A56	9	0,25	3	0,507	0,215	0,257	0,222
A84	6	0,167	4	0,444	0,05	0,247	0,467
A62	5	0,139	3	0,48	0,069	0,219	0,5
A67	8	0,222	3	0,462	0,181	0,201	0,107
A69	4	0,111	3	0,45	0,024	0,196	0,333
A85	6	0,167	3	0,462	0,086	0,196	0,2
A19	6	0,167	4	0,391	0,005	0,177	0,267
A16	3	0,083	4	0,4	0	0,157	1
A79	3	0,083	4	0,409	0,003	0,146	0,667
A21	2	0,056	4	0,4	0	0,135	1
A42	6	0,167	4	0,387	0,069	0,132	0,067
A9	3	0,083	3	0,424	0,002	0,13	0,667
A2	3	0,083	4	0,396	0,056	0,121	0,333
B4	2	0,056	4	0,379	0	0,119	0
B1	4	0,111	4	0,371	0,056	0,116	0,167
A49	5	0,139	4	0,414	0,162	0,115	0,1
A96	1	0,028	4	0,343	0	0,088	0
A94	1	0,028	4	0,343	0	0,088	0
A65	2	0,056	4	0,409	0	0,073	0
A97	1	0,028	4	0,343	0	0,062	0
A86	1	0,028	4	0,343	0	0,062	0
B5	1	0,028	5	0,308	0	0,061	0
A61	2	0,056	4	0,346	0	0,061	0
A43	2	0,056	4	0,346	0	0,05	1
A95	1	0,028	4	0,34	0	0,04	0
A98	1	0,028	4	0,319	0	0,031	0
A15	1	0,028	4	0,319	0	0,031	0
A57	1	0,028	5	0,281	0	0,029	0
A4	1	0,028	5	0,286	0	0,027	0
A7	1	0,028	5	0,273	0	0,026	0
B2	1	0,028	5	0,308	0	0,024	0
A50	1	0,028	5	0,295	0	0,018	0
A99	1	0,028	5	0,295	0	0,018	0
B3	1	0,028	5	0,295	0	0,018	0

N211 Wippolderlaan

Table 22: Statistics N211 Wippolderlaan network

Label	Degree	Degree centrality	Eccentricity	Closeness centrality	Betweenness centrality	Eigenvector centrality	Clustering coefficient
B8	9	0,273	4	0,508	0,39	0,476	0,194
A62	6	0,182	3	0,434	0,087	0,417	0,267
B6	6	0,182	4	0,508	0,234	0,407	0,333
A60	9	0,273	3	0,452	0,298	0,311	0,056
B7	7	0,212	4	0,423	0,231	0,271	0,143
A50	8	0,242	3	0,446	0,333	0,252	0,036
B30	2	0,061	4	0,363	0	0,231	1
A85	3	0,091	4	0,388	0,039	0,203	0
A47	2	0,061	4	0,379	0	0,118	1
B37	1	0,03	4	0,306	0	0,108	0
B9	1	0,03	5	0,34	0	0,086	0
B28	1	0,03	5	0,34	0	0,086	0
B11	6	0,182	4	0,371	0,168	0,08	0
A53	1	0,03	4	0,314	0	0,08	0
B31	1	0,03	4	0,314	0	0,08	0
B34	1	0,03	4	0,314	0	0,08	0
A18	2	0,061	4	0,347	0,017	0,077	0
B19	1	0,03	4	0,311	0	0,065	0
B3	2	0,061	4	0,351	0,074	0,06	0
B21	1	0,03	4	0,314	0	0,056	0
B38	1	0,03	5	0,3	0	0,049	0
B13	1	0,03	5	0,3	0	0,049	0
A84	1	0,03	5	0,3	0	0,049	0
B22	4	0,121	3	0,388	0,185	0,049	0
B39	1	0,03	5	0,3	0	0,049	0
A21	1	0,03	4	0,311	0	0,046	0
B33	1	0,03	4	0,311	0	0,046	0
B35	1	0,03	4	0,311	0	0,046	0
B36	1	0,03	4	0,311	0	0,046	0
B29	1	0,03	5	0,273	0	0,021	0
A42	1	0,03	5	0,273	0	0,021	0
B27	2	0,061	4	0,314	0,062	0,017	0
B26	1	0,03	4	0,282	0	0,013	0
A4	1	0,03	4	0,282	0	0,005	0

Appendix F

The RCA conducted in this study aims to identify the underlying causes behind challenges faced during the tender process, specifically focusing on issues related to knowledge sharing and lessons learned. The purpose of the analysis is to uncover deeper, systemic problems by repeatedly asking "Why?" to trace back to the root causes of inefficiencies or miscommunication.

The tables in the appendix document participants' answers during the RCA process, showing how they responded to the "5 Whys" questions. These tables capture detailed insights into their reasoning, providing an overview of the fundamental issues that affect the effective use of lessons learned in tender processes. Each table concludes with the final root cause identified, allowing for a deeper understanding of the problem areas and contributing to the development of targeted recommendations.

In-depth interviews N211

B8

Statement 1 Agree with the statement and also applies to me in the tender	Statement 2 Agree with the statement and also applies to me in the tender
Why? Plays a crucial role in driving the integration of most if the knowledge management processes Why is that the case? That as a project leader or project manager, you have an overview of the entire process Why do you have an overview? You are in a position to guide your team to ensure that lessons learned are effectively applied Why do you think having a better overview stimulates lessons learned usage? In my experience, leadership was essential in making sure that lessons from past projects and experiences were utilized within his team. He achieved this by maintaining a clear overview, providing direction, and connecting current activities with past experiences. Why you think this is usually the case? I was aware of what My team was working on, knew the issues that had arisen in the past, and was therefore able to apply relevant lessons and steer his team accordingly	Why? I see myself as a leader, and I believe that leadership plays a key role in encouraging the use of lessons learned within the team. But at this tender I can't remember this happening. Why didn't it happen Lot of time constraints so usually I would do it. From my experience, knowing what's going on within the organization and being aware of lessons learned in past projects allows me to effectively connect colleagues who have similar work experiences. Why you only use your experience? Within BAM, we currently don't have a well-established database or system for lessons learned Why you use an informal approach then? I believe that this informal approach to sharing lessons has been crucial and effective, especially in the absence of a formal system. Why is it effective? To get the people involved to make connections and ensure that relevant experiences are shared among colleagues
Root cause Process overview	Root cause Open communication

Statement 3 Disagree with the statement and it does not apply to me in the tender	Statement 4 Disagree with the statement but applies to me in the tender
Why? In reality, it's often unclear where to locate lessons learned reports from previous tenders. This has been a recurring challenge in our organization. Why is it recurring? Despite the importance of these reports for improving our processes and avoiding past mistakes, there isn't a well-defined, accessible system or database where these reports are stored. Why is there no well-defined location? For instance, there have been several occasions where I needed to refer to lessons learned from past projects to inform our current tendering strategy. However, when I attempted to find these reports, I quickly realized that they either weren't documented properly or were scattered across various locations, making them practically impossible to retrieve, so need to use an informal way. Why what way you use an informal way? This means that instead of relying on documented reports, I often have to fall back on informal channels. I might reach out directly to colleagues who worked on similar projects to gather their insights, or I rely on my own memory and experiences. Why you rely on your own memory? While sometimes effective, is far from ideal. It introduces a significant risk of overlooking critical lessons simply because they weren't captured in an easily accessible format.	Why? On one hand, lessons learned during the tender process are often communicated quite effectively, but this communication tends to happen informally. Why is that a problem? the real issue lies. Despite the good communication practices, these lessons are rarely documented in a formal, systematic way Why are they not documented? Most of the knowledge sharing happens through word of mouth, and because it's not formally recorded, it's not easily accessible to others who might need it in the future. Why is that a problem that it is not recorded? Valuable lessons can be lost or forgotten, particularly when team members move on to different projects or leave the organization. Why can nobody access the information? If someone in another part of the organization wanted to learn from our experiences, they would likely struggle to find the information they need
Root cause Fragmentation	Root cause Informal communication

Statement 5 Agree with the statement but it does not apply to me in the tender	Statement 6 Agree with the statement but it does not apply to me in the tender
Why? It would be a very good solution, eventhough it is never applied to tenders I worked in Why is it never applied? we don't have a formal system in place at our organization, but I think implementing one could greatly enhance our knowledge management Why would that enhance it? I believe that having a standardized system or template would make it much easier to document important lessons and ensure that critical information is consistently captured. Why would it be easier? This would allow teams to access and apply these lessons in future projects, improving overall project performance and helping us avoid repeating past mistakes.	Why? we lack a centralized system where all the lessons learned from various projects are stored Why a centralized system? A central repository would help avoid the fragmentation we currently experience Why is it fragmented where lessons learned are either buried in individual project files or shared informally and then forgotten. -

Why is the access better then? With just a few key words documents can be found. This would make this knowledge more accessible to everyone in the organization	
Root cause No formal system	Root cause: Fragmented

Statement 7 Disagree with the statement but applies to me in the tender	Statement 8 Disagree with the statement but applies to me in the tender
Why? As project leaders, we meet regularly, about four times a year, and during these meetings, there is always room to share and discuss experiences from previous projects. Why does it happen enough? I think the statement implies that this is not happening enough, and in my experience, that's not entirely accurate Why is it not accurate? We do make time for these discussions, and they happen both formally in meetings and informally through conversations with colleagues. The real issue might not be the frequency of discussions Why is it not the frequency? The challenge is ensuring that these discussions lead to actionable outcomes and that the lessons are captured in a way that others can access them later. Why is that more important? The focus should perhaps be more on improving how we document and share these lessons rather than simply increasing the frequency of discussions.	Why? Mentorship and incentives can definitely play a significant role in fostering a proactive culture around lessons learned, but they are not the only factors. Why is that not enough? In my experience, simply offering mentorship or incentives isn't enough to ensure that people actively engage in capturing and applying lessons learned. Why do people need to actively engage? For mentorship to be effective, it needs to be paired with clear communication about the importance of lessons learned and how they contribute to the success of future projects. Why is that not an incentive? I think the foundation of a proactive lessons learned culture lies in making the process itself as simple and integrated into our daily work as possible. Why is it not simple? If capturing lessons is seen as just another bureaucratic task, no amount of mentorship or incentives will make it effective. It should be part of a broader strategy that includes clear processes, easy-to-use tools, and strong leadership support
Root cause Lack of actionable outcomes.	Root cause Process improvement

A50

Statement 1 Agree with the statement and also applies to me in the tender	Statement 2 Agree with the statement ans also applies to the tender
Why? When I heard the statement, I found myself questioning what exactly is meant by "leadership" in this context. I think this might indicate that within our company, we don't have a single, clear definition or expectation of what leadership should look like Why is that not clear? Our tender manager in in the tender. I wouldn't describe her as a "born leader," but she has a particular	Why? We exchange lessons and input across different levels, especially in my department. It's not always formal, but it's highly valued because it ensures that crucial insights are shared and used in the tender process. Why does this communication method work well in the department? We actively seek input, especially in larger projects. We make sure to involve people with direct experience, and

strength in involving everyone and keeping us all informed. Why is that important? In my view, effective leadership in the tender process isn't necessarily about having traditional leadership qualities like authority or charisma. Instead, it's more about the ability to bring the team together and provide them with the necessary information. Why is the information so important? I believe that having the right information is critical. When we're well-informed, we feel more involved in the process. This involvement is key to integrating and using lessons learned. How to apply lessons learned is not very clear then Why is that not clear? This variation points to a bigger challenge within our company: we don't have a uniform approach or set of best practices for leadership in the tender process. Some tenders benefit from tenders some don't	this open communication makes our collaboration more effective. Why are there limitations to how broadly this communication spreads? While we exchange valuable input within the department, it doesn't always extend beyond that. Often, the lessons remain implicit, shared in evaluations or through conversations, but not always through formal channels. Why does ad hoc communication prevail over formalized documentation? A lot of what we share is verbal, especially during internal team reviews. We focus on what's practical and immediate, so documenting everything formally isn't always a priority. Why would more formal processes benefit the organization as a whole? If we had a more structured way of documenting and sharing these insights, it would ensure that lessons aren't just confined to our department but can be applied across the whole organization.
Root cause uniform leadership practices.	Root cause Formalized approach

Statement 3 Disagree with the statement but applies to me in the tender	Statement 4 Disagree with the statement but applies to me in the tender
Why? When I think about this statement, I have to admit that it's not always clear to me where these reports are located. Even though I know that the reports exist and are stored somewhere Why it's hard to find them then? They are in MS teams or SharePoint. I often find myself struggling to locate them when I need them. I've noticed that I'm not the only one with this issue; several of my colleagues have mentioned the same thing. Why don't you put them there then? For me, the problem lies in how the information is organized and labeled. It might be in a logical place according to whoever set up the system, but if it's not intuitive or clearly marked, it becomes difficult to find. This lack of clarity can be frustrating, especially when time is of the essence during the tender process. Why aren't these platforms useful? They're only as good as the structure that underpins them. If the organization of the information isn't straightforward or if there isn't a clear and consistent way to categorize and access the reports, then it doesn't matter how much information we have, people will struggle to find it. -	Why? For instance, while we do have our own channels, such as lessons profiles and evaluations, if you were to ask me right now where to find specific lessons or how they are shared, I wouldn't be able to point you to an exact location. Why don't you know that? This is partly because, in our current setup, there isn't a straightforward or centralized way to access this information. Why isn't that communicated? Communication is another challenge. Although we share certain insights verbally during meetings or through emails, there isn't a consistent or formalized process for ensuring that these lessons are captured and made accessible to everyone who might benefit from them. Often, the sharing of lessons is more ad hoc and relies heavily on personal interactions rather than a structured system. Why is that not applicable for you? For someone like me, who might be somewhat removed from the day-to-day tender management, it's even less clear where to go for this information. This lack of accessibility and communication means that valuable insights might be lost or underutilized, which can hinder our ability to improve and learn from past experiences effectively.

Root cause Fragmentation	Root cause Informal communication

Statement 5 Agree with the statement but it does not apply to me in the tender	Statement 6 Agree with the statement but it does not apply to me in the tender
Why? It would make it much clearer what's expected when documenting lessons learned, and it would ensure that everyone is on the same page. Why is that better for the process? Clarifying expectations is crucial because, right now, the way we document lessons can vary significantly depending on who's responsible and what their individual focus is. For instance, what a contract manager finds important might differ from what's prioritized by someone in another role. By making expectations clear, we can ensure that these differences don't lead to inconsistent documentation, which could hinder the effective sharing and application of lessons. Why is a consistent approach necessary? A consistent approach is necessary because it helps remove ambiguity in the process of sharing knowledge. If we standardize how lessons are documented, then it becomes much easier for everyone to access and interpret the information correctly. Without consistency, there's a risk that lessons will be miscommunicated or overlooked, which could reduce their effectiveness in future tenders or projects. Why is removing ambiguity important? Removing ambiguity is important because it makes the knowledge more straightforward to understand and apply. This is especially critical for new team members or people from different departments who might not have the same context as those who originally documented the lessons. By reducing ambiguity, we can ensure that everyone, regardless of their background or experience, can easily grasp and utilize the lessons learned, which ultimately improves our overall performance in future tenders.	Why? It's important to have a structured and trustworthy place where we can store and share what we've learned. Why should you focus on that? I also think that we need to be careful not to see reporting lessons as an end in itself. It's not just about documenting lessons; it's about making sure those lessons are actually internalized and applied by the people who need them. Why might lessons be forgotten or overlooked if only stored in a system? Because simply documenting them isn't enough, people need to internalize and apply the lessons for them to be effective. Why do lessons need to be internalized and applied? because the true value of lessons learned comes when they're actively used to improve future projects. It's not enough to just have the lessons documented; they need to be understood and incorporated into decision-making processes and everyday practices Why is it challenging to ensure lessons are understood and used? It's challenging because there are often time constraints, especially during tenders, which make it difficult for teams to find the time to reflect on past lessons and engage with them meaningfully. Additionally, just having a system isn't enough—there needs to be active communication, engagement, and involvement from team members to keep these lessons "alive" and relevant. Without this, even the best repository might not achieve its full potential.
Root cause Informal communication	Root cause: Engagement into daily practices

Statement 7 Agree with the statement but it does not apply to me in the tender	Statement 8 Disagree with the statement but applies to me in the tender
Why? Because it's crucial for reflecting on what's been done well, where mistakes were made, and how we can improve going forward. Why is reflecting on successes and mistakes important? Reflecting on successes and mistakes allows the team to	Why? Employees need a reason to contribute lessons learned. When they see that their input is valuable and useful for the team, they are more likely to continue contributing. **Why do employees need to experience that their contributions are valuable?** When employees see that the lessons learned system works effectively, they are

learn from their experiences and avoid repeating the same mistakes in the future. Why is it important to avoid repeating mistakes? Avoiding mistakes is essential for improving processes and outcomes, ensuring that each project or tender is better than the last. Why does improving processes and outcomes matter? Improving processes and outcomes leads to more successful projects, better collaboration across departments, and ultimately, a stronger overall performance. Why is cross-departmental collaboration necessary for success? Cross-departmental collaboration brings together different perspectives, ensuring a comprehensive understanding of the issues and fostering a culture of continuous improvement.	more motivated to participate, knowing that their efforts lead to concrete benefits. **Why is seeing the system work important for motivation?** If employees don't see results from their input, they may not see the value in contributing. Seeing practical outcomes ensures ongoing participation. **Why do practical outcomes make a difference?** Concrete, visible results make it easier for employees to understand the relevance of the process, rather than it feeling like an extra burden or unnecessary task. **Why is this the root cause?** Without clear evidence that their input is valued and used, employees may not feel the need to engage with the lessons learned process, making it harder to foster a proactive learning culture.
Root cause prioritization	Root cause Recognition

Statement 9 Disagree with the statement but applies to me in the tender
Why? While I believe that most of the information captured is accurate and useful, I sometimes question whether all relevant lessons are included, or if the context provided is sufficient to fully understand the situations described. Sometimes the relevant things for someone else are overlooked Why would someone overlook something? This could happen if there's no standardized process or guidelines in place for documenting lessons, leading to variability in what is considered important or worth noting. Why is there variability in how lessons are documented? Variability exists because different people compile these documents, each with their own approach and understanding of what should be included, leading to inconsistencies in the documentation. Why is it important to have consistent and standardized documentation? Consistent and standardized practices are crucial to ensure that all relevant information is captured accurately and thoroughly, making the lessons learned documents more reliable and useful across the organization.
Root cause: No standardized documentation

In-depth interviews Alexia viaduct

A56

Statement 1 Agree with the statement and also applies to me in the tender	Statement 2 Agree with the statement and also applies to me in the tender
Why? Yes they leader decide whether a SharePoint for the tender is set up. which is critical for ensuring that every	Why? Bottom-up communication is actively encouraged, especially during technical discussions where input

team member has access to the same data from the outset. Why is centralizing information on SharePoint critical for the tender process? It's leadership that sets the tone for how rigorously these tools are used. If leaders prioritize the integration of lessons learned and make it clear that tools like SharePoint and UPOs are non-negotiable, the team is more likely to follow suit. Why do some projects fail to establish this centralized system? There may be inconsistencies in how leadership prioritizes the setup and use of such systems across different projects, possibly due to varying levels of understanding or commitment to these tools. Why might there be inconsistencies in how leadership prioritizes these systems? The value of such systems, like SharePoint and UPOs, might not be fully understood or communicated within the organization, leading to differences in how these tools are implemented and used. Leadership might be more focused on immediate project deliverables rather than long-term process improvements. Why might the value of long-term process improvements be underappreciated? There might be a broader cultural or organizational focus on immediate project outcomes rather than investing in process improvements that pay off in the long term. This can stem from a lack of incentives for project leaders to prioritize and maintain these systems beyond their immediate project goals.	from various levels, including juniors and mediors, is crucial. These inputs help refine project strategies and decisions, ensuring a well-rounded approach. Why is there a structure for communication from different levels? The tender process includes regular monthly group meetings specifically to discuss technical issues, ensuring that communication flows upward and that insights from all levels are considered for improving the project. Why is the group dynamic important for decision-making? During group discussions, team members openly share their challenges and solutions, which fosters a collaborative environment. This helps the team avoid pitfalls and make informed decisions based on shared knowledge. Why does the team focus on both technical and process-driven feedback? Both technical feedback and process-oriented input are shared during meetings, ensuring that solutions are both practical and executable. This structured communication helps the team align on objectives. Why is it essential to maintain this communication structure? Maintaining a consistent feedback loop through structured communication helps prevent recurring issues and ensures that lessons learned are applied efficiently in real-time across various levels of the team.
Root cause Prioritization	Root cause Open communication

Statement 3 Agree with the statement but it does not apply to me in the tender	Statement 4 Agree with the statement but it does not apply to me in the tender
Why? Because although I agree that having clear locations for lessons learned reports is important, in my experience, it doesn't apply effectively in the tender process. Why doesn't it apply effectively in the tender process? Because even though there are systems like SharePoint intended to store these reports, actually finding and accessing the relevant documents during the tender process is often difficult. Why is it difficult to find and access these reports? Because older project files are frequently restricted, and the system is not user-friendly or well-organized, making it challenging to retrieve the necessary	Why? I think this is definitely important, but in my experience, communicating and accessing lessons learned during the tender process isn't always as easy as it should be. Why isn't it always easy? Even though we have tools like SharePoint, they aren't always used optimally, and there's no streamlined process to effectively share the lessons. Why aren't these tools used optimally? The problem often lies in the lack of a clear standard for documenting and sharing lessons learned. This results in the usage of these tools being inconsistent and dependent on individual efforts.

information. I couldn't even have access to one of my old reports of a tender. Why are older files restricted, and why is the system not user-friendly? Because the current document management system lacks transparency and clear access controls, making it difficult for users to know where to find the documents or who to contact for access. Additionally, there hasn't been enough focus on optimizing the system for ease of use, leading to a platform that is cumbersome to navigate and not intuitive for the average user. Why hasn't there been enough focus on optimizing the system? Because the organization might prioritize immediate project deliverables over long-term process improvements, like enhancing the accessibility and usability of the lessons learned systems. This focus on short-term goals often results in less investment in the infrastructure needed to make these systems more effective, leading to persistent issues with accessibility and user experience.	Why is there no clear standard? Because within the organization, there's a lack of focus on implementing a unified system that centralizes the communication of lessons learned. This leads to teams creating their own methods, which causes inconsistency. Why is there a lack of focus on implementing a unified system? In my experience, there's more emphasis on achieving short-term project goals rather than investing in long-term process improvements like centralizing lessons learned. This often results in the potential of these lessons being underutilized.
Root cause No centralized system	Root cause Fragmented systems

Statement 5 Agree with the statement and applies to me in the tender	Statement 6 Agree with the statement but it does not apply to me in the tender
Why? I believe standardized documents could definitely streamline the sharing and application of knowledge, and we do use them in principle. Why does it only happen "in principle" and not fully? Although we have these standardized documents, their use isn't consistent across all projects, which limits their effectiveness. Why aren't they consistently integrated or applied? The implementation and adherence to these documents vary depending on the team or project, and there's a lack of strict oversight ensuring they're used uniformly. Why is there variation depending on the team or project? Some teams may not fully appreciate the value of these standardized documents or may prioritize other tasks, leading to inconsistent application. Why don't all teams appreciate the value or prioritize differently?	Why? I believe that a reliable and impactful repository for lessons learned, like the best practices database, could greatly improve how we report and apply lessons across projects. However, in its current state, this isn't fully realized. Why isn't this fully realized? Although we have a best practices database, it's incomplete and doesn't cover all the necessary topics, which limits its usefulness as a comprehensive tool for capturing lessons learned. Why is the best practices database incomplete? The development of these documents often gets pushed aside because those responsible are occupied with pressing project tasks, leaving the database underdeveloped. Why are project tasks prioritized over completing the best practices? Project demands usually take precedence over long-term initiatives like developing the best practices database. This results in delays and a lack of focus on completing these essential resources. Why do project demands take precedence?

Because leadership doesn't always emphasize the importance of these documents, and there's a lack of ongoing communication and training to reinforce their use.	The organization places more emphasis on meeting immediate project deadlines rather than investing in the long-term value of resources like the best practices database. This leads to the database being underutilized and not as impactful as it could be.
Root cause Inconsistent implementation	Root cause: Underdeveloped database.

Statement 7 Disagree with the statement but applies to me in the tender	Statement 8 agree with the statement but does not applies to me in the tender
Why? I disagree with the statement because, as a group leader, I already ensure that lessons learned are discussed regularly during our monthly technical meetings with my team. Why do I ensure that lessons learned are discussed regularly? Because it's crucial for maintaining a high level of technical expertise within the team. We use these meetings to discuss technical challenges, share solutions, and make sure that everyone learns from each other's experiences. Why is it crucial to maintain technical expertise within the team? By regularly discussing these lessons with a group of about 20 colleagues, we prevent the repetition of mistakes and ensure that knowledge is continuously shared and applied in future projects. Why does preventing the repetition of mistakes matter so much? Preventing repeated mistakes is essential for improving the quality of our work and ensuring that projects run more smoothly. These meetings allow us to collectively learn from past experiences and improve our processes. Why does collective learning improve our processes? Regularly sharing insights and documenting these discussions ensures that the entire team can benefit from individual experiences, creating a strong knowledge base that helps us handle future challenges more effectively.	Why? Mentorship and incentives play a crucial role in fostering a proactive culture of learning within our organization. Why are mentorship and incentives so important? Mentorship, especially within BAM, is designed to help employees develop not just their technical skills but also their soft skills. This comprehensive approach ensures that individuals are better equipped to contribute to the organization's success. Why does a comprehensive approach through mentorship matter? It matters because it provides employees with both the guidance and the confidence needed to apply lessons learned effectively in their work. Having a mentor who supports both technical and personal development helps in embedding a culture where learning is continuous. Why does this lead to a continuous learning culture? When employees feel supported and valued through mentorship and incentives, they are more likely to actively participate in discussions and share their own experiences and lessons learned. This active participation reinforces a culture of continuous improvement. Why does active participation reinforce continuous improvement? Active participation means that the collective knowledge of the team is constantly growing. By sharing insights regularly, we can prevent the repetition of mistakes and ensure that best practices are applied across projects, making the entire team more effective and resilient.
Root cause Structured monthly discussions.	Root cause Active learning

Statement 9 Disagree with the statement and does not apply to me in the tender
Why? I generally trust the lessons learned documents, but I recognize that they sometimes lack the full context needed to be entirely reliable for new projects. Why could they be more reliable and useful with better searchability and context? Because right now, while the documents are factually accurate, they lack the ease of searchability that would allow users to quickly find relevant lessons, similar to how you can find a house on Funda using a few keywords. Why is the lack of searchability an issue? Because it makes it harder to find the specific lessons that apply to a particular situation, leading to missed opportunities to apply valuable insights. Why does the difficulty in finding specific lessons reduce their reliability? When users can't easily locate the information they need, they may either overlook important lessons or not use the documents at all, reducing the overall effectiveness of the lessons learned system. Why does this reduce the overall effectiveness? Without an efficient search function, the full potential of the lessons learned is not realized, as the system becomes more cumbersome and less user-friendly, which discourages consistent use.
Root cause: Fragmentation

A46

Statement 1 Agree with the statement and also applies to me in the tender	Statement 2 Agree with the statement and also applies to me in the tender
Why? I analyzed previous tenders for clients like Havenbedrijf Rotterdam to identify what worked and what didn't. The commercial manager was instrumental in highlighting both successful strategies and areas of weakness, ensuring these insights were directly integrated into the new tender planning. Why is leadership critical in this process? The commercial manager understands the value of historical data and experiences, recognizing that previous successes and failures are invaluable for refining strategies and avoiding past mistakes in future tenders. Why does he tell you these lessons? In my role, the focus is on shaping the economic outcomes of tenders through strategic decisions. Technical details, like types of viaducts, while crucial for	Why? I regularly review past tenders to identify what has worked and what hasn't. The commercial manager plays a key role in emphasizing which strategies succeeded and where we fell short, and this guidance is crucial in planning new tenders. Why is leadership from above important? Leadership ensures that the insights from past experiences are not just collected but actively used. Not every lesson is useful for each person but encourages self-exploration Why does management's encouragement matter for bottom-up initiatives? Without management's support, bottom-up initiatives might not gain the traction they need. The group of the tender had 30 people so everyone looks for themselves for what is useful

our technical teams, don't directly impact the economic strategies I develop. Why do they impact the strategy? These lessons affect our strategic positioning. They enable me to develop proposals that are not just compliant, but also economically advantageous. Why are they not just compliant? They also easy my work and are not complicated	Why do bottom-up initiatives need this encouragement to be successful? When management signals that these initiatives are valued, it empowers teams to share insights and take ownership of improvements. This creates a culture where continuous learning and application of lessons is the norm. Why does this cultural shift matter for tender strategies? This cultural shift is essential because it ensures that every level of the organization is aligned in the pursuit of economically and strategically sound tenders, making our proposals stronger and more competitive.
Root cause Recognition	Root cause Stimulation initiatives

Statement 3 Don't agree with the stamen and also doesn't apply to me in the tender	Statement 4 Disagree with the statement but it does apply to me in the tender
Why? There is no fixed location or format for storing lessons learned, which means everyone handles it in their own way. Sometimes these reports are scattered across different locations. Why is there no fixed location or format? There is no standard process or tool within the organization that consolidates this information in one central place, everyone has its own way, leading to a lack of structured approach. Why isn't there a standard process? There has never been an urgent need to establish one because everyone is used to working and gathering information in their own way. Why hasn't this need been addressed? The current system is considered workable despite its inefficiencies, leading to a lack of urgency to implement a standardized process. Why does the current system persist despite inefficiencies? The stakeholders do not experience direct inconvenience or have adapted to the way things are done. Without clear pain points or pressure from upper management, everything remains as it is	Why? Lessons learned during the tender process are mostly factual and stored in the tender database. However, accessing deeper context or additional insights requires active inquiry, which is often neglected due to time constraints. Why is active inquiry often neglected? The process of reaching out to individuals for additional context takes significant time and effort, which is not always feasible given the tight deadlines and workload during tender processes. Why isn't it more streamlined ? The current system relies on individual initiative rather than providing a centralized and easily accessible repository for detailed contextual information. Why hasn't a more centralized system been implemented? There is a lack of perceived need or urgency to overhaul the existing system, as the current approach is seen as sufficient for most situations, despite its limitation Why is there no perceived need to improve the system? The limitations of the current system do not create immediate and obvious problems for most users, leading to a complacency that prevents the pursuit of a more efficient solution.
Root cause No initiative	Root cause prioritization.

Statement 5 Agree with the statement and applies to me in the tender	Statement 6 Agree with the statement but it does not apply to me in the tender
Why? Standardized documents could help ensure that important lessons and knowledge are actively brought to everyone's attention and not overlooked. Why isn't this already happening effectively? It's challenging to standardize how these documents should be created and shared, leading to inconsistent practices. Why is it challenging to standardize these documents? There hasn't been a clear, consistent approach or mandate within the organization to develop and enforce these standardized processes. Why hasn't a clear approach been developed? The focus has often been on other aspects of the tender process, and the importance of systematically capturing and sharing lessons learned hasn't been fully emphasized. Why hasn't this been fully emphasized? The current practice of sharing lessons learned is seen as sufficient by some, and there hasn't been enough pressure or recognition of the potential benefits of a more standardized approach.	Why? A reliable repository ensures that important lessons are captured and easily accessible, improving how lessons are reported and utilized in future tenders. Why isn't this always the case? In some tenders, such as the Alexiaviaduct, tools like Brainial, an AI-based Tender Assistant, were used, but this isn't standard practice across all projects. Why isn't Brainial or a similar tool used in all tenders? The use of such tools depends on the specific requirements of the tender and the availability of external resources, like the bureau that provides Brainial. Why is the usage dependent on specific tender requirements? Not all tenders have the same complexity or budget, leading to variability in the tools and resources allocated, meaning such advanced tools might not always be justified. Why isn't there a standardized approach to using these tools across all tenders? There hasn't been a consistent push to implement such tools universally, as their perceived value varies depending on the project's scale and importance. VBam already has contracts with other platform suppliers like microsoft
Root cause No initiative.	Root cause: Inconsistent implementation

Statement 7 Agree with the statement but it does not apply to me in the tender	Statement 8 Disagree with the statement and also does not apply to me in the tender
Why? Discussing lessons learned more frequently during meetings can ensure that valuable insights are captured and shared, enhancing the overall tender process. Why isn't this always happening? In the case of the Alexiaviaduct tender, lessons learned were discussed adequately, but in other tenders, this might not happen as frequently due to time constraints or the tender manager's priorities. Why do time constraints or priorities impact this? When time is limited or the tender manager deems other aspects more critical, discussions around lessons learned might be deprioritized or skipped. Why are discussions deprioritized or skipped in some tenders?	Why? they encourage people to actively engage in sharing and applying what they've learned by providing examples to follow and rewards for their efforts. Why do you believe process improvements are more impactful? We already spend a significant amount of time focusing on lessons learned, and I think with some process improvements, we could make this even more effective. Why do you think there's enough focus on lessons learned? In our current approach, we do manage to incorporate lessons learned, but it might lack some structure. However, I don't feel that adding incentives or mentorship would necessarily improve this.

The amount of available information varies. For example, if the client is new or there's less context available, there may be fewer relevant lessons to discuss. Why is there less context or information available for some clients? If the team has no previous experience with a particular client, the lack of prior interaction means there are fewer specific lessons learned that can be applied, making such discussions less impactful or less prioritized.	Why wouldn't incentives or mentorship improve the situation? I believe that the issue isn't about motivation or guidance, but more about how structured and consistent our processes are. Why do you think the focus should be on process improvement? I feel that with better processes in place, we can achieve a more systematic approach to integrating lessons learned, making it less dependent on individual efforts or extra motivation.
Root cause No time	Root cause Process improvement.

Statement 9 Agree with the statement and applies to me in the tender
Why? It depends on the source and the process used to compile them. Why does it depend on the source and process? The reliability of these documents can vary depending on who compiled them and how thorough they were in capturing all relevant insights. Why is there variability in how thorough the documents are? There isn't always a standardized process in place for documenting lessons learned, which can lead to inconsistencies in the quality and reliability of the information. Why isn't there a standardized process? The organization may not have fully emphasized the importance of a consistent approach to capturing and documenting lessons, leading to variations in how this is done. Why hasn't the importance of a standardized process been fully emphasized? There may be a perception that the current system is sufficient, or that the variability in documentation doesn't significantly impact outcomes, so it hasn't been prioritized for improvement.
Root cause: Consistent approach

A73

Statement 1 Agree with the statement but it does not apply to me in the tender	Statement 2 Agree with the statement and it applies to me in the tender
Why? I agree that management should always do this, but in practice, it doesn't always happen. It's more often left implicit rather than actively directed. Why is it often left implicit? The process relies heavily on individual initiative rather than a structured, management-driven effort to integrate lessons learned. Why is there no structured approach? There is a gap between what should happen and what actually happens. Lessons are often shared informally,	Why? During the tender process, input from different levels is taken seriously and acted upon. It's seen as a key factor, especially in the initial phases where various solutions are explored. Why is input from all levels important in this process? In the early phases of the tender, everyone is open to suggestions and ideas, ranging from very practical to abstract ones. It encourages a collaborative environment.

and there's a lack of consistent, visible action from management to formalize the process. Why does this gap exist? It depends on the person responsible. Some take the initiative to incorporate lessons, but it's not a standard procedure in the organization. Why is it dependent on the individual? The integration of lessons learned is more likely to occur when someone takes it upon themselves to share their insights, rather than it being a systematic part of the process.	Why does this work effectively? Teams composed of members from various departments and disciplines are engaged in the tender. The process depends on gathering valuable input from different perspectives, making the final solutions more comprehensive. Why is there a positive response to suggestions? Suggestions from all team members are taken seriously and used throughout the tender. While some ideas may not be pursued, the openness to various insights fosters a positive atmosphere for collaboration. Why does this create a productive tender environment? The integration of ideas from different levels ensures that the best options are considered. It also helps to align the team by balancing practical and innovative ideas.
Root cause: Prioritization	Root cause: Open communication

Statement 3 Disagree with the statement and it does not apply to me in the tender	Statement 4 Agree with the statement but it does not apply to me in the tender
Why ? I have no idea where these reports are stored. They are probably saved somewhere, but I don't know where to find them. Why do you not know where they are? After tenders are evaluated and documented, the reports often disappear into some database like SharePoint or Teams, and it's hard to retrieve them later. Why does this happen? The lessons learned get documented, but they are not stored in an easily accessible or centralized location that everyone can access. Why isn't there a better system for this? It seems there are many databases across the organization, which creates confusion about where to look for these reports. Why does this make accessing reports inefficient? With reports scattered across multiple databases and no clear central repository, it becomes difficult to know where to search for the information, leading to inefficiencies.	Why? Lessons learned are often discussed openly among the team, and this makes them accessible in conversations, but there is no formal system to ensure consistent access to documents. Why does this informal approach work for accessibility? Even though lessons learned are not always stored in a formal repository, the open communication among team members ensures that information is shared when needed. Why is the lack of formal documentation a problem? While discussions make the lessons accessible, the absence of a centralized system means that finding formal, written records later becomes difficult. Why does relying on informal communication create challenges? Without a structured system for documenting and storing lessons, the team depends on memory and interpersonal exchanges, which can lead to gaps in information sharing over time. Why hasn't this been addressed? Although open communication fills some gaps, the organization hasn't prioritized creating a formalized, easily accessible repository for lessons learned, leading to inconsistencies in accessibility.
Root cause: Fragmentation	Root cause: Informal communication

Statement 5 Agree with the statement but it does not apply to me in the tender	Statement 6 Agree with the statement but it does not apply to me in the tender

Why? having standardized documents would certainly help streamline the process, but this hasn't been implemented in the tender I worked on. Why hasn't this been implemented? There was no formal initiative to create standardized documents during this tender, so everyone followed their own methods for documenting lessons learned. Why does this happen? The tender process moves quickly, and there wasn't a clear directive to take the time to create or use standardized formats for documenting lessons learned. Why does the absence of standardization create issues? Without a standardized format, lessons are documented in different ways, which makes it harder to access or apply them across different tenders. Why is this problematic in the long run? When lessons learned are not standardized, they can easily be overlooked or inconsistently applied, leading to inefficiencies and repeated mistakes.	Why? Yes, I believe that a reliable and impactful repository would improve how we report lessons learned. However, it hasn't been implemented in the tender. Why hasn't this been implemented? The tender process has various databases and storage systems, but they are not well connected. This creates confusion about where to store and retrieve lessons learned. Why are the databases disconnected? There are multiple systems, like SharePoint and Teams, which are not integrated, and this makes it hard to create a single point of access for lessons learned. Why does this lack of integration cause problems? People often lose motivation after facing barriers, like not being able to find information across systems, and they resort to informal methods like calling colleagues instead. Why has this not been addressed? The complexity of multiple databases and the lack of a centralized system means the idea of a repository hasn't materialized, despite its potential value.
Root cause: No initiative	Root cause: Fragmentation

Statement 7: Agree with the statement and it applies to me in the tender	Statement 8: Agree with the statement and it applies to me in the tender
Why? Lessons learned are a regular topic of conversation, especially in larger tenders where formal evaluations occur more often. These meetings allow teams to adjust strategies and implement improvements in real-time, making them a critical part of the process. Why does the size of the tender affect these discussions? For larger tenders, midterm evaluations are held more frequently, leading to more structured discussions of lessons learned. However, in smaller tenders, while lessons are still discussed, these conversations may be less formal. Why are discussions equally valuable for both large and small tenders? Regardless of the tender size, frequent discussions of lessons learned help the team remain aligned and avoid repeated mistakes. It also reinforces best practices and ensures that all team members are informed. Why are these discussions not always structured? In smaller tenders or when time is tight, lessons learned may be discussed informally to focus on execution. Nevertheless, even in these cases, lessons are still addressed in team meetings. Why is it essential to formalize this process further? Formalizing lessons learned as a regular part of midterm meetings for all tender sizes would promote a	Why? Stimulants, such as mentorship programs or incentives, are necessary because they encourage continuous knowledge sharing within teams. These motivators ensure that lessons learned are captured and actively discussed in the project lifecycle, which reinforces a learning culture. Why is it important to institutionalize these practices? By having structured incentives like recognition programs or formal mentorship, it ensures that even when the pressure is on, team members will continue to contribute to knowledge sharing and learning. Without this, valuable lessons might be lost or not shared effectively. Why are stimulants valuable for both new and experienced team members? Stimulants help create a platform where both new and experienced team members feel valued and recognized for sharing insights. This benefits the whole team by expanding the collective knowledge base. Why might there be reluctance in implementing formal stimulants? In some projects, the focus might be more on speed and execution, rather than on reflection and learning. However, even in these environments, informal conversations can help bridge the gap. Why is it important to formalize this process further? Formalizing stimulants and mentorship ensures that

proactive approach and ensure continuous improvement across the board.	knowledge transfer happens consistently and that team members are recognized for their contributions, which boosts overall engagement and continuous learning.
Root cause: Consistent approach	Root cause: Active engagement.

Statement 9: Agree with the statement and it applies to me in the tender
Why? There is an inherent trust in the information provided in lessons learned documents. People often believe in the reliability of the information shared within their network or by colleagues. This is largely due to the implicit trust built through ongoing collaboration, making the data feel dependable. Why is context important in understanding the reliability of documents? Even though the information is trusted, the context in which the lessons were learned is often missing. It is essential to have context, such as when and under what conditions the lesson was applicable, to ensure its relevance and usability for future projects. This lack of context can sometimes lead to challenges in determining how applicable the lesson is. Why are additional discussions with colleagues necessary? When there is insufficient context in a document, people often follow up by contacting the person who originally contributed the lesson to get a clearer understanding. This ensures the lesson's applicability to the current tender and helps in drawing the right conclusions from the data. Why do lessons need to be critically assessed? While there is trust in the accuracy of the lessons, it is still necessary to assess whether the lesson is relevant to the current tender. Lessons from older projects or outdated practices might no longer apply, and critical judgment is needed to determine their value. Why should lessons be documented with more context? Providing detailed context with each lesson would make the documents more universally useful, reducing the need for follow-up and ensuring that future teams can understand the relevance and application without needing to seek additional clarifications.
Root cause: Need for context

In-depth interviews N346

A66

Statement 1 Disagree with the statement but applies to me in the tender	Statement 2 Disagree with the statement but applies to me in the tender
Why? There are initiatives, however there is no specific focus from management to integrate lessons learned. **Why isn't management steering the use of lessons learned more directly?** Management doesn't explicitly push for it; it's more of an individual responsibility to store and apply these lessons. Each person, like me, has their own way of collecting and managing lessons learned, which works well for their specific tasks. **Why do individuals prefer their own systems?** Central systems, such as SharePoint, often come with	**Why?** There are evaluations at the end of a project, but it own initiative, not really bottom up structured. **Why does input mostly happen at the end of the project?** The organization has a structure where lessons learned and evaluations are typically part of the project's conclusion rather than an ongoing part of the process. **Why isn't the process more continuous?** There's no formal system in place to ensure regular input from all team members throughout the project.

access issues or limitations, making personal storage and tracking more reliable. **Why are there access issues with central systems?** Centralized platforms like SharePoint often result in permission problems or sites being difficult to access, causing inefficiencies. **Why does this create inefficiencies?** Because if a person loses access to a shared platform, they lose valuable information, making it more reliable to keep things locally or in personal systems.	**Why isn't there a formal system for continuous feedback?** The organization relies on post-project evaluations and sees those as sufficient, without recognizing the potential benefits of integrating feedback throughout the project. **Why does the organization rely on post-project evaluations?** It has become standard practice, and the lack of perceived urgency or understanding of the value of continuous feedback means this process hasn't been improved.
Root cause: Reliance on personal systems.	Root cause: Open communication

Statement 3 Agree with the statement and also applies to me in the tender	Statement 4 Agree with the statement but it does not apply to me in the tender
Why? I store all my important information and lessons learned in my own systems, including my cost monitoring model and calculation program. **Why do you store information in your own systems?** It's more efficient for me to have everything stored locally, and I know exactly where to find the data I need for different projects. **Why don't you rely on SharePoint or other centralized platforms?** SharePoint often comes with access issues, and I find it more practical to store everything on my own computer where I have full control. **Why do you prefer full control over centralized systems?** Centralized systems can be cumbersome, and if I lose access, I can't rely on those platforms. By storing data locally, I eliminate that risk. **Why is avoiding access issues important for you?** It saves me time and ensures I always have access to the exact information I need, which helps me work more efficiently without delays.	**Why?** There's too much text, and it's a hassle to go through everything. I prefer just calling a colleague directly for specific information. **Why do you prefer calling colleagues over reading documents?** Calling is faster and more efficient. I get the exact information I need without sifting through long documents or reports. **Why do you think documents are less efficient?** Documents often include too much unnecessary information, and it takes time to figure out how someone else has structured their knowledge. **Why does the structure of the documents make it harder?** Everyone has their own way of organizing things, which makes it difficult to quickly find the relevant details when you're in a time crunch. **Why isn't there a more standardized or streamlined approach?** It's not as practical for me, and I think face-to-face or phone communication is more effective in real-time scenarios.
Root cause: Desire for control	Root cause: Informal communication

Statement 5 Agree with the statement but it does not apply to me in the tender	Statement 6 Agree with the statement but it does not apply to me in the tender
Why? Standardization would ensure that everyone follows the same structure, making it easier to share and apply knowledge across the organization. **Why isn't this already happening effectively?** In a large organization, everyone works in their own	**Why?** A repository could centralize important data, making it easier to access and use for future projects, especially for cost-related lessons. **Why doesn't this apply to your work?** I believe that while cost-related data can be

way, and standardizing across different departments and teams is challenging because of varying interests and methods. **Why is it challenging to implement standardization across the organization?** Each department or individual has their own goals, and whenever a new director or manager takes over, the existing standards are often questioned or changed. **Why do new directors or managers change the standards?** Everyone has their own approach or system they are comfortable with, and convincing new leadership to stick to established standards can be time-consuming and difficult. **Why is it hard to maintain consistent standards across the organization?** It's difficult to enforce a standardized system from the bottom-up without support from upper management, and individual influence is often limited.	standardized and shared, the dynamic nature of tenders makes it difficult to maintain a reliable repository that covers all aspects of project planning. **Why is it hard to maintain a reliable repository for tender projects?** Tender processes are highly flexible and change frequently, which makes it hard to keep everything up-to-date and relevant in a central database. **Why does the flexibility of tenders make it difficult?** Changes in project details, such as cost estimations or timelines, often break connections in the system, requiring additional time and energy to update and adjust the data. **Why aren't these processes streamlined?** The systems and standards are not fully aligned across departments, and management changes can further disrupt the implementation of standardized processes.
Root cause: No management enforcement	Root cause: Under developed data base

Statement 7 Disagree with the statement but applies to me in the tender	Statement 8: Agree with the statement and applies to me in the tender
Why? For me, it's not necessary to formally include this as an agenda item unless there's a specific need for it. **Why do you feel there's no need to include it formally?** We have partners and experts connected to the project who handle specific technical aspects, so lessons are picked up as needed. **Why don't you see the need for formal documentation of lessons learned?** I trust that we are all professionals, and when there's a need to address or implement lessons, we'll do so without needing formal processes. **Why do you rely on professionals rather than formal processes?** I believe that a more flexible, case-by-case approach works better. If a lesson is relevant, we'll address it in the moment. **Why do you prefer this flexible approach over formalized structures?** Formalizing everything adds unnecessary bureaucracy, and I prefer relying on practical expertise and real-time problem-solving.	**Why?** New employees need guidance, and it helps them learn quickly and integrate better into the team. **Why is mentorship particularly important for new employees?** They don't have the experience that longer-tenured employees do, so they need someone to show them the way and explain procedures. W**hy does this process need to be formalized through mentorship and not just informal learning?** A structured mentorship program gives new employees the tools and resources they need to understand how the company operates, which speeds up their integration. W**hy does mentorship need to be paired with incentives to foster a proactive learning culture?** Without incentives, employees may not feel motivated to actively engage in the mentorship process or take initiative in learning lessons from past projects. **Why do you think a lack of incentives or inconsistent leadership undermines this culture?** When management changes or fails to support these initiatives, it discourages employees from putting in the effort, knowing their work may not be recognized or continued.
Root cause: Prioritization.	Root cause: Consistent approach

Statement 9: Agree with the statement and applies to me in the tender
Why?

I create these documents myself, so I know they are reliable and based on accurate data. And I also trust my colleagues. **Why do you think the documents you create are reliable?** I use my own knowledge and experience to compile the information, and if there's anything I'm unsure about, I ask colleagues or the client for clarification. **Why do you consult colleagues or the client if you're unsure?** They often have specific expertise or knowledge that can help clarify certain details, especially in areas I might not be as familiar with, like engineering or technical matters. **Why do you trust their input when it comes to lessons learned?** I work with professionals I trust, and I know that most of my colleagues are skilled and knowledgeable in their respective areas. It's important to collaborate to ensure the accuracy of our work. **Why is it important for you to validate the information with your own judgment as well?** Even though I trust my colleagues, I always use my own critical thinking and technical knowledge to ensure that the information aligns with the project's needs and standards, especially when it's part of a contract or crucial decision-making.
Root cause: Trust

A71

Statement 1 Agree with the statement and it applies to me in the tender	Statement 2 Agree with the statement but it does not apply to me in the tender
Why? Management, especially those in leadership roles like tender managers, are responsible for ensuring that the lessons learned from previous projects are incorporated into new tenders to enhance decision-making and efficiency. Why is management responsible for ensuring lessons learned are applied? Management holds oversight of the tender process and typically has the experience and strategic view to identify critical lessons from past projects that can improve current performance Why do they rely on past lessons? The tender process is often based on accumulating knowledge to mitigate risks, reduce inefficiencies, and increase the likelihood of project success. This is especially important since tendering involves high stakes, such as financial investments and competitive advantages. Why do lessons from past projects matter in the tender process? Each tender can be unique in scope and challenges, but similarities across projects mean that past experiences can provide invaluable insights, preventing the repetition of mistakes and improving overall execution. Why is it critical for management to ensure these lessons are not only integrated but also consistently used? Without management pushing for their integration, lessons learned could be neglected or forgotten, leading to recurring issues and missed opportunities for	Why? To ensure all levels of the organization contribute valuable insights and feedback, making the decision-making process more informed. Why is it important to have input from all levels in the process? Different roles within the organization have varied experiences, and gathering insights from all levels helps capture a more holistic view of potential issues and solutions. Why does it not apply during this tender? The tender team is often small and focused, meaning fewer opportunities exist for input from broader levels of the organization Why is the team size small in the tender process? Tender processes typically operate under tight deadlines, requiring compact and efficient teams to make quick decisions. Why does this small team limit bottom-up communication? With fewer people involved, the range of input is naturally narrower, and communication tends to focus more on immediate team members rather than across the organization.

optimization, ultimately affecting project outcomes negatively.	
Root cause: Management enforcement	Root cause: Informal communication

Statement 3 Disagree with the statement and it does not apply to me in the tender	Statement 4 Agree with the statement and it applies to me in the tender
Why? I have no idea where to find them. It's really a matter of searching, and I end up calling people to ask where they are. Why do people need to search for these reports? When I start searching, someone refers me to one person, who refers me to another, and eventually, I find out where they are. But it's a hassle. Why are people unsure of the location of reports? There isn't a central place like SharePoint where you can just click and find everything. You have to ask around. Why hasn't this issue been addressed? There's no standardized system for storing lessons learned. It's a bit chaotic. Why does the current method of finding lessons learned hinder efficiency? Because people have to call and ask around, which leads to inefficiencies and wasted time	Why? If I don't have access to certain documents, I simply ask for it, and I always receive access without any issues. Why is there no problem with accessibility? In my experience, gaining access to the required documents is straightforward as long as I request it. Why does this work effectively? There are no major barriers to obtaining lessons learned, and the system is set up to ensure that the necessary permissions are granted quickly. Why does asking for access work so well? Because the organization is responsive, and people are willing to provide access when requested. Why is this system efficient for accessing lessons? The culture within the organization supports open communication, so when someone needs information, it's provided promptly.
Root cause: No centralized system	Root cause: Easy request

Statement 5 Agree with the statement but it does not apply to me in the tender	Statement 6 Agree with the statement but it does not apply to me in the tender
Why? Yes, having a standardized format would help, because everyone would document lessons in the same way. Why is a standardized format useful? It ensures consistency, making it easier to access and understand the lessons learned across different projects. Why is this not the only solution? A standardized document alone is not the solution; it needs to be supplemented with personal communication to provide context. Why does communication remain necessary? Because a document can't capture all the nuances of a lesson, and further explanation or discussion is often needed to apply the lesson effectively. Why is personal communication still important despite having standardized documents? Standardized documents can only go so far in sharing lessons learned, but the added context from direct	Why? Yes, a well-organized repository would help, as it ensures that all lessons are stored in a centralized and easily accessible place. Why is this repository not available in the tender? There isn't a dedicated repository for lessons learned in this project; accessing lessons is more reliant on informal communication and searching. Why has a repository not been implemented? The organization does not have a formalized system in place to gather and store lessons learned in a centralized location. Why does this hinder the reporting of lessons learned? Without a centralized repository, the process of finding and sharing lessons becomes inconsistent, often depending on individuals rather than an organized system. Why is this an issue for future tenders? The lack of a reliable system makes it harder to quickly

communication enhances understanding and application.	find relevant lessons, leading to missed opportunities to apply past experiences effectively.
Root cause: Lack of context	Root cause: No centralized system

Statement 7 Agree with the statement but it does not apply to me in the tender	Statement 8 Agree with the statement and it applies to me in the tender
Why? We did not discuss lessons learned during the tender process itself, only during the final evaluation at the end. Why were lessons learned only discussed at the end? The tender was under time pressure, so there wasn't enough time to hold midterm evaluations focused on lessons learned. Why does time pressure limit midterm discussions? Shorter tenders (two to three months) don't allow for reflection or meetings dedicated to lessons learned, as the team is focused on meeting deadlines. Why is this a challenge in longer tenders? Even in longer tenders, like the one that lasted 10 months, there was no formal moment set aside to reflect on lessons learned midterm. Why would discussing lessons midterm improve the process? Midterm discussions would allow teams to identify issues early on and make adjustments before the tender is completed, improving the process overall.	Why? Management incentives help, particularly for those who do not naturally share lessons learned. During this tender, people were encouraged to document and share lessons learned in Relatics. Why is this necessary even when people already share lessons? While most people share lessons learned on their own, there are always a few who need encouragement from management to do so. Why does mentorship also help? Mentorship, especially for younger or less experienced employees, helps guide them in the importance of documenting and sharing lessons learned. Why is mentorship especially helpful for new employees? New employees are still learning the processes, and mentorship can instill the habit of sharing and documenting lessons learned early on. Why does this combination foster a proactive culture? By combining mentorship and management incentives, even those who are less inclined to share can be encouraged, creating a more open and proactive knowledge-sharing environment.
Root cause: No time	Root cause: Consistent knowledge sharing

Statement 9 Agree with the statement and it applies to me in the tender
Why? Yes, I trust the documents, because if I couldn't trust them, it would make no sense to use them. Even if a document is a bit older, I still trust its value. Why is this trust important? When dealing with lessons learned from past projects, it's crucial to rely on them, even if some time has passed since they were created. Why could older documents still be useful? Even if documents are five years old, they still offer valuable information. However, if a document is 15 years old, especially concerning client relationships or legal frameworks, it may be outdated. Why is filtering important for older documents? The world changes, and with it, things like regulations and relationships evolve. While older documents may still have useful insights, they require filtering for current relevance. Why does this approach help maintain reliability? By filtering and cross-checking older information, I can still trust the core lessons while being cautious about outdated specifics like client interaction methods or changing legal standards.
Root cause: Trust

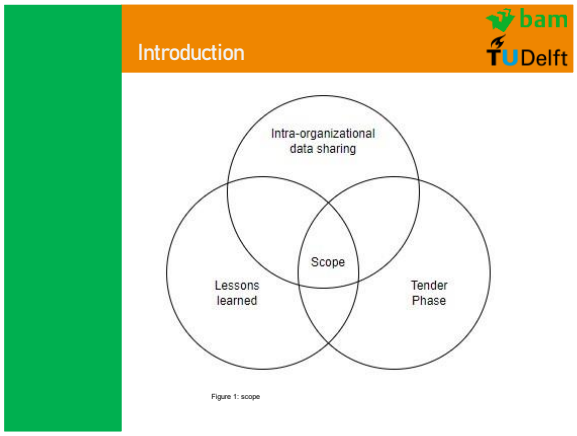
Appendix G

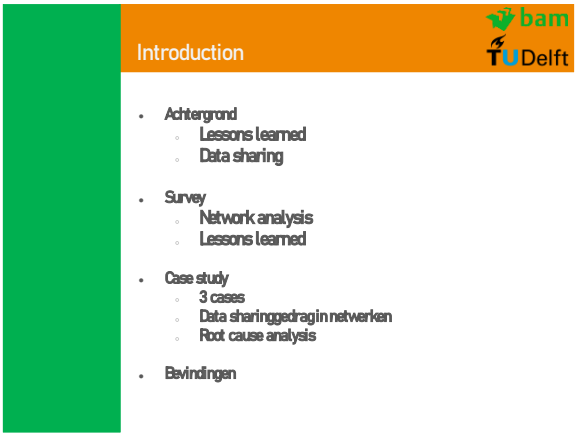
Appendix G provides a detailed overview of the validation process conducted to evaluate the findings of this research. Four key experts within the organization were consulted for this validation: the Commerce Director, the PMC Director, the Design Manager, and the Knowledge Manager. These experts were involved due to their extensive knowledge and experience with the tender process and knowledge management within the company.

The validation session, conducted in Dutch, included a PowerPoint presentation to outline the research findings and explain the proposed GIS-based knowledge-sharing application. This application aims to improve knowledge sharing within the tender process, specifically by making lessons learned and project documents visually accessible through a GIS portal. The presentation served to demonstrate the structure and functionalities of the tool, as well as to gather feedback from the attending experts.The Commerce Director and PMC Director offered perspectives on how the GIS tool could enhance communication and data flows in future projects, while the Design Manager and Knowledge Manager provided specific suggestions to optimize the integration of the tool into existing systems. Their feedback was essential in refining the practical implementation of the GIS application, ensuring it better aligns with daily work processes and existing software such as SharePoint. Additionally, a GIS specialist was interviewed separately to offer insights into the technical aspects and feasibility of the GIS application. His feedback focused on the application's integration with the existing systems and the benefits of using GIS for document visualization while ensuring that the storage of documents remains within platforms like SharePoint. This input further strengthened the tool's design by emphasizing its role as a visual interface rather than a storage solution.

The validation process, as presented in Appendix G, was a crucial step in ensuring the usability and applicability of the proposed recommendations, including the development of the GIS tool, across the broader organization.

Presentation





Literature review

- Lessons learned:
  - Level 1 – Reactive Capture
  - Level 2 – Reactive Change
  - Level 3 – Proactive change

Kern vraag

Hoe kunnen we de integratie en vastlegging van geleerde lessen binnen tenderprocessen verbeteren?

Literature review

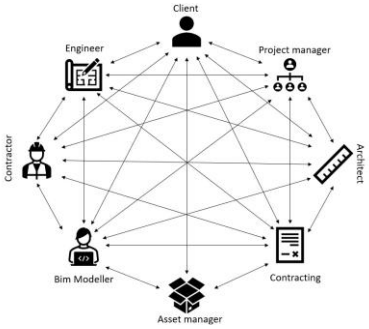


Figure 2: Conventional data sharing

Literature review

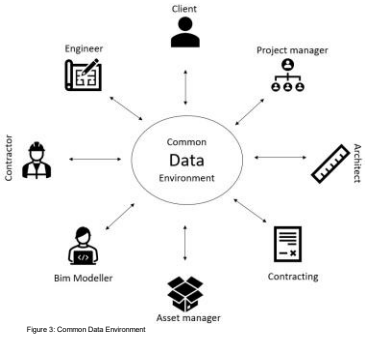
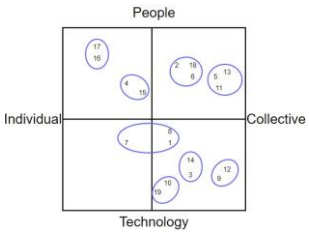


Figure 3: Common Data Environment

Literature review

Factor
1. Searchability and Accessibility of Lessons Learned
2. Shared Learning Sessions for Knowledge Exchange
3. Use of Digital Platforms for Knowledge Sharing
4. Mentorship and Coaching to Reinforce Lessons Application
5. Top-Down Support for Prioritizing Lessons Learned Integration
6. Encouraging Bottom -Up Communication to Capture Insights
7. E-Learning Modules to Train Employees on Lessons Learned
8. Formalized Processes for Capturing and Applying Lessons Learned
9. Continuous Improvement Cycles Driven by Lessons Learned
10. Data Analytics to Identify Trends in Lessons Learned
11. Fostering a Learning -Oriented Culture for Knowledge Integration
12. Integration of Lessons Learned into the Tender Lifecycle
13. Active Involvement of Management in Promoting Lessons Learned
14. Effective Documentation Tools for Capturing Lessons Learned
15. Motivation and Incentives to Encourage Participation in Lessons
16. Ongoing Training Programs for Lessons Learned Best Practices
17. Psychological Safety to Encourage Open Sharing of Insights
18. Interdepartmental Communication for Cross -Project Learning
19. Monitoring and Adjustments to Refine Lessons Learned Processes

Literature review



Root cause analysis

Case studies

- 3 cases
  - N346
  - Prinses Alexiaviaduct
  - N211 wippolderlaan

Case studies

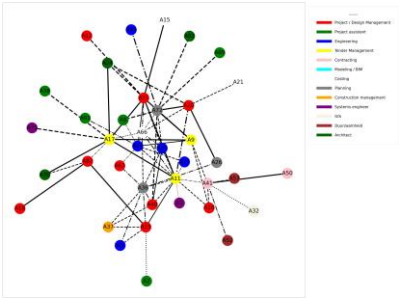


Figure 4: N346 Network

Case studies

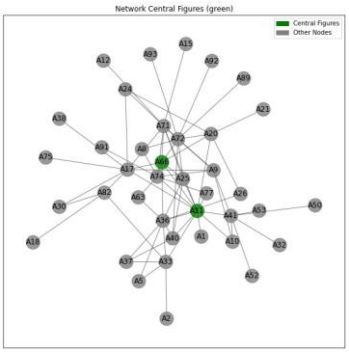


Figure 6: N346 Central figures

Data Analysis

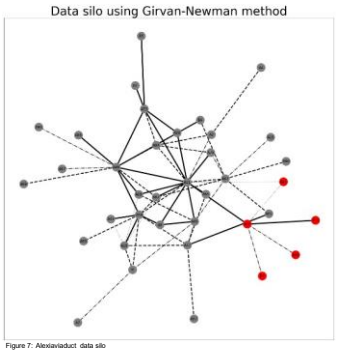


Figure 7: Alexiaviaduct data silo

Case studies

Chart 1: lessons learned used

Case studies

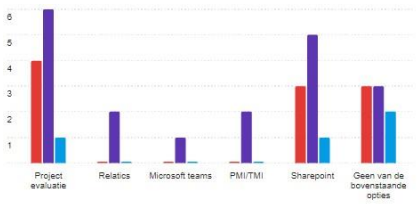


Chart 2: lessons learned tools

Case studies

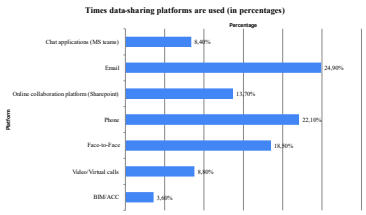


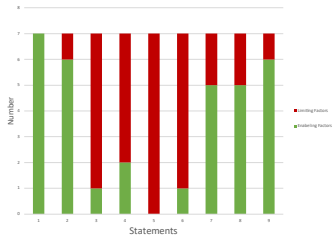
Chart 3: Tools used for data sharing

Root cause analysis

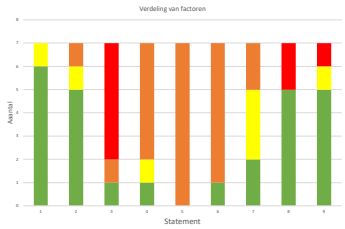
Root causes

Reading guide			
Agree with the statement and also applies to me in the tender (Enabling factor)	Disagree with the statement but applies to me in the tender (Enabling factor)	Agree with the statement but it does not apply to me in the tender (Limiting Factor)	Disagree with the statement and it does not apply to me in the tender (Limiting factor)

Root causes



Root cause



Root cause

Root causes of enabeling factors	#	%
Prioritization	5	16%
Open communication	4	13%
Consistent approach	4	13%
Active learning	2	6%
Recognition	2	6%
Need for context	2	6%
Trust	2	6%
Decentralized department storag	2	6%
Structured discussions	1	3%
Actionable outcomes	1	3%
Uniform leadership practices.	1	3%
Formalized approach	1	3%
Stimulation	1	3%
Engagement into daily practices	1	3%
Management enforcement	1	3%
Easy request	1	3%
Process overview	1	3%

Rootcauses of limiting factors	#	%
Fragmentation	7	22%
Informal communication	6	19%
No centralized system	3	9%
No initiative	3	9%
Inconsistent implementation	2	6%
No time	2	6%
Process improvement	2	6%
Underdeveloped database.	2	6%
No formal system	2	6%
No standardized documentation	1	3%
Lack of context	1	3%
No management enforcement	1	3%

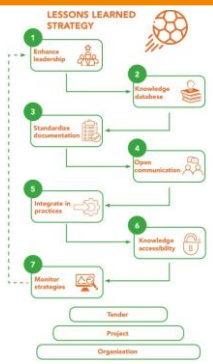
Root cause

Root cause	Lessons learned factors from theory	En.%	Im.%	Tot%
• Prioritization • Management enforcement •Uniform practices. - No management enforcement	Top-Down Support for Prioritizing Lessons Learned Integration	25%	3%	12%
• Consistent approach • Formalized approach - No formal system	Formalized Processes for Capturing and Applying Lessons Learned	16%	6%	11%
• Open Communication • Easy request - Underdeveloped database	Use of digital platforms for knowledge sharing	14%	6%	10%
• Stimulation • Recognition - No initiative	Motivation and Incentives to Encourage Participation in Lessons	9%	9%	9%
• Active learning - Lack of process - No time	E-Learning Modules to Train Employees on Lessons Learned	6%	12%	9%
• Structured discussions - **Informal communication**	Encouraging Bottom-Up Communication to Capture Insights	3%	-	2%
• Trust	Psychological Safety to Encourage Open Sharing of Insights	6%	-	3%
• Actionable outcomes - Inconsistent implementation	Monitoring and Adjustments to Refine Lessons Learned Processes	3%	6%	5%
• Decentralized department storage - **No centralized system** - **Lack of context**	Searchability and Accessibility of Lessons Learned	6%	12%	9%
• Need for context - No standardized documentation - Informal communication	Effective Documentation Tools for Capturing Lessons Learned	6%	22%	14%
• Process overview • Engagement into daily practices • Fragmentation	Integration of Lessons Learned into the Tender Lifecycle	6%	22%	14%

Strategie

Hoe kunnen we de integratie en vastlegging van geleerde lessen binnen tenderprocessen verbeteren?

Road map



Appendix H

Appendix H provides a detailed overview of the GIS application design, focusing on its structure for knowledge sharing and metadata integration. This appendix demonstrates how the GIS interface organizes and categorizes project knowledge documents by geographic coordinates, project type, and other metadata. It illustrates the prototype's design elements, including the filtering options and visual layout that enable users to quickly locate and upload relevant documents. Additionally, Appendix H showcases how metadata, such as geographic location and project phase, is utilized to enrich document context, supporting intuitive navigation and efficient knowledge retrieval.

GIS Application Design

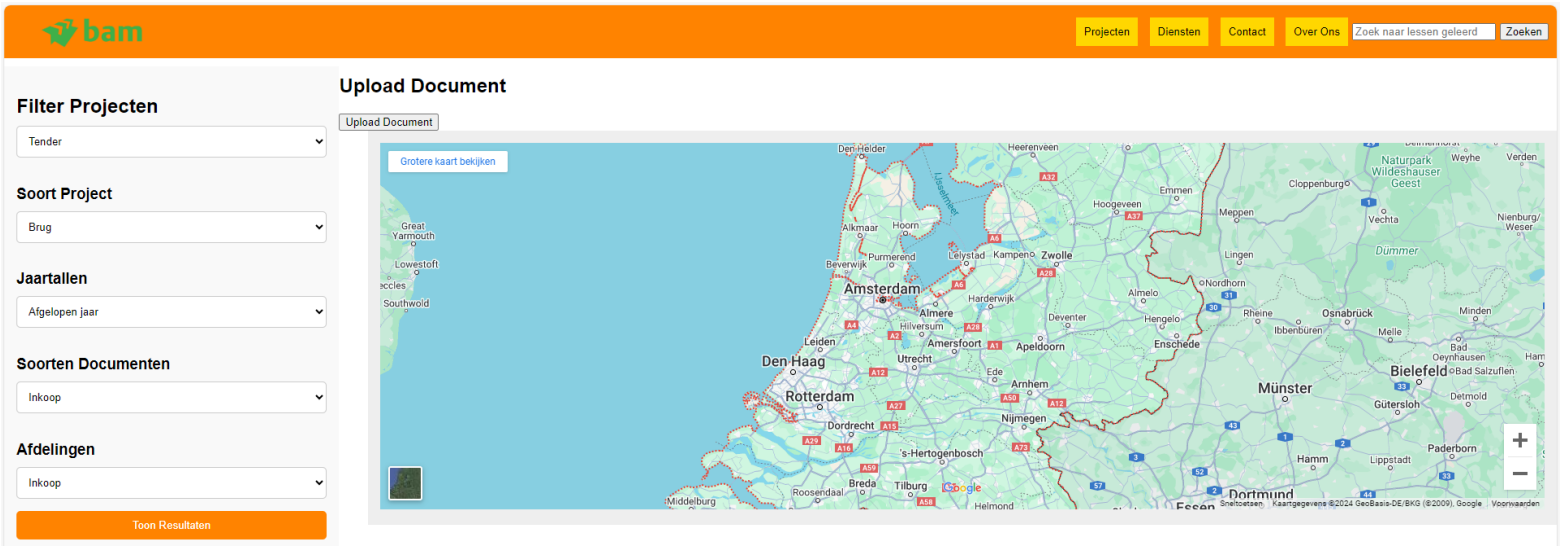


Figure 46: GIS-Based Document Upload and Filtering Interface

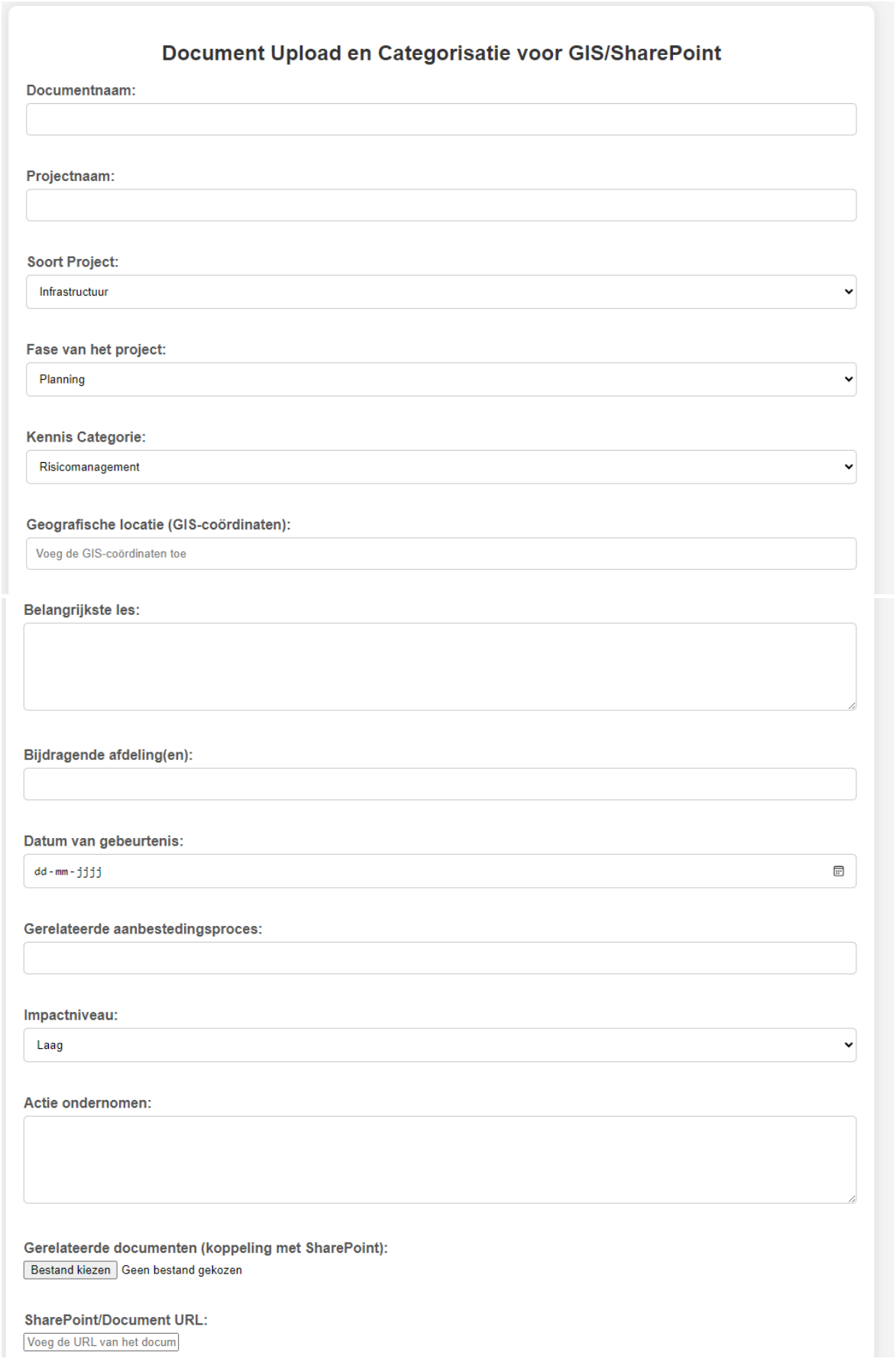


Figure 47:Document Upload and Categorization Interface for GIS/SharePoint Integration

Metadata Structure for Geographical Tagging

Name	Project	Tender	Project Phase	Knowledge Category	Latitude	Longitude	Date	Impact Level	Document Owner
Lessons Learned	Project Alpha		Execution	Lessons Learned	52.370216	4.895168	2024-10-20	High	John Smith
Best Practice		Tender 002	Design	Best Practice	51.9225	4.47917	2024-10-21	Medium	Mary Johnson
Near Miss	Project Gamma		Construction	Near Miss	52.090736	5.12142	2024-10-22	Low	James Lee
Incident Report		Tender 004	Completion	Incident	52.070498	4.3007	2024-10-23	Critical	Emma Williams

Figure 48: Metadata Structure for Geographical Tagging