USING POST-PROJECT REVIEWS FOR RISK ASSESSMENT OF CONSTRUCTION PROJECTS

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ABSTRACT

POST-PROJECT REVIEWS FOR RISK ASSESSMENT OF CONSTRUCTION PROJECTS

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Risk management (RM) is about identifying risk factors, analyzing their impacts on project success, and developing management strategies to mitigate them. Learning from previous projects to make better predictions in forthcoming projects is critical for the success of RM activities. Many construction companies conduct post-project reviews (PPRs) to record lessons learned (LL) from projects. However, if these reports do not contain the necessary risk-related information and are not prepared and stored in the proper format, they cannot be utilized during a risk assessment. This thesis aims to explore post-project appraisal practices in construction companies, types of knowledge retained by these reports, and particularly investigate how these reports used during risk informed decision making. In order to explore current practices and learn the opinions of experts on the utilization of PPRs in forthcoming projects, semi-structured interviews are conducted. Four experts from four medium-large scale construction companies that have international experience are interviewed. Interviews were transcribed, and qualitative analysis of semi-structured interviews was carried out by using the QSR

Nvivo qualitative data analysis software. Findings revealed how PPRs could be used for learning from previous projects and risk assessment and formulating potential ways/strategies to improve this process. The study's key findings include as follow: organizations must determine required risk knowledge and LL and target those lessons to particular audiences; the format and content of the PPRs dictate how the lessons should be obtained, stored, and disseminated for risk assessment of projects; lack of administration involvement to the PPR process is the most critical barrier to include and use risk knowledge. The findings strongly indicate that collecting and sharing risk knowledge should be based on a structured strategy to increase the benefits of applying PPRs for risk assessment of construction projects. It is believed that thesis findings will contribute to the body of knowledge on project risk management, and the study will provide practical contributions for construction companies aim to improve their risk management systems.

Keywords: Risk Management, Post-Project Reviews, Knowledge Management, Lessons Learned

ÖZ

İNŞAAT PROJELERİNİN RİSK DEĞERLENDİRMESİ İÇİN PROJE SONRASI İNCELEMELERİN KULLANILMASI

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Risk yönetimi, risk faktörlerini belirlemek, bunların proje başarısı üzerindeki etkilerini analiz etmek ve bunları azaltmak için yönetim stratejileri geliştirmekle ilgilidir. Gelecek projelerde daha iyi tahminler yapmak için önceki projelerden öğrenmek, risk yönetimi faaliyetlerinin başarısı için kritik öneme sahiptir. Birçok inşaat şirketi, projelerden öğrenilen dersleri kaydetmek için proje sonrası incelemeler yapar. Ancak bu raporların riskle ilgili gerekli bilgileri içermemesi ve uygun formatta hazırlanıp saklanmaması durumunda risk değerlendirmesi sırasında kullanılamaz. Bu tez, inşaat şirketlerindeki proje sonrası değerlendirme uygulamalarını, bu raporlarda tutulan bilgi türlerini ve özellikle bu raporların riske dayalı karar verme sırasında nasıl kullanıldığını araştırmayı amaçlamaktadır. Mevcut uygulamaları keşfetmek ve gelecek projelerde proje sonrası incelemelerin kullanımına ilişkin uzmanların görüşlerini öğrenmek için yarı yapılandırılmış görüşmeler yapılmıştır. Uluslararası deneyime sahip dört orta-büyük ölçekli inşaat firmasından uzmanlarla görüşülmüştür. Görüşmeler yazıya dökülmüş ve QSR

NVivo nitel veri analiz yazılımı kullanılarak yarı yapılandırılmış görüşmelerin niteliksel analizi gerçekleştirilmiştir. Bulgular, proje sonrası değerlendirme raporların önceki projelerden öğrenmek için nasıl kullanılabileceğini, bunların nasıl yakalanması, saklanması ve inşaat projelerinin risk değerlendirmeleri için paylaşılması gerektiğini ve bu süreci iyileştirmek için olası yolları/stratejileri formüle etmeyi ortaya koymuştur. Çalışmanın temel bulguları arasında şunlar yer almaktadır: kuruluşlar, gerekli risk bilgisini ve alınan dersleri belirlemeli ve bu dersleri belirli hedef kitlelere hedeflemelidir; proje sonrası değerlendirme raporların formatı ve içeriği, projelerin risk değerlendirmesi için derslerin nasıl alınacağını, saklanacağını ve dağıtılacağını belirler; proje sonrası değerlendirme raporların sürecine yönetim katılımının olmaması, risk bilgisini dahil etmek ve kullanmak için en kritik engeldir. Bulgular, risk bilgisinin toplanması ve paylaşılmasının, inşaat projelerinin risk değerlendirmesi için proje sonrası incelemelerin uygulanmasının faydalarını artırmak için yapılandırılmış bir stratejiye dayanması gerektiğini kuvvetle göstermektedir. Tez bulgularının proje risk yönetimi konusundaki bilgi birikimine katkı sağlayacağı ve çalışmanın risk yönetim sistemlerini geliştirmeyi hedefleyen inşaat şirketlerine pratik katkılar sağlayacağı düşünülmektedir.

Anahtar Kelimeler: Risk Yönetimi, Proje Sonrası İncelemeler, Bilgi Yönetimi, Alınan Dersler

Dedicated to my precious brother Mohammad

and the memory of my beloved Cousin Ilyar…

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LIST OF ABBREVIATIONS

ABBREVIATIONS

CBR: Case-Based Reasoning

COSO: Committee of Sponsoring Organizations of the Treadway Commission

ERM: Enterprise Risk Manegement

IT: Information Technology

KM: Knowledge Management

KRM: Knowledge Risk Management

LL: Lessons Learned

PMBoK: Project Management Body of Knowledge

PMI: Project Management Institute

PPR: Post-Project Review

PRM: Project Risk Management

QDA: Qualitative Data Analysis

RM: Risk Management

RMMM: Risk Risk Management Maturity Model

VSM: Vector Space Model

CHAPTER 1

INTRODUCTION

The construction industry is well known as one of the most risk-prone industries in the world. Unique nature of projects, complexity of the work involved in construction activities, long project duration, construction finance, and dynamic organizational structures make this industry more predisposed to risk than other industries (Okudan et al., 2021; Park et al., 2010). It is hard to achieve construction objectives such as time, cost, and quality without effective detection and proper control of risk. As a result, risk management has become an essential concept among construction firms (Okudan et al., 2021).

Risk management is the process that comprises a systematic process of identifying, analyzing, and evaluating risks, developing strategies to mitigate them, and monitoring risks throughout the life cycle of a project. The risk identification stage specifies the prospective hazards that might endanger the processes. Qualitative and quantitative analyses are undertaken to observe the consequences of identified risks on project objectives, and appropriate mitigation techniques are designed and controlled accordingly. Several researchers emphasized the importance of risk management for desirable project outcomes and the successful delivery of a project. As a result, risk management should be well-planned and developed, including a practical assessment, control, and monitoring of all risks and their dependencies to which the organization is exposed.

Several types of research have been carried out to add to the risk management literature by creating risk detection and assessment approaches. Also, many barriers have limited the efficient usage of these strategies, preventing them from simulating real-world applications.

Risk checklists and risk breakdown structures are used in most of the proposed approaches to identify possible project risks, allowing risks to be assessed separately. Also, many researchers emphasized the necessity of addressing interdependencies among risk-related components and evaluating risks based on their sources to achieve better project simulation. Quantitative risk management approaches such as Monte Carlo Simulation, Sensitivity Analysis, and Fuzzy Risk Rating have also been examined in certain studies. However, the usefulness of these strategies is limited by several typical shortcomings.

Moreover, according to some other studies, the unique nature of construction projects makes estimating the probability of risk results difficult; as a result, decision-makers mainly depend on intuition and judgment.

As stated by several researchers, knowledge systems must be used to learn from previous risks to improve risk assessment processes by reducing subjectivity in assessment results. Therefore, it is believed that valuable knowledge of earlier projects, such as lessons learned from risks, would help make better predictions in forthcoming projects and the success of risk management activities. Project Management Body of Knowledge (PMBoK) also emphasizes the value of knowledge derived from personal experience for risk management. Since risk management produces and utilizes a large amount of information, it is a knowledge-intensive process. Therefore, several researchers have proposed knowledge-based risk management to increase the efficacy of companies' risk management activities.

In construction industry several projects have failed due to an absence of knowledge among the project team or throughout the project's development. Catching the necessary knowledge at an inappropriate project time might also lead to failure. Learning from past projects is one technique to overcome these issues. While there are various ways to do this, post-project reviews are one option since they seek to chronicle what went well and where there is room for improvement to

varying degrees of detail. Many construction companies conduct post-project reviews to record lessons learned from projects. However, if these reports do not contain the necessary risk-related information, are not prepared, and stored in the right format, they cannot be utilized during a risk assessment.

The aim of this study is to explore construction organizations' post-project assessment methods, the types of knowledge maintained by these reports, and the strategies that are applied to use these reviews during risk-informed decision-making. For this purpose, a research study has been designed, and qualitative data has been collected by conducting semi-structured interviews with experts from four medium-large scale construction companies with international experience. The thesis aims to report the qualitative analysis of the semi-structured interview results performed by the Automated Content Analysis (ACA) method to explore how post-project reviews can be used to learn from previous project risks and, subsequently, how to use these reviews in the risk assessment process. Finally, the study will assist in formulating potential strategies to improve knowledge-based risk management in the construction industry based on the findings from the analysis.

This thesis includes the following contents. The literature review on risk management is covered in Chapter 2. Definitions of risk, risk management, literature on risk management process, enterprise risk management, and construction risk management are presented to clarify the concept of “risk” in the construction industry. Chapter 3 starts with providing definitions of knowledge and examining the literature on types of knowledge and continues by emphasizing the importance of lessons learned from project risks and the value of conducting post-project reviews. Finally, performing a literature review on previous studies of knowledge-based risk management in construction projects concludes this chapter. Chapter 4 covers the research objective, research methodology, and data collection steps. Qualitative analysis of semi-structured interviews is utilized as the research methodology to explore current practices and to learn experts' opinions on the utilization of post-project reviews in forthcoming projects by applying ACA.

CHAPTER 2

LITERATURE REVIEW ON RISK MANAGEMENT

2.1 Definition of Risk

All human activities are associated with risk. The word “risk” has various definitions in the literature, such as hazard or uncertainty, which is believed to be caused by a lack of information, knowledge, or experience (Al-Bahar & Crandall, 1990). According to Loosemore et al. (2005) “Risk is a potential future event that is uncertain in likelihood and consequence and, if it occurs, could affect a company's ability to achieve its project objectives.” Other definitions for risk are presented several times in the literature, such as “financial loss or profit,” “physical injury,” “delay,” “a barrier to success,” and “the possibility of a detrimental situation occurring to the project” (Nieto-Morote & Ruz-Vila, 2011). Risk is frequently misunderstood to refer only to the “negative” consequences of an event when it includes both “positive” and “negative” effects. According to Renault & Agumba (2016), a positive risk can be turned into an opportunity, while a negative risk is a warning. The Project Management Body of Knowledge (PMBoK) by Project Management Institude (PMI) (2008), also defines risk as “an uncertain event or condition that, if it occurs, has a positive or negative effect on one or more project objectives such as scope, schedule, cost, and quality” with both positive and negative consequences. These possible consequences of the unknown event would be referred to as “threat” in the case of negative effects and “opportunity” in the case of positive outcomes. However, the fact that most risks usually have negative consequences has led studies to confirm the negative or undesirable changes as risk outcomes most.

Unique nature of construction projects, complexity of the activities, long project duration, construction finance, and dynamic organizational structures make construction industry more predisposed to risk than other industries (Renault & Agumba, 2016, Zou et al., 2006, Park et al., 2010,Okudan et al., 2021).

In the construction industry, the risk is defined as a disagreeable event resulting from imaginable but unexpected circumstances (Renault & Agumba, 2016). It is defined by Akintoye and MacLeod (1997) as "a variable in the process of a construction project whose variation results in uncertainty as to the project's final cost, duration, and quality." It's also defined as the likelihood of occurrence, the intensity of the impact, and the exposure to all hazards that negatively affect activities(Jannadi & Almishari, 2003).

Because of the complexity and uniqueness of construction projects, not only do the number of risks always outnumber those in other industries, but the risks also differ from one project to the next (Panthi et al., 2009). Many other factors, such as market conditions, level of competition, project size, political and economic fluctuations, and party expertise, all influence the level of risk PMI (2008). These risks are dispersed throughout the project life cycle, occurring in more than one phase. There are disagreements about the level of risk in various stages of a construction project. According to Godfrey (1996), the most significant degree of risk exists in the early stages, when there is the least amount of available information.

This is in line with the findings of Chapman and Ward (1997), who claim that risk is highest during the conceptual stage although contrasts with Zou et al. (2006), who believe that the construction is a riskier phase. In addition, some theorists believe that the risks of construction projects increase as the project progresses, implying that each phase of the construction project has more risks than the previous one (S. Q. Wang et al., 2004). Ozorhon et al. (2005) believes that the loss of knowledge after project completion and the consequent organizational amnesia are considerable risks in the construction domain.

The forms and intensity of risk exposure that an organization faces are numerous and vary from one organization to the next. However, it is essential to notice and identify risks as early as possible to establish a proper plan to retain or transfer specific risks and minimize any potential negative consequences (Wang et al., 2004).

2.2 Definition of Risk Management

Risk management (RM) is defined as an organized form of controlling risk areas and consciously selecting the right decision to manage them. It is a management technique that tries to identify the origins of risk and uncertainty, assess their effect, and plan suitable management actions (Uher, 2003). Thevendran and Mawdesley (2004) defined RM as "continuously monitored integrated formal process for defining objectives, identifying sources of uncertainties, analyzing these uncertainties and formulating managerial responses in order to produce an acceptable balance between risk and opportunities." Dikmen et al. (2008) also in their study described RM process as "identifying potential causes of uncertainty, predicting the outcomes of uncertain events, developing strategies to react based on anticipated results and depending on outcomes and identified risks, repeating the processes throughout a project's life cycle to guarantee that the project's objectives are realized." PMBoK (2018) confirms RM as a list of works undertaken to enhance the likelihood or impact of positive risks and minimize the probability or impact of negative risks. Considering that risks have the potential to prevent projects from achieving their objectives, PMBoK (2018) highlights the direct effect of project RM to project success (Okudan et al., 2021). Berkeley et al. (1991) also believe that an organized RM process includes classifying, identifying, analyzing risks, and planning responses for them. Risk response itself includes retention, reduction, transfer, and avoidance. A practical RM process may assist in determining the types of risks that may appear and the proper methods to manage them throughout the project's life cycle.

Today RM has become necessary, and most businesses have started to pay attention to it due to its growing importance. Therefore, a set of processes has been created to limit the impacts brought on by prospective risks.

PMBoK (2018) described the process of project RM as Planning Risk Management, Identifying Risks, Performing Qualitative Risk Analysis, Performing Quantitative Risk Analysis, Planning Risk Responses, and Controling Risks.

2.2.1 Planning Risk Management

The planning stage determines how the RM process will be implemented. Managers have to plan every step to have an idea of what, when, and how to manage. This process prepares the organization for RM by developing policies, determining the steps that must be taken, the order of the steps, discovering resources that might be required, the time frame for completion, and choosing responsible people. It may also incorporate training sessions to improve the staff's RM expertise (PMI., 2018).

2.2.2 Identifying Risks

Risk identification is a clear definition of the project objectives. The process includes identifying, categorizing, and primary assessment of the project's risks. Checklists, brainstorming sessions, stakeholder discussions, review of historical records related to other similar projects, cold eyes reviews, collecting historical information available, and strengths, weaknesses, opportunities, and threats analysis are some of the tools and techniques that can be used in the identification process. The risk identification process produces a risk register that contains the risk ID, risk description, estimated impacts, risk probability, and risk score (Adams, 2008).

2.2.3 Performing Qualitative and Quantitative Risk Analysis

Once a risk has been identified, it should be evaluated for its severity and prioritized. The qualitative and quantitative information from the risk description, probabilities, and impacts are also analyzed in this process. The goal of risk analysis is to identify and assess the likelihood of risks as well as their impact on project outcomes. The quantitative and qualitative evaluation of expert/analyst judgments about risk probability and impact based on their experience can be considered the starting point for this process. In the risk analysis process, some tools and techniques are used to assess the probability and impacts of the identified risks more precisely. Probability analysis, sensitivity analysis, scenario analysis, simulation analysis, and correlation analysis are examples of quantitative techniques. Qualitative techniques include direct judgment, ranking options, comparing options, and descriptive analysis (Minassian & Jergeas, 2009).

2.2.4 Planning Risk Responses

Risk response is the process that assesses risk's potential consequences to minimize the adverse effects while maximizing the positive ones. The following are the risk responses, which are generally dependent on whether the risk represents a threat or an opportunity:

In response to adverse risks, PMBoK, (2018) suggests:

- Avoiding: It is a risk response method that alters some aspects of the project so that the threat no longer has an impact or can no longer occur.
- Transferring: This type of "reduce" response focuses solely on reducing the impact, which is usually only the financial impact (a third party takes this responsibility).

- Mitigating: It is a proactive action taken to reduce an event's likelihood or impact.
- Accepting: It is a conscious decision to keep the threat alive.

On the other hand, for positive risks it offers:

- Exploiting: This response strategy is following an opportunity to ensure that a specific risk occurs and that its impact is realized.
- Enhancing: It is a proactive action taken to enhance the probability of the risk occurring or its impact.
- Sharing: This method entails assigning some or all the positive risk privilege to third parties to share the project's benefits.
- Accepting: This strategy is used when you are enthusiastic about taking advantage of an opportunity if it arises, but you do not actively pursue it.

2.2.5 Controlling Risks

Risk monitoring and control certifies that the risk identification, analysis, and response processes are still in progress. This process includes checking the status of identified risks in risk registers regularly, evaluating the effectiveness of risk responses used, identifying new risks, assessing them, and developing risk responses for them. Identifying new risks in this sub-process arises not only from changes in the project and its environment but also from the emergence of secondary risks. A secondary risk is a new risk that may occur after a risk response has been implemented (del la Cruz et al., 2006). Figure 2.1 recaps the risk management process of PMBoK, (2018).

2.3 Construction Risk Management

Several industries have confirmed the importance of RM and developed RM departments to identify, control, and monitor risks. Various parties associated with a construction project, the external factors influencing the project's performance, and the construction industry's complex and dynamic nature have also raised the need to apply proper risk management processes to the construction industry (Federico et al., 2014). According to RM definitions, construction RM could be defined as a systematic and ongoing process of detecting risks that have arisen in the project, analyzing their influence on the project's capacity to achieve its objectives, and adopting RM techniques. RM in the construction industry aims to save a company's assets, reputation, and achievements by minimizing the loss before the risks happen (Bing & Robert L. K. Tiong, 1999). Effective RM will allow the client to complete a project within the pre-determined project timeline and within the allocated budget, ensuring quality. (Thevendran & Mawdesley, 2004). It helps the key project participants meet their responsibilities and reduce adverse consequences on construction project performance related to cost, time, and quality goals (Banaitienė, 2011).

However, failure is not unusual in RM. Understanding obstacles to successful RM, use of suitable RM techniques, active supervision to prevent the barriers, employee perspective, enough resources, organizational culture, and top management engagement are essential factors in RM effectiveness (Dandage et al., 2018). According to Dikmen et al. (2008), the primary obstacles to RM are an inadequate definition of risk and a lack of clarity about the importance of RM in construction projects. They state that RM is commonly believed to be a method for better measuring risk consequences and contingency planning while it should also support sufficient risk monitoring, more risk communication among the group, and create a corporate risk memory to offer RM practices based on experience.

Furthermore, it is essential to keep in mind that it's not enough for construction organizations to rely only on project RM. RM should cover both project risks and risks that emerge by running the business (John E. Schaufelberger, 2008).

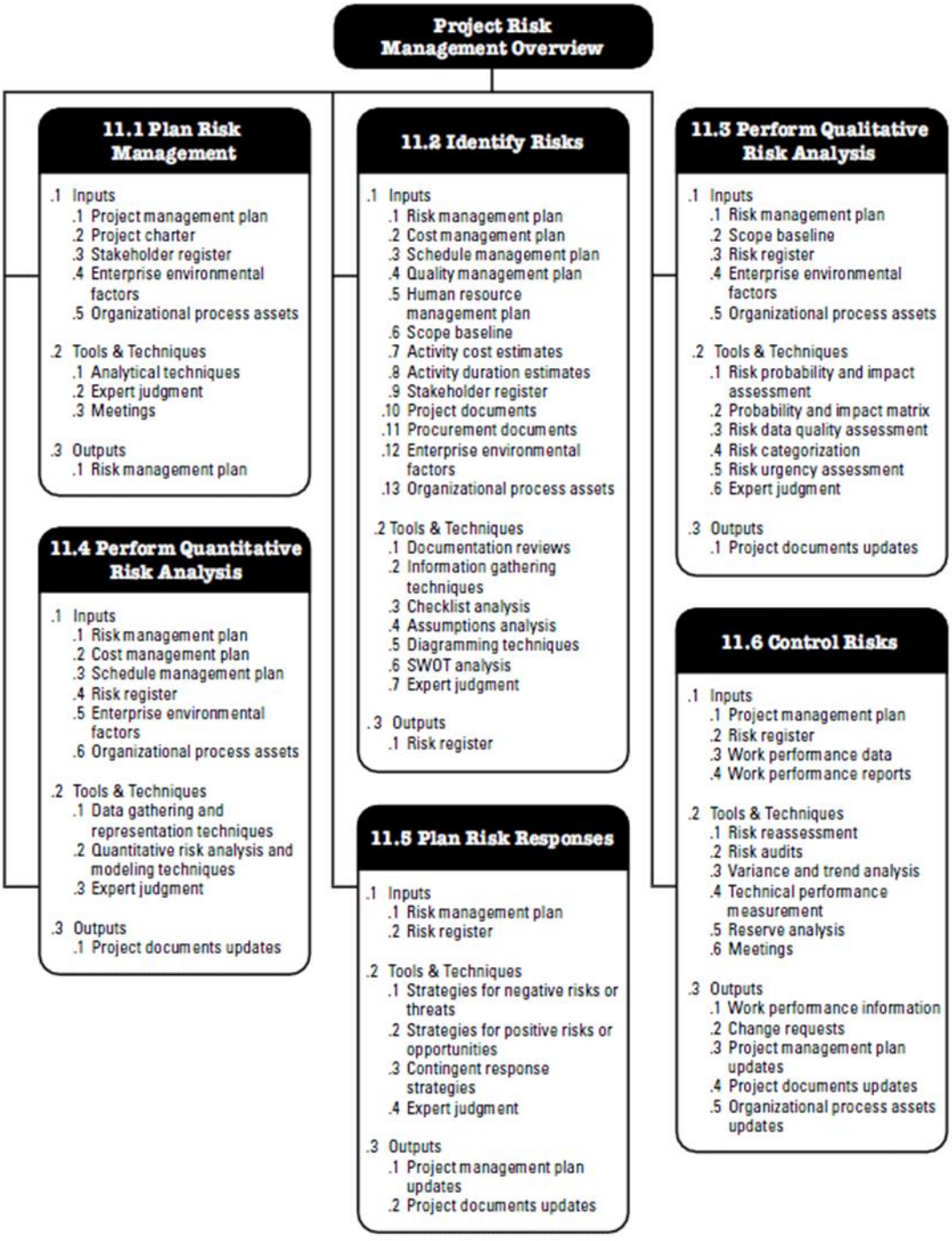

Figure 2.1 Project Risk Management Overview (PMBoK, 2018)

2.4 Enterprise Risk Management and Maturity Levels

Construction companies rely on projects to make money. Therefore, project risk management (PRM) is used to control risks at the project level, known as the silo technique, that focuses on addressing one risk at a time (Hallowell et al. 2013; Zhao et al. 2014). PRM, on the other hand, is not a solution for construction companies. Overemphasis on PRM, may lead to a slew of issues, and managing projects based on the silo approach can be deceptive (Laslo & Goldberg, 2008). Construction companies should carry out risk management in a way to cover both project risks and risks that emerge by running a business (Schaufelberger, 2008). As a result, Enterprise Risk Management (ERM) which entails collecting and managing risks at the highest level inside the business, has been promoted and is predicted to become more common in the construction industry towards a holistic approach (Hoyt & Liebenberg, 2011; Zhao et al., 2014). Committee of Sponsoring Organisations of the Treadway Commission (COSO) Commission, 2004, defines ERM as "a process, effected by an entity's board of directors, management and other personnel, applied in strategy setting and across the enterprise, designed to identify potential events that may affect the entity, and manage risk to be within its risk appetite, to provide reasonable assurance regarding the achievement of entity objectives". COSO created the widely used ERM technique, which its main steps are summarized in Table 2.1. The main advantage of this strategy is that it takes an outside-in approach to RM, preventing the company from facing a single systemic risk.

ERM assists companies in accomplishing long-term goals because managers can examine the possible impact of risk-based choices on the whole business at the enterprise level (Berry & Phillips, 1998). ERM's advantages could be listed as more effective use of critical resources, the ability to assess risk interdependence and manage strategic risks, enhanced financial stability, and the establishment of a RM culture (Hallowell et al., 2013).

However, each company has its viewpoint, priorities, and requirements for RM. Although the core aim and concepts of ERM are similar, the degree and nature of the risks faced by the businesses are distinct. It demonstrates that each company faces unique risks based on their industry. The efficacy of an organization's ERM is determined by its ability to manage risks that may arise internally or externally, as well as its ability to react to changes. In other words, the efficiency of ERM is determined by the maturity of the company (Alijoyo et al., 2021). As a result, risk management maturity models (RMMM) have emerged as a key tool for companies to assess their risk management efficacy and maturity, especially at the enterprise level (Audit Office Of New South Wales., 2019; Zhao et al., 2013). Companies should evaluate their ERM maturity to obtain a comprehensive picture of implementing ERM in their organization, strengths, and weaknesses.

There are different enterprise RMMM presented by Audit Office Of New South Wales (2019), CGMA (2012), New Zealand Government (2020), and Association for Federal Enterprise Risk Management., 2020, which mainly focus on the practical part of assessing a company's risk management maturity. Each model contains comparable core aspects or criteria for evaluating a company's risk management maturity, particularly in terms of culture and RM process. In terms of differences across the models, however, the range of measuring the firm's RM maturity differs. Thus, the enterprise RMMMs have their features and sophistication based on these similarities and differences, which may not be proper for a given company. In this sense, the enterprise maturity level tends to assess a company's maturity precisely depending on its nature and the environment in which it works (Alijoyo et al., 2021)

Table 2.1 Outline of ERM Steps (Coso, 2004)

ERM Steps	Function
1. Establish context	Determine who is in charge of the program and who will be involved in the management process
2. Identify risks	Identify risks, with specific attention paid to external, local, and strategic risks
3. Analyze risks	Analyze risks and focus on creating a common nomenclature and scales for risk quantification
4. Integrate risks	Correlate and aggregate risks at multiple levels of the organization
5. Assess/prioritize Risks	Conduct sensitivity analyses to determine the impacts of risk events to a multitude of organizational functions
6. Treat/exploit risks	Consider risks based on their impact on the organization's risk portfolio; consider four basic responses: avoid, transfer, mitigate, or accept
7. Monitor and review	Iterate and continually update the data in the risk register for future analyses

CHAPTER 3

LITERATURE REVIEW ON KNOWLEDGE BASED RISK MANAGEMENT

Risk management is a knowledge-intensive procedure because it creates a large quantity of knowledge and uses it later (Yildiz et al., 2014). The value of knowledge derived from personal experience for managing risks is also emphasized by PMBoK (2018). Therefore, many studies have advised knowledge-based risk management to increase the efficacy of firms' RM activities. Marty et al. (2020) believe that if an organization does not manage its knowledge, it will not be able to manage its risks successfully. Neto et al. (2021) also stated that knowledge management is able to improve project RM by encouraging the reuse of risk-related knowledge and facilitating decision-making. However, it's not always easy for organizations to perform knowledge-based risk management correctly. Many companies store risk-based knowledge, but they don't have the proper techniques and technologies to use them later.

This chapter introduces the concept of knowledge management. It begins by providing definitions for knowledge, knowledge management, and lessons learned from risks, classifying knowledge categories, and introducing essential knowledge management techniques and technologies for risk management. Furthermore, PPR is defined as one of the most successful lessons learned capturing approaches. Also, the importance of knowledge management methods in the construction domain is then discussed, as well as the problems that construction businesses face in implementing knowledge management systems. Finally, it provides a background for the study and presents previous research on learning from risks and using risk knowledge of previous projects to manage the risks of future projects in the construction domain.

3.1 Definition of Knowledge

Comprehending the meaning of Knowledge has been a topic of interest for many years. Due to the difficulties of obtaining a clear definition of knowledge that everyone generally accepts, many knowledge definitions exist, each serving a particular type of scholar. Plato defines knowledge as "justified true beliefs". In contrast, others have asserted broader views on the definition of knowledge, such as production operator and a Dynamic human approach to detecting, developing, storing, communicating, and applying it to improve corporate performance (Nonaka & Takeuchi, 1995).

The three concepts of data, information, and knowledge are linked by a knowledge hierarchy. The cornerstone of this knowledge hierarchy is considered to be "data" (Perrott, 2007). Data, in general, is defined as specific information regarding events (Davenport & Prusak, 1998). Many companies and businesses store large volumes of data in well-organized databases. The vital move regarding the company data is to gain an adequate capacity to evaluate, merge, and then turn data into information and knowledge. The next concept, "information," is defined as systematically structured data and the result of recording and providing context to events and ideas. "Knowledge" is knowing, an intuitive process that combines facts in a social context with experiences, best practices, and feelings and generates new data, information, and understanding (Spiegler, 2000).

Experience is one of the essential kinds of knowledge in the construction industry, which is accepted as gained knowledge and talents in projects. Construction industry is considered as a robust, knowledge-based industry that primarily relies on the knowledge contribution of various project team members (Carrillo et al., 2004). Construction experiences include knowledge about construction procedures, site processes, and previous projects. Issue explanations, issue solutions, ideas, and techniques are examples of this knowledge. Records such as reports, papers,

manuals, pictures, and tapes can be used to gain an explicit form of experience (Lin, 2008).

Based on different studies, risk knowledge in the construction industry is essential to manage risks sufficiently (Dikmen et al., 2008; he et al., 2012; Joseph HM, 2001; Li et al., 2021). In addition, one of the most critical issues about RM implementation is practical ways to reuse the knowledge efficiently (Tserng et al., 2009).

3.2 Types of Knowledge

Polanyi (1967) was the first to introduce the difference between knowledge as explicit (external) and tacit (internal). Based on his description, tacit knowledge is subjective and context-sensitive, making it difficult to define and express. It is impossible to see, communicate, duplicate, or control since it is kept in the individual mind. On the other hand, explicit knowledge can be easily documented, communicated, and distributed. It can be expressed in the appropriate language containing grammatical propositions, mathematical expressions, and instructions. Tacit knowledge should be translated to explicit knowledge to be expressed and shared throughout the organization (Nonaka & Takeuchi, 1995).

Earlier study findings indicated the necessity of tacit knowledge in terms of company performance and competitiveness, as well as the value of tacit knowledge in the construction sector (Pathirage et al., 2007). Construction is a project-oriented sector and construction projects create substantial knowledge that can be shared and reused inside and between projects (von Krogh, 2002). Zhang et al. (2009) stated that project information, design sketches, cost information, and risk estimation findings are examples of explicit knowledge for the construction sector. Tacit knowledge, on the other hand, is developed through construction specialists' experience or lessons learned, personal views, attitudes, impressions, and conventions (Ozorhon et al., 2005; Ramaprasad & Prakash, 2003).

3.3 Lessons Learned

Lessons learned (LL) are knowledge obtained from successful or unsuccessful experience for enhancing future performance (Ferrada et al., 2016). They are beneficial to organizations since gained knowledge has a tangible influence on operations, and experiences benefit organizational growth by determining particular strategies that mitigate or eliminate future failures or support favorable outcomes. (Carrillo et al., 2013; Ferrada et al., 2016). PMBoK by PMI. (2008) suggests that "the causes of variances, the reasoning behind the corrective action chosen, and other types of lessons learned should be documented so that they become part of the assets of an organization". LL practices are a typical method of discovering progress and innovations in project-based workplaces, yet, these practices have shown to be challenging for businesses to succeed in (Jugdev, 2012). However, this technique can help project managers reuse project knowledge to avoid repeating the same mistakes in future projects (Wiewiora & Murphy, 2015). Rezgui et al. (2010) stated that LL, together with documents, experiences, and connections, are essential knowledge bases in the construction sector. Organizations must examine the practical ways to share the experience and knowledge of professionals with beginners who ought to know. Earlier research has proposed that the company should manage its knowledge by techniques of project reports or lessons learned (Carrillo & Chinowsky, 2006; Tan et al., 2007).

3.4 Learning from Risks

Risk case records from completed projects can help predict what will happen in comparable projects in the future. Lessons learned by providing information about planned and completed tasks illustrate the changes in the schedule of tasks in past projects. According to Dikmen et al. (2008), lessons learned from risks are beneficial for designing realistic risk management techniques and more informed predictions regarding forthcoming projects. Furthermore, risk cases in past projects

may repeat in similar future projects under certain circumstances. Obviously, the project's interior features illustrate how much the risk events will influence the project; however, documenting the risk case histories might imply the degree of risk events and benefit the organizations by the known risk outcome. Understanding the types of risks that happened in completed projects, their severity, and their consequences on project objectives may help to enhance the accuracy of risk forecasts in the present projects. Knowledge-based technologies might assist the process of risk management and improve straightforward choices by explaining the risk event and its sources in earlier projects. Instead of documenting only risk events, reporting the driver elements for these events and explaining the outcomes are essential in acquiring a complete awareness of the conditions for upcoming projects. Risk cases are unique in various projects; however, Dikmen et al. (2008) stated that all projects have relative risk factors and vulnerabilities. As a result, understanding the relations between risk-related factors and establishing historical risk route chains may improve forecasts about risks in forthcoming projects.

3.5 Post-Project Reviews

Ever-growing competition in the construction industry has led the organizations through constant improvement and learning from their experiences. Analyzing the details of completed projects is one way to promote the concept of organizational learning. Different kinds of project reviews, which may be recorded at various steps in the project process, can be used in this regard. Nevertheless, post-project reviews (PPRs) are specifically helpful since they register the project's entire procedure after the project is completed, and evaluate successes and failures throughout the project.

(Von Zedtwitz, 2002) defined PPR as one of the most successful lessons learned capturing approaches since it strives to capture project knowledge and enhances

performance in forthcoming projects. According to Anbari (1985) “A post-project assessment must be undertaken at the last phase of the project to assess its effectiveness based on its original and amended goals. This report should include reasons for key differences, lessons learned, and suggestions to help future projects.”

The advantages of conducting post-project reviews for companies are highlighted in several studies (Carrillo, 2005; Tan et al., 2006) as follows:

- PPRs allow project participants to discuss the details of the project, such as best practices and failures, brainstorm, and exchange opinions which will facilitate the learning process.
- A practical PPR process can provide valuable knowledge for upcoming projects, although this knowledge is generally implicit and challenging to reuse.
- A good PPR can provide a better understanding of how assets are managed, letting the project community improve its procedures.
- Reviewing each project phase instead of doing one review at the end allows for better project management at the phase level. As a result, errors may be caught at the phase level, helping the other project stages.
- Their project-related knowledge should be captured and made clear to others through a PPR to avoid knowledge loss

However, in spite of their significant effect on organization success and future initiatives, PPRs and lessons learned are not valued in real life (Paranagamage et al., 2012; von Zedtwitz, 2003). In the construction industry, knowledge is not shared among the project participants for reuse in forthcoming projects, and it is kept in the minds of individuals (Kazi & Wolf, 2006). The temporary nature of construction projects causes a lack of personnel consistency and, finally, knowledge loss (Graham & Thomas, 2008). It is believed that the construction industry will lose considerable experienced and qualified personnel in the

future years, and it's essential to be aware that there is no one solution for issues to be solved. To summarize, every form of useful knowledge (e.g., lessons learned, innovations, best practices, post-project reviews) should be managed to help the company from a knowledge management perspective. Therefore, setting knowledge management frameworks to take LL in an organized manner is crucial (Kanapeckiene et al., 2010). Mcadam & Reid (2001) also stated that, PPR process is built on the knowledge management cycle, which entails the following steps: 1) capturing knowledge, 2) sharing knowledge, 3) storing knowledge, and 4) reusing knowledge.

3.6 Knowledge Management

One of the most success factors of companies and businesses turns out to be knowledge. It has become a critical resource for companies to place in an ideal business rank (Nonaka & Takeuchi, 1995). Knowledge of a finished activity can lead to a new and more successful approach to the work in the future (Persson, 2006). A collection of methods for developing, obtaining, organizing, using, and sharing knowledge is practical in converting knowledge into a value which is called knowledge management (KM) (Liebowitz & Chen, 2001). KM assists the construction sector in collecting explicit and tacit knowledge related to the workflow to aid decision-makers in obtaining, retaining, and reusing the captured knowledge (Tserng et al., 2009). Thereby, knowledge has been addressed in a systematic manner like other physical resources, and multiple businesses and organizations are investigating knowledge management to be more successful and to keep their competitiveness.

The term “knowledge management” has a variety of definitions in the literature. Jennex (2005), believes KM is a method of using relevant past experiences from past decisions to apply them in ongoing and forthcoming decisions with the specific objective of increasing the effectiveness of the company. According to

KPMG (2000), KM is an ordered and systematized attempt inside an organization to enhance its capacity to retain and apply knowledge to increase performance. According to Wiig (1997), KM is about managing knowledge-related activities such as knowledge creation, classification, communication, and application to add value to an organization. Other academics have used various terminologies to describe the KM sequenced techniques with differing viewpoints, emphasis, and details (Tan et al., 2006 ; Carrillo & Chinowsky, 2006).

Construction projects are unique and involve interdisciplinary teams. Distinctive features, such as complex operations, a diverse range of tasks, expertise, and organizations, permanent replacement of project members, significant dependence on experience, and limited time and budget, have encouraged administrators to pay attention to the importance of KM (Ozorhon et al., 2005). It is believed that in construction projects, a considerable amount of the new knowledge is lost as project participants transfer to other projects, quit, or retire, and the valuable lessons from this lost knowledge are not effectively saved or distributed (Park et al., 2010). The type and severity of knowledge a construction company needs relies on the fields of the work, which consist of the work, the process of work, and participants (Egbu & Robinson, 2005). Kivrak et al. (2008) stated that the key benefits of KM for the construction domain could be listed as project time and cost mitigation, quality improvement, and supplying a significant source of competitive advantage for enterprises. Barriers to performing KM tasks in the construction industry could be listed as the accumulation of information, time deficiency to communicate knowledge with others, inefficient use of technology to transfer knowledge, challenges in collecting tacit knowledge, weak management assistance, hesitation of participants to disseminate knowledge, inadequately stated strategy, difficulties in measuring advantages, and deficient corporate culture (Carrillo et al., 2004; Robinson et al., 2005). Tan et al. (2006) suggested considering out of date knowledge and knowledge reliability in four essential KM steps that other researchers previously developed:

3.6.1 Capturing Knowledge

The knowledge capturing method consists of three steps. The first step is identifying the types and locations of new knowledge to be handled (Kamara et al., 2003). Describing and storing knowledge is the next step which includes listing, categorizing, and structuring knowledge. Writing knowledge in the layout appointed with the details about the generated place of knowledge, the possible used areas in the future, and conditions for reuse is also essential in this step. The last step, validating the captured knowledge, is to confirm the collected knowledge is reasonable and stored in the proper format, with essential details (Tan et al., 2006). The post-project review (PPR) is a practical tool in conducting knowledge capture and is widely utilized in multiple sectors to capture lessons learned and valuable knowledge at the termination phase of the project (Chin Bo Wei Andrew, Gao Shang, 2015).

3.6.2 Sharing Knowledge

People frequently look for knowledge and guidance from group members rather than knowledge sources in the project since knowledge is stored in individual minds (Koskinen et al., 2003). According to Ipe (2003), knowledge sharing is converting one's knowledge into a format that can be accessible, utilized, and absorbed by others. (Tan et al., 2006) believes that knowledge management is bringing the appropriate knowledge to the right person at the requested moment. This operation can be inactive, like providing knowledge storage, or active, like alerting those who need specific knowledge (Markus, 2001).

3.6.3 Reusing Knowledge

This method is about applying best practices and reusing knowledge for innovation (Egbu et al., 2001). Accordin to (Majchrzak et al., 2004), it involves various

actions such as reviewing the issue, looking for practical ideas that can be used later, assessing, and analyzing these ideas, selecting the best ones, and developing them.

3.6.4 Maintaining Knowledge

During time and because of applying new information, regulations, and ideas, knowledge may become outdated. Therefore, knowledge should be examined, updated, refined, and deleted if it is no longer valid (Rollett, 2012).

3.7 Knowledge Management Tools

Knowledge management (KM) tools can be classified as “techniques” and “technologies,” which are defined as non-information technology (IT) and information technology (IT) tools, respectively (Al-Ghassani et al., 2005), which can be used to efficiently manage knowledge inside an organization (Eken et al., 2020). Al-Ghassani et al. (2005) stated that, these tools are used to assist knowledge discovery, knowledge communication, and knowledge modification and should be selected considering the organizational objectives for adopting a KM strategy. Table 3.1 shows some of the suggested examples of KM techniques and technologies.

Table 3.1 KM techniques and Technologies (Al-Ghassani et al., 2005)

KM tools	
KM techniques	Example of tools
• Require learning strategies	• Brainstorming
• More participation from individuals	• Communities of practice
• Affordable for most businesses	• Face-to-face interactions
• Simple to use and maintain	• Recruitment
• Greater emphasis on tacit knowledge	• Training
KM technologies	Example of tools
• Require IT infrastructure	• Data and text mining
• Require IT skills	• Knowledgebases
• Sophisticated execution/keeping	• Intranets/extranets
• More emphasis on explicit knowledge	• Taxonomies/ontologies
• Costly to acquire and maintain	• Groupware

3.8 Relationship of Risk Management and Knowledge Management

As mentioned before, the fundamental purpose of knowledge management is to provide the proper knowledge to the related person at the proper time so that they can make the best decision by merging knowledge management and risk management through the decision-making process. Risk and knowledge management are inexorably intertwined. Good communication, along with the establishment of a learning culture, and a willingness to investigate and understand previous mistakes, are fundamental principles of practical knowledge and risk management (Webb, 2007). Neff believes that "Risk management is knowledge management," and the best way to a successful risk management process is the company's capability to record its employees' knowledge so that managers can obtain the right and in time information about a risky situation (Neef, 2005). Massingham (2010) recognized two primary topics in his research into a suggested framework for "knowledge risk management (KRM)": how knowledge may

mitigate risk, resulting in improved risk management, and how knowledge management might enhance risk management. His study concluded that incorporating knowledge management provides managers with a better understanding of the true nature of organizational risk. Aeronautics is another area of concentrated research on this subject, specifically the ways in which NASA engages risk management and knowledge management to control the risks associated with human spaceflight. This handbook draws various links between forgetting or not having enough information and uncertainty, as well as particular expectations for knowledge management and risk management, such as risk management decisions and rationales documented as part of the organization's institutional knowledge (Marty et al., 2020).

3.9 Previous studies on Learning from Risks in Construction Management Domain

According to the studies, practical risk management is typically reliant on experience and knowledge (Han et al., 2008; Tserng et al., 2009), and using the gained knowledge again is an essential topic in the construction risk management domain (Öztürk et al., 2016; Zoysa & Russell, 2003). Though numerous attempts have been made in the construction management domain to establish efficient KM processes, especially to improve RM, this topic is not yet developed enough, and there is much room for improvement (Dikmen et al., 2012; Eken et al., 2015).

In their study, Dikmen et al. (2008) suggest a risk management strategy based on learning, in which risk-related data is described, saved, and updated in the form of lessons learned database so that decision-makers may be able to make more trustworthy judgments about future projects based on risk knowledge from past projects.

An ontology-based risk management framework is suggested by Tserng et al. (2009) for construction projects. By building a project risk ontology, the study

investigates knowledge derivation for better risk management. The outcomes of the study show that ontology-based risk management may be used in the risk management process to improve efficacy.

Yildiz et al. (2014) present a technique for assessing the risk of international construction projects that takes into account causalities between variables associated with risk, the consequences of risk paths, and lessons learned from past projects.

Fan et al. (2015) suggests a practical strategy for developing project risk response processes based on case-based reasoning (CBR) of the lessons learned in projects with similar risk scenarios. The proposed approach can aid in the discovery of previously recorded solutions, allowing the project manager to select the best method combination for managing risks in future projects.

The retrieval of useful knowledge is the first and most important phase in the CBR process. Y. Zou et al. (2017) suggested a strategy based on semantic query expansion and Vector Space Model (VSM) approaches to increase the efficiency and implementation of risk case retrieval for risk-based knowledge management in construction projects.

An ontology-based semantic network technique for managing construction risk knowledge in a BIM domain is presented by Ding et al. (2016). Risk knowledge is structured semantically and dynamically connected to specific building items in a BIM environment. The technique supports reusing knowledge for risk knowledge management tools during the construction risk analysis process. By choosing the construction components in the BIM model, the construction risk knowledge saved in the knowledge base is retrieved and shown.

In their study, Okudan et al. (2021) used case-based reasoning (CBR) to create a web-based knowledge-based risk management tool called CBRisk. It employs a powerful risk case retrieval mechanism that considers many construction project similarity criteria expressed as fuzzy linguistic variables.

In the following chapter, the proposed methodology of the thesis will be explained in detail. The scope of this study is to reveal how incorporating risk-related knowledge into post-project appraisal reports can improve learning from risks and subsequently improve the risk management process in construction projects.

CHAPTER 4

RESEARCH METHODOLOGY

This chapter presents the methodologies used in the study. First, the research questions, aims, and objectives are explained. Then, the study context, participants, tools, and data collection methods, are described in individual sections.

4.1 Research Objective and Aims

The literature review has revealed that applying knowledge of the completed projects to new projects is essential for successful project management. Many construction companies conduct PPRs to record the lessons gained from completed projects. However, using PPRs during the risk assessment phase of the construction projects requires following a systematic approach. PPRs cannot be used during risk assessment if they lack the essential risk-related knowledge and were not written and kept in the proper format. To explore how construction companies use PPRs for risk assessment of their new projects and what are the contents and format of the PPRs in their companies, the most appropriate method was decided to be qualitative research which is explained further in the next section. These questions were important because, firstly, illuminated how people perceive the importance of conducting PPRs in construction companies and whether there are formal procedures for conducting PPRs in their organization to become familiar with the strategies, strengths, and weaknesses of companies in this process. An exploratory study was carried out by interviewing experts from construction companies in Turkey to answer the research questions.

The objectives of the research include:

I. Examine the advantages and features of PPRs
II. Examine how knowledge management and post-project evaluations are used in the construction industry.
III. To examine the research on the effectiveness of PPRs and the justifications for conducting or not conducting them in the construction industry.
IV. To examine the research on the thoroughness of PPRs in the building industry
V. To research the practical use of PPRs
VI. To evaluate the data gathered through interviews
VII. To summarize, PPR processes' level of use and efficiency in construction project risk management

4.2 Research Design

The research design in this study was mainly qualitative because the study revealed the participants' opinions and experiences regarding using PPRs during risk assessment of construction projects. Qualitative research was a reliable design to support the research process when the aim was to explore the research questions from the viewpoint of individuals (Maxwell, 2012).

Qualitative studies' data typically comes in words rather than numerical values. This method is preferred when the researchers want to explore thorough comprehension of a process, experience, or ideas, when they require more details to determine the features and limitations of the subject of study, or when they only have access to non-numeric resources of data. Successful qualitative research requires building good connections with appropriate individuals or groups of people and displaying compassion to collect data.

A basic qualitative design suggested by Sharan B. & J.Tisdell (2015) was decided to be proper for the ongoing study as the main goal was to understand experts' opinions and experiences within the context of PPRs and risk management.

4.3 Qualitative Data Collection

An extensive review of the literature on PPRs and their application to risk assessment in construction projects was the foundation for the methodology used. To understand the process of conducting PPRs in construction companies and explore the value of lessons learned during the RM process, relevant information was drawn from a literature review related to PPR and RM.

After a comprehensive literature review, construction companies were investigated utilizing internet sources. The companies that had been taught to fit the study's objectives were then contacted through email with a brief description of the research and a request for their participation. Four participants from medium/large-sized construction companies were approved to participate and provide data. Table 4.1 pesents information about participants' profiles. Each participant was given a unique interviewee letter due to the confidentiality assurance.

Table 4.1 Expert profile details

Category	Item	Number of Participants
Gender	Female	2
	Male	2
Education Background	B.Sc.	2
	M.Sc.	1
	Ph.D.	1
Years of experience	5-10	2
	11-15	1
	16-20	1
Experience with conducting PPRs	Medium	1
	High	2
	Very High	1

4.4 Data Collection Instruments

As the aim of the study was to explore the opinion and experiences of experts, the interview is used as the data collection method.

For the interview, both structured and semi-structured questions were created. The first section of the interview was created with structured queries to gather demographic information from the participants, such as interviewees' ages, educational backgrounds, occupations, and experiences. The next phase of the interview was semi-structured, allowing the researcher to ask a list of open-ended questions while maintaining the freedom to modify the questions' sequence and language to explore the study subject further. The language of the interview was English.

The interview started with questions about the general purposes and contents of PPRs. It then expanded into the risk assessment process and utilizing PPRs during the risk assessment phase of the projects in companies. Finally, it included questions associated with the benefits and barriers of the mentioned process. Details related to interviewes are presented in Table 4.2.

Table 4.2 Interview details

Interview Number	Participant	Position	Years of experience	Interview Duration (min)
Interview 1	Participant A	Risk Officer	10	95
Interview 2	Participant B	Architect	5	70
Interview 3	Participant C	Technical Office Manager	17	45
Interview 4	Participant D	Internal Auditor	15	60

Here are some examples of questions:

- What is the purpose of conducting post-project reviews in your company? What contents and particular knowledge items do you include in your post-project reviews?
- How do you collate post-project reviews to be used for risk management? Do you use a particular format to make it easy to access? Is there a special software for this?
- Do you think that the way you are applying post-project reviews for risk management in your company has been successful? Can you please suggest any improvements?

Before asking participants the interview questions, they asked permission to record their voices during the interview session. They were informed that taking part in the study was completely optional, and they might stop it at any time. They were also told that the researcher would be the only one to hear the recordings, and their identity would be kept private. Each interview took between 60 and 90 minutes.

Participant control is one technique to guarantee validity and improve the results' trustworthiness. Participant confirmation involves re-presenting the information gathered and any comments concerning it and asking participants whether the comments and conclusions align with what they stated during the interview. In this study, the interview transcripts were written up and submitted back to the appropriate interviewee, along with a request for confirmation of their accuracy and authenticity.

4.5 Data Analysis Method

The qualitative data analysis (QDA) of semi-structured interviews is discussed in this section. Thematic analysis is used to provide general information regarding qualitative coding processes. Finally, the procedures involved in coding with QDA software are described.

4.5.1 Qualitative Data Analysis

QDA can be described as making sense of appropriate data acquired from interviews, observations, and documents and illustrating what the data demonstrate later (Newcomer et al., 2015). Patton (2015) states that QDA transforms data into findings; however, there is no formula for that transformation. Therefore, the researcher's involvement in evaluating qualitative data becomes critical in characterizing or illustrating the participants' perceptions through understanding while excluding any bias concerning the topic under inquiry.

There are numerous and complex methods for analyzing qualitative data. According to Wolcott (1994), fifty different analysis types are used for qualitative data analysis, including content analysis, narrative analysis, conversation analysis, and thematic analysis; each serves a distinct goal and has advantages and disadvantages. The three parallel “flows of activity” that all qualitative studies must adhere to are: data reduction, data presentation, and conclusion formulation (Miles & Huberman, 1994).

4.5.2 Thematic Network Analysis

The research methodology significantly impacts the data analysis. After studying various approaches, the abduction approach has been determined to be the most appropriate for this study. Most methods directly address the research strategy, such as grounded theory for inductive research and pattern matching for deductive research. Rather than using one of these approaches, the author decided to use a more generic and frequently used technique that may be applied in qualitative research, embracing an inductive and deductive approach, which is the thematic network analysis. This method focuses on themes, exploring “concepts,” and developing “categories,” which facilitates organizing the data by splitting it into smaller pieces.

According to Virginia and Victoria, the thematic analysis provides fundamental techniques used in many other qualitative analysis methods, suggesting all researchers first attempt to learn thematic analysis (Braun & Clarke, 2006). Thematic analysis, according to Fereday & Muir-Cochrane (2006), is "an investigation for themes that are relevant to the explanation of the phenomena". We can say it identifies and groups the themes the researcher considers crucial for explaining the phenomenon under investigation and is often linked to a research question.

Thematic analysis is characterized as being separated from theory and epistemology in contrast to other methods for analyzing qualitative data, such as grounded theory or interpretative phenomenological analysis (Braun & Clarke, 2006). This separation and independence from a particular framework enable the analytical process to be broadly and adaptably applied to various epistemologies (Braun & Clarke, 2006).

Thematic analysis has been criticized by Braun & Clarke (2006) as hard to limit however this is not a flaw exclusive to this method. Thematic analysis, like all forms of research, must be precise. Making the process as visual or evident as possible is essential so the reader can observe and appraise how it was accomplished.

The primary function of the thematic network analysis is to separate the data and text into various layers, hence allowing the depiction and organization of the themes. The theme network is made up of a web-like structure with three levels (Attride-Stirling, 2001).

- **Basic Themes:** The lowest level inferences drawn from the data depending on their relationships to the categories, which, when taken out of context, are useless or difficult to understand.

- **Organizing Theme:** The clusters of signification that summarize the principal assumptions of a group of basic themes, so they are more abstract and more revealing of what is going on in the texts.
- **Global Themes:** The global themes gather collections of organizing themes that collectively claim a particular problem or reality.

Thematic network analysis is summarized in Figure 4.1. Each theme is connected to another theme, which allows the more prominent themes to provide further context for the accumulated minor themes.

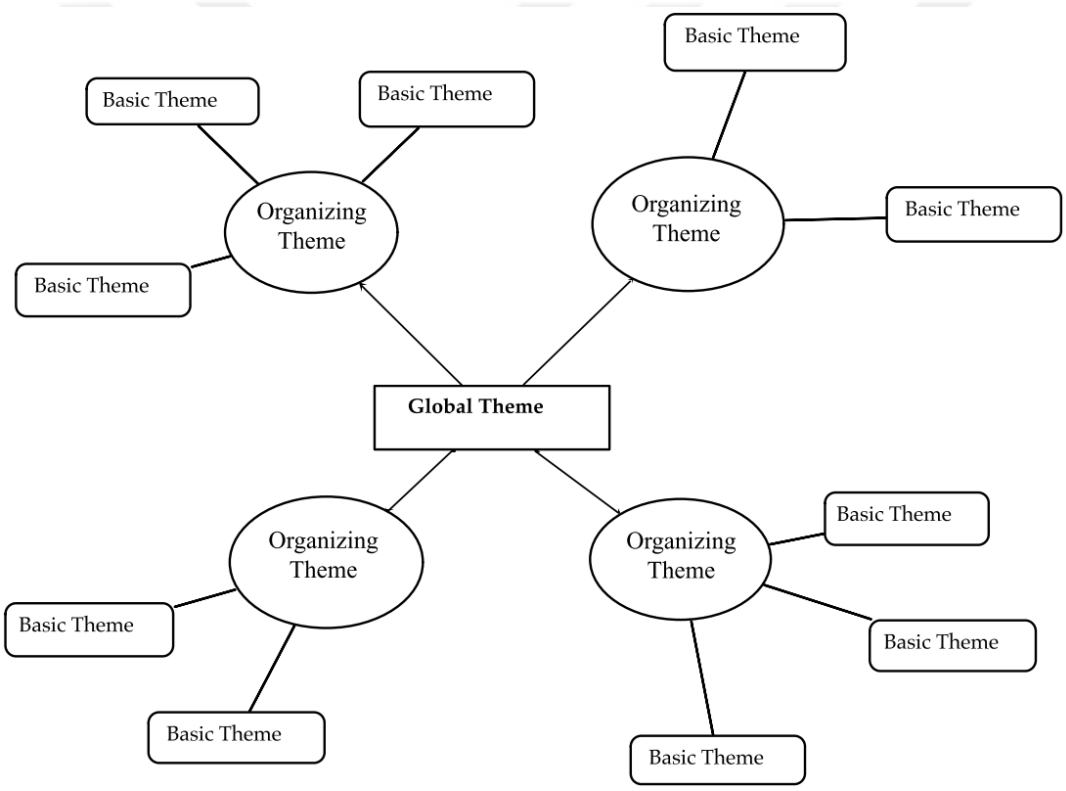

Figure 4.1 Structure of the Thematic Network (Attride-Stirling, 2001)

4.6 Qualitative Analysis Software

QDA can be aided by a variety of qualitative analysis software packages. The data analysis in this study was carried out utilizing the latest version (Version 12) of the QSR NVivo QDA program to manage and analyze interview transcriptions, among other software packages. The NVivo program assists the analysis in moving beyond just describing the occurrences under investigation. Figure 4.2 illustrates the methodological approach employed in the QSR NVivo software.

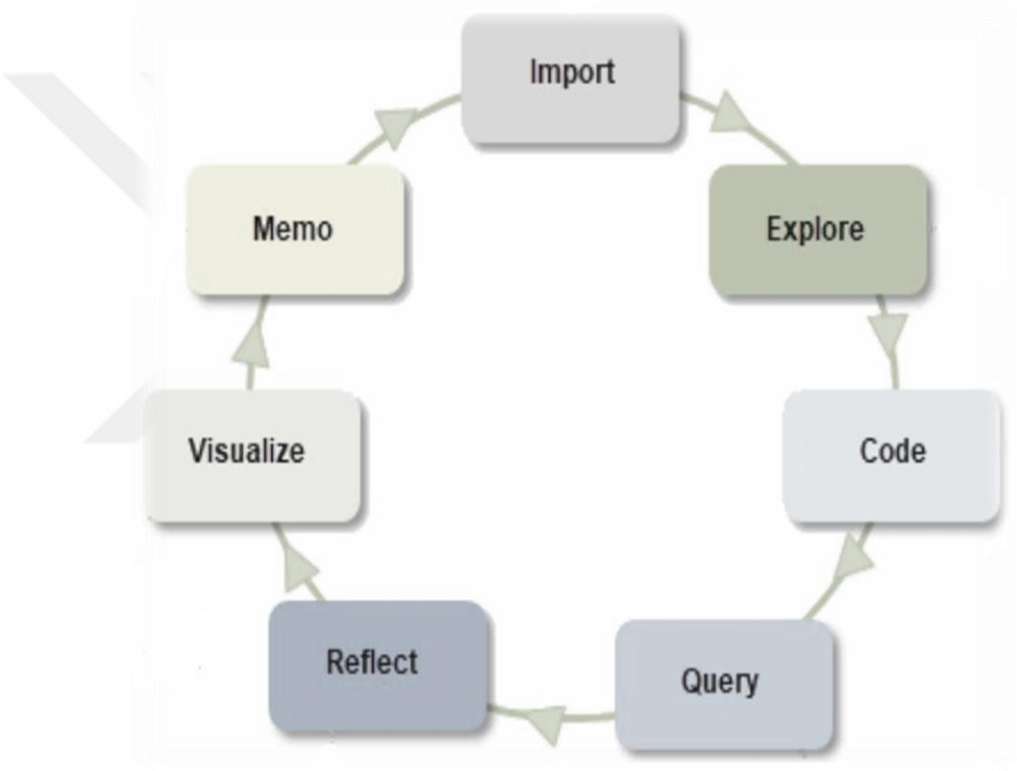

Figure 4.2 Process used in QSR NVivo software (QSR International, 2021)

4.7 Analytic Steps

The steps of analyisis explanained in this section. Attride-Stirling (2001) have outlined rules for six steps of thematic networks analysis (see Figure 4.3). It is not

mandatory to carry out the steps sequentially, and it is accepted if the researcher goes back to the initial phases as the study progress. Figure 4.3 summarizes the primary steps, beginning from the coding, considering that the previous research stages of design, fieldwork or data collection, and transcription, have already been done. As previous research stages were done in separate sections, data transcription was included in the analysis process under the "familiarizing with data" step as the first step of the analysis.

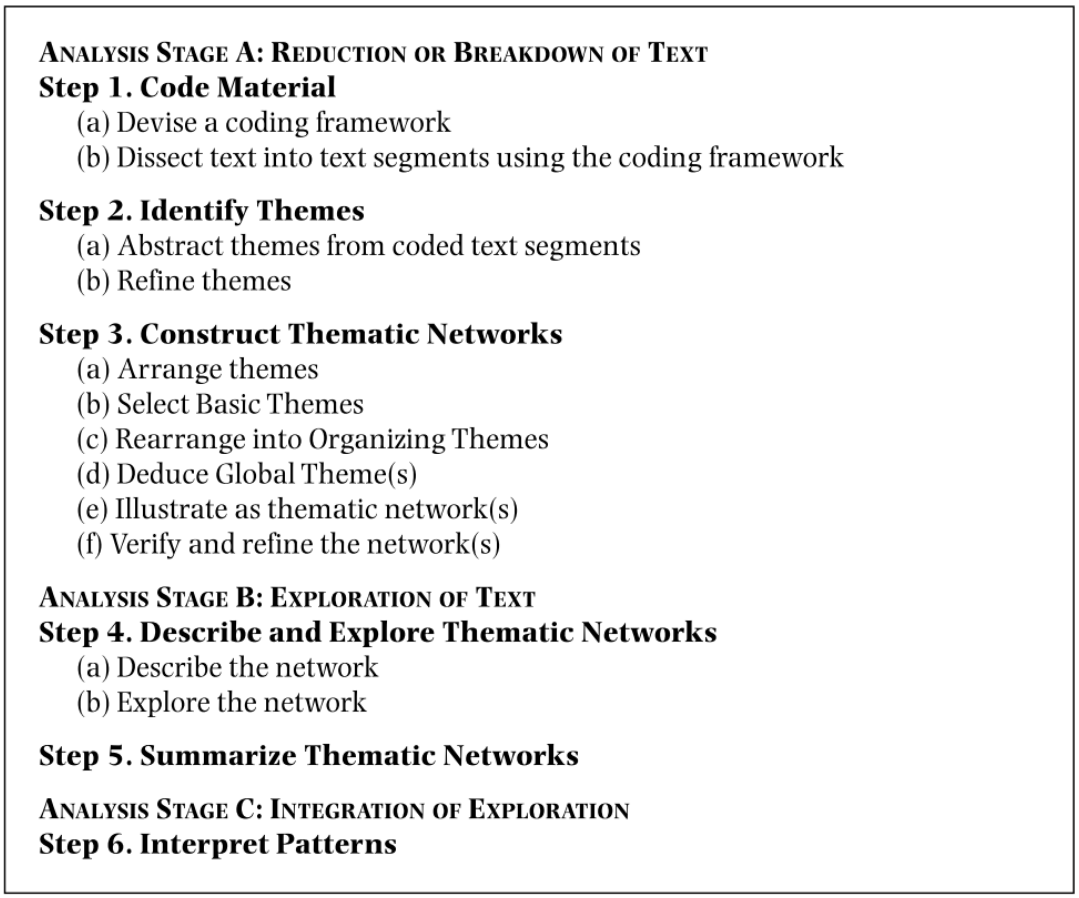

Figure 4.3 Steps in Analyses Employing Thematic Networks (Attride-Stirling, 2001)

4.7.1 Familiarizing with Data

It is believed that during data gathering, listening to participants' experiences and recognizing prior codes and themes begins the process of familiarizing yourself

with data. In this study, transcribing the recorded interviews reveals the potential codes and themes. Reading the whole data set twice to assure a complete understanding of specific points was also helpful in this process. Finally, using the Nvivo software's cluster and word cloud analysis tools, interviews and representations of words appearing more frequently in the source were illustrated.

4.7.1.1 Transcribing the Interview Data

Transcribing the audio recordings of interviews is the initial step before data coding. The process starts with word-by-word transcription of the recordings. While this process may take much time, it's essential because it facilitates getting familiar with the data before beginning to analyze. Express Scribe, which is a professional audio player software for PC, is used to help transcribe audio recordings. Using audio playback with keyboard hotkeys made it possible to use Word to write transcription while simultaneously listening to the audio records, which reduced the turnaround time. The transcription of the audio records was carried out as close to the actual conversation to avoid losing emotional overtones as Bazeley (2013) highlighted in her study. During transcribing, changes in the size, style, color, etc., are used to shape the data, highlight the essential parts, and explain the complexities of what's going on. Then, the data is imported into Nvivo software.

4.7.1.2 Cluster and Word Cloud Analysis

The Nvivo software's word cloud analysis and cluster analysis were used to visualize the interview data before beginning the coding process. The outcome of the word cloud analysis of the full coding is shown in Figure 4.4. It is clear that the most frequently used words are "project," "risk," "management," "knowledge," "information," and "reviews."

Word cloud analysis helps get keywords for exploring each interview's potential research topic. The result of four interviews' word cloud analysis was pictured in Figure 4.5. The keywords of four interviews were adopted to summarize the possible topics of each interview.

Figure 4.4 Word cloud analysis of the whole data

Interview (1)

Interview (2)

Interview (3)

Interview (4)

Figure 4.5 Word Cloud Analysis for each interview transcript

4.7.1.3 Queries in NVivo

Before coding, extra information was obtained using NVivo's query feature, which helps identify patterns by grouping sources with matching terms. As a result of the text search query, a list of the chosen data, including the word or phrase, was listed. It was helpful to check to see if a concept or subject is frequently brought up in the interview, look for any expressions used more regularly in the project, and look for ideas that use comparable terminology. The possibilities for conducting the cluster analysis include attribute value similarity, coding similarity, and word similarity. The cluster analysis was carried out via word similarity in this study. Grouping the interview data using Pearson Correlation Coefficient was most plausible when comparing the cluster analysis results based on the three similarity criteria. Similar sources were grouped based on word frequency and vice versa. As a result, a tree with branches is used to depict the word or phrase's multiple connotations. It was helpful to comprehend how several aspects related to one another. Figure 4.6 shows an example of a text search query for identifying the relationship between using post-project reviews and risk management from the interviews.

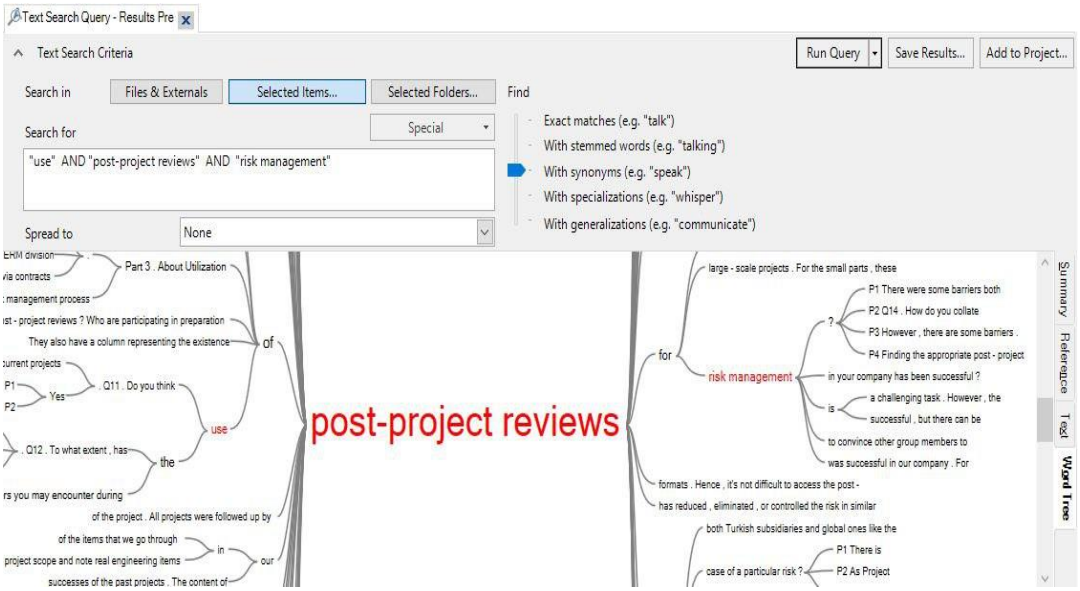

Figure 4.6 An example of text search query

4.7.2 Coding the Material

After becoming familiar with the data, a systematic coding process was used to create codes, organize the data, display valuable categories, and highlight significant parts of the data. The data was split into smaller pieces by coding into groups. The coding framework was focused on the theoretical aspect of the study. Still, it was also searched for new findings, which resulted in coding to became "concept-driven" and "data-driven" and reflecting the combination of deduction and induction approaches (Attride-Stirling, 2001).

Codes were developed as nodes in the Nvivo program based on the study objectives, interview questions, cluster and word cloud analysis, and query results of Nvivo software. A new collection of codes were developed as a continuous process until all the interview transcripts were studied. During data coding in NVivo, it was found that various participants used the same or similar terms to share the same idea. These mutual and repeating ideas were essential in revealing information and details regarding study questions. Therefore, related concepts were categorized and arranged into parent nodes and labeled. Figure 4.7 shows an example photo of the coding process in NVivo.

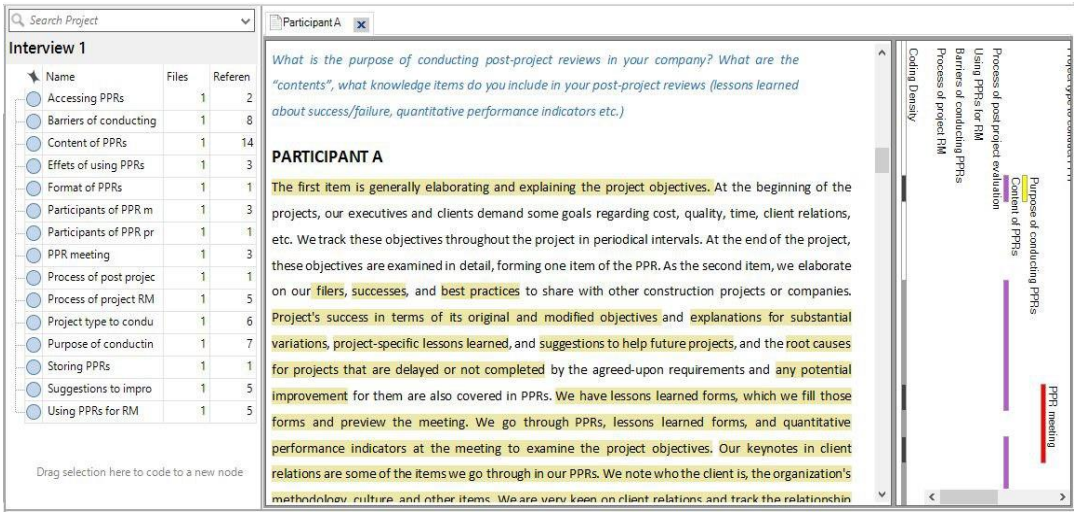

Figure 4.7 Sample of coding analysis

4.7.3 Identifying Themes

This step's primary goal is to find basic patterns and relationships between the recognized themes. Themes will be found inside the codes, making it possible to create abstracts of the coded data pieces. To improve the data, it will be required to classify each theme's level within the "thematic network" and determine whether the themes are not duplicated, provide an idea, and form a larger image.

Each of the top codes will be assessed independently. Potential basic themes will be discovered and imported to Nvivo and given a number. Then the relevant codes will be collected under the numbered basic themes.An example of this application is shown in Figure 4.8

Figure 4.8 Identified codes for reseasons to conduct PPRs

4.7.4 Constructing the Networks

The construction of the network will be started once the basic themes had been created, categorized, and summarized into organizational themes. The central claim, proposal, statement, idea, or hypothesis related to organizing themes will be outlined by considering the basic themes and serving as the network's global theme. The process will be carried out for each group of themes to produce distinctive global themes for each set since there will be multiple groupings of themes developed. Figure 4.9 presents the analysis of codes related to the reasons construction companies conduct PPRs, and Figure 4.10 illustrates an example of the separation of basic themes under organizing themes and organizing themes under global themes.

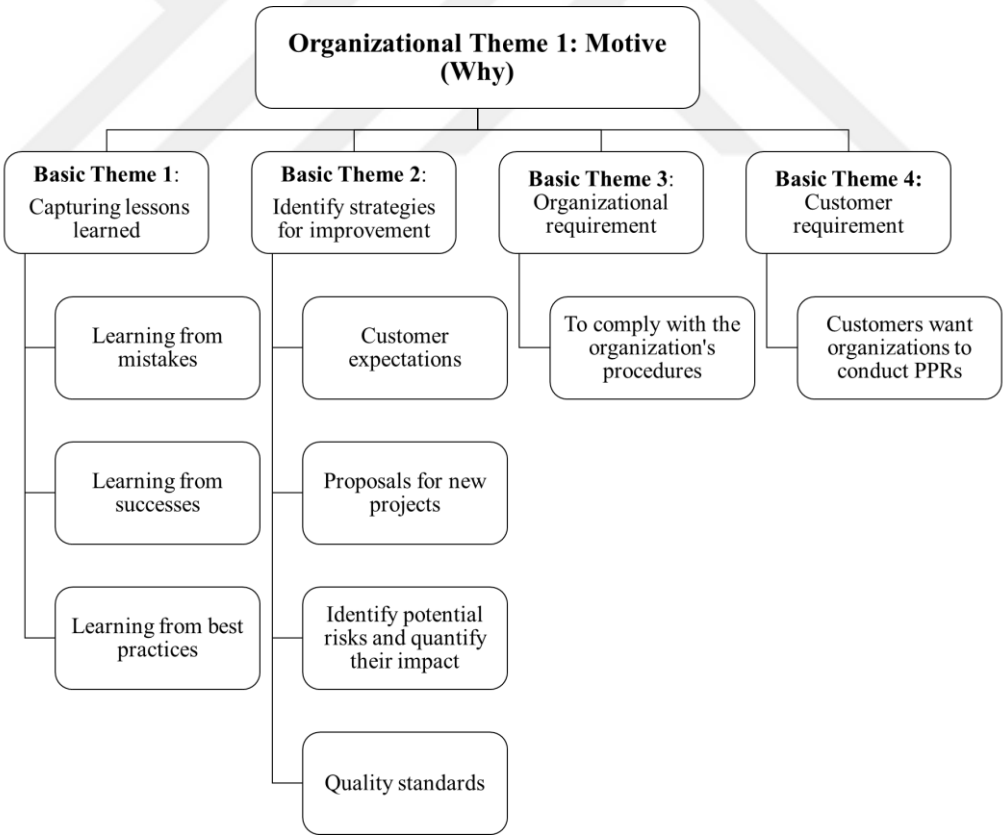

Figure 4.9 Analysis of codes in basic themes

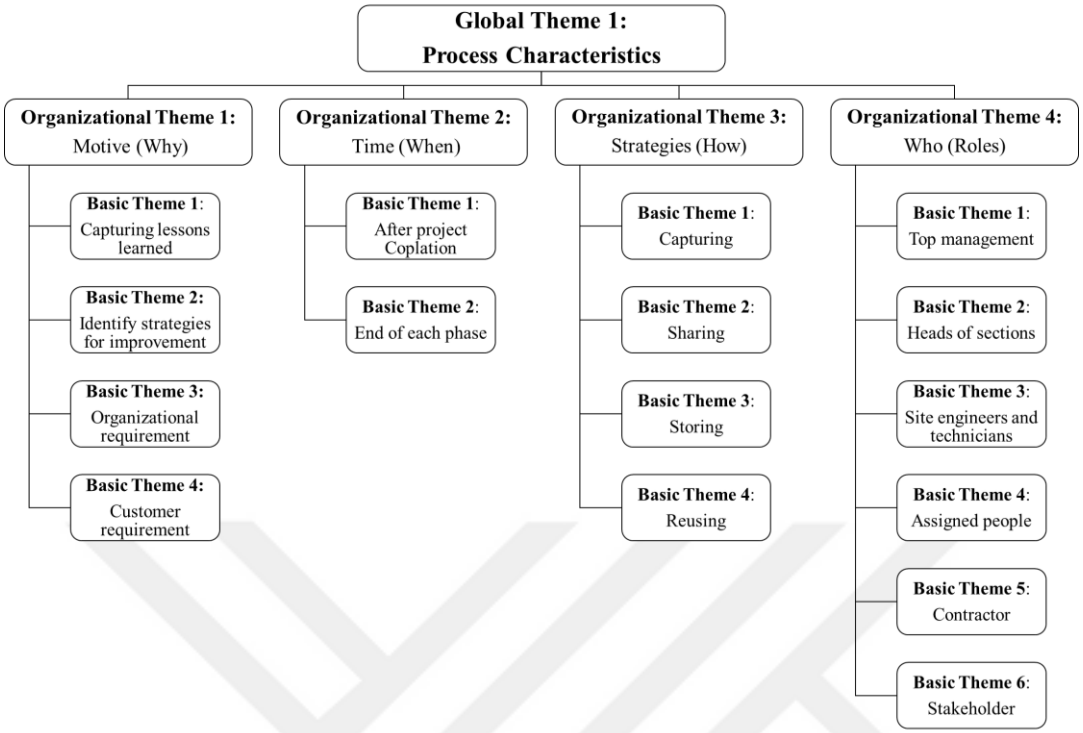

Figure 4.10 Separation of basic themes under organizing themes and organizing themes under global themes

4.7.5 Describing and Exploring the Thematic Networks

To ensure consistency researcher switched back and forth between the interview data and the global themes throughout the analysis. A detailed examination of each identified theme will be created to understand how it suits the overall dataset considering the study questions. Patterns will be found and investigated through the use of global themes. It's important to note that while thematic network analysis can be used to interpret data, it cannot do it independently. The researcher is responsible for analyzing the data. With the help of the network that organizes the data in an understandable and informative manner, the researcher interprets the data in accordance with their view of the data (Attride-Stirling, 2001).

4.7.6 Summarizing the Thematic Network

When a network has been described and investigated, an overview of the key themes and patterns will be provided. The goal is to enumerate the key ideas that emerged in the network description and express the patterns that emerged during the study.

4.7.7 Interpreting Patterns

The final step encourages the interpretation of the patterns while considering the research question and the theoretical framework employed; given that this piece of research started with a research problem and heavily relied on its theoretical foundation, the primary data should be subtracted from the theoretical framework's foundation. The main goal of this step will be to draw conclusions from prior research and shed light on new findings while taking the entire network into account (Attride-Stirling, 2001).

CHAPTER 5

FINDINGS FROM THE INTERVIEWS AND ANALYSIS

This chapter presents the findings from interviews to address the main research questions. The data analysis revealed three global themes, including “process characteristics,” “benefits realization,” and “challenges.” The “Process characteristics” theme describes why construction companies conduct PPRs, when they conduct PPRs, how they conduct PPRs, and who conducts them. The “Benefits realization” theme describes construction companies’ benefits from conducting and reusing PPRs. Finally, the “challenges” theme describes companies’ barriers while conducting and using PPRs to improve the process.

A broad overview of the themes and sub-themes below are presented the data's overall structure. The themes were collected precisely following the method used to gather the data, and figures with details of each theme .The emerging themes offered a thorough grasp of the value and advantages of PPRs and LL for risk management, the obstacles that prevent project managers from carrying out PPRs, and the techniques used by administrators to ensure project managers carry out PPRs and incorporate valuable risk knowledge in these reviews.

5.1 Findings from the Inteviews

Question 1:

How many construction projects have you participated in your career? About how many of them were followed up by a post-project review? Can you please give a percentage?

The participants' experiences were different regarding conducting PPRs for the projects they have been involved. Participant A had three years of academic and seven years of professional experience and had participated in approximately fifty projects. She believed that 30% of the projects she has participated in had structured PPRs. Participant B had five years of professional experience and had participated in approximately twenty projects. She claimed that 50% of projects she has participated in were followed up by PPRs. In the past 17 years, participant C has been involved in more than ten projects. He claimed that PPRs were conducted only for multi-national and large-scale projects, which equals 20% of the projects in which he had participated. Participant D has been involved in approximately thirty construction projects, and as he mentioned, PPRs were conducted for 50% of the projects in which he was involved. Still, he believed that PPRs should be conducted in all types of projects, except for some small and simple ones. Table 5.1 summarizes the interviewee's answers to the first question.

Table 5.1 Experience of participants with PPRs

	Numbers of projects involved	Percentage of the involved projects followed up by a PPR
Participant A	50	30%
Participant B	20	50%
Participant C	17	20%
Participant D	30	50%

Question 2:

Are the post-project reviews conducted in all types of projects or large-scale projects? International projects or domestic projects? In Turkish construction companies, multi-national companies?

According to participant A, whether domestic or international, PPRs usually conducted in large-scale projects. On the other hand, participant B emphasized the importance of the PPRs and stated that PPRs should be conducted for all projects regardless of their type. Participant C believes that international and large-scale projects necessarily need to conduct PPRs. Finally, participant D stated that all project types—aside from a few small, simple projects—should conduct PPRs.

Table 5.2 Types of projects in which PPRs are conducted

	Participant A	Participant B	Participant C	Participant D
Large-scale projects	x		x	x
All projects		x		
International/ multi-national			x	x

Later interviewees were asked to frame their company and state whether they conduct PPRs in their organization to continue the interview questions further to explore how post-project reviews are conducted and further utilized in their company.

Question 3:

Do you conduct post-project reviews in your organization?

All interviewees stated that their companies are classified as large-scale companies based on the number of employees, and they conduct PPRs, except participant C, who was working in a family-run medium-sized company that doesn't carry out PPRs.

Table 5.3 Information related to company size and conducting PPRs

	Participant A	Participant B	Participant C	Participant D
Employees	5000+	5000+	500+	1000+
Company size	Large	Large	Medium	Large
Conducting PPRs	x	x	-	x

Question 4:

What is the purpose of conducting post-project reviews in your company? What are the "contents", what knowledge items do you include in your post-project reviews?

Most interviewees responded: "to find out what went right/wrong," "to identify strategies for improvement of future projects." As participant C mentioned in the previous question, the organization he was working for does not conduct PPRs. Therefore, he answered this question based on his previous experiences. Table 5.4 presents the participant's responses to reasons for conducting PPRs. The mentioned reasons were those that were frequently cited in the literature to support knowledge management initiatives in businesses, including to comply with the organization's knowledge and quality management procedures (Gibson et al., 2007); to avoid mistakes, and repeating successes of past projects (Caldas et al., 2009); to learn from similar projects in the future (Carrillo et al., 2011; Jugdev, 2012; Matthies & Coners, 2018); to learn lessons from successive stages of ongoing projects (Manotas-Niño et al., 2016; Matthies & Coners, 2018); and to give the business a competitive edge (Alhawari et al., 2012). All respondents showed interest in learning and growing through a PPR. Other reasons mentioned were: (1) to improve customer satisfaction and, (2) to assist in the career development of the employees.

Table 5.4 Reasons for carrying out PPRs

	Participant A	Participant B	Participant C	Participant D
Identifying what went right/wrong	x	x	x	x
Identify strategies for improvement of future projects	x	x	x	x
Record keeping; knowledge production	x	x	-	-
Organizational learning	x	-	-	-
Organizational requirement	x	-	-	x
Improving customer satisfaction	x	x	-	-

Answers regarding the contents of PPRs is presented in table 5.5. “Basic project information”, “performance” and “lessons learned” were mentioned by most of the participants. Besides the mentioned items, participant A added “keynotes about client relations” and further explained it as follow:

“Our keynotes in client relations are some of the items we go through in our PPRs. We note who the client is, the organization's methodology, culture, etc. We are very keen on client relations and track the relationship with clients.”

As participant C mentioned in the previous question, the organization he works for does not conduct PPRs. Therefore, he answered this question based on his previous experiences. Participant D also mentioned the same items which they included in the PPRs:

"Project name and overview, participants, anticipated results vs. actual results, variation notes, project costs, project milestones, program, and project risks."

Question 5:

Who is preparing (the department) the post-project reviews? Who are participating in preparation of post-project reviews? Can you please explain me the "process" of post-project evaluation?

Participant A declared that, they distributed a template to all project participants and requested their feedback on good practices, any possibilities for improvement, and any suggestions of variation for the following projects. Additionally, construction site team members recorded identified risks, causes, consequences, and risk treatment strategies.

"Our technical office at the head office publishes a request list for the construction site. They want them to fill in the lessons learned and the risk assessment forms, record the building engineering studies, and prepare the quantitative performance indicators and realizations for those indicators. The actual documents are separate to be prepared by the construction site. The head office's technical office reviews the reports, corrects them, or asks further questions from the construction site to clarify some parts if needed. Then the reports will be sent to the participants of the post-project appraisal meeting."

Participant A shared that the meeting is held in one week, and participants go through the report and discuss the critical issues. Individuals from the construction site and the head office departments attend the meeting:

"From the construction site: construction manager, site manager, and head of the technical office and depend on the project type for some projects like industrial projects mechanical, electrical units and people from the industrial process management also attend the meeting. From the head office, the group president attends at the highest level. Members from the executive board, head of the

technical office, head of finance, head of the legal department, and head of procurement attend the meeting."

She added that, after the meeting, the technical office drafts the meeting notes and publishes them to the participants. Finally, PPRs will be sent to the company database.

Participate B stated that they have a "Risk and Opportunities Table" for every project during the construction stage for risk management and project tracking reviews. As she explained, this table is prepared by the site units, site management, and quality department and is updated regularly. On the other hand, the ERP system allows them to control the cost and determine whether the project exceeds the budget or not. They include the recorded knowledge in the project closure report.

"The project closure report is prepared when the construction site is finished. All documents such as risk and opportunities table, asbuilt drawings, cost reports, sales catalogs, calculations, photographs, tab, site annual/monthly/weekly/daily reports, meeting minutes, work schedules, and reports to which the project manager conveys his experiences and suggestions are filed and completed."

Participant C answered the question based on previous projects he was involved. According to him, the task of post-project evaluation is delegated to project participants, the project support office, and a specific department. In the processes run by a particular department, the evaluation team and consultants are in charge in the main. The project manager's and the team's responsibility is to impart their knowledge to the evaluation team by writing reports. The evaluation panel decides upon the primary discussion points. Project support offices can facilitate the procedure. The project team, project office, stakeholders, and users of project deliverables typically play critical roles in the post-project evaluation processes.

According to participant D, the team captures knowledge at each project phase. The project manager encourages the project participants to record lessons learned

as the project moves along rather than waiting until it is finished to avoid losing valuable knowledge. He reported that when the project is completed, the team meets to discuss project details and conduct PPRs with the owner and contractor. To finalize the PPR, the group discusses the problems and risks that arose during the design and construction stages and provides suggestions to improve the management process. Project control and management engineers are mainly responsible for conducting PPRs.

Table 2.1 shows the participant's answers about the people involved in conducting PPRs.

Table 5.5 People involved in PPRs

	Participant A	Participant B	Participant C	Participant D
Top management	x			
Heads of sections	x	x	x	x
Site engineers and technicians	x	x	x	x
Assigned people	x	x	x	x
Contractor			x	x
Stakeholder			x	x

According to Gibson et al. (2007), an effective knowledge management program would assign and distinguish the roles responsible for different stages. Managers must provide leadership and direction while delegating responsibility for creating and sharing knowledge and lessons learned. Participant C believed they do not capture LL or even conduct PPRs in his current organization due to the lack of proactive leadership.

Question 6:

Are the post-project reviews/reports stored in corporate memory/database? If yes, who can access to post-project reviews in your company? Who are using them and what purpose?

Participant A stated that they store PPRs in the shared drive. As she mentioned, the technical office mainly accesses PPRs because they coordinate everything related to the process. However, anyone in the company related to construction management and project management responsibilities can access the PPRs based on a request.

"They must fill out a form to get approval to access those files from the technical office and our IT team."

Participate B shared that their internal contacts have access to reports in a web portal where the knowledge management department publishes the latest versions of reports. She continued that everyone in the company related to the project has access to project closeouts.

Participant C declared that in previous projects that he was involved, lessons learned were collected by conducting PPRs and were stored in company's cloud storage. He stated that due to the financial information included in the reports, only a small number of individuals were permitted access to the PPRs such as project managers; everyone else had to request permission from the project manager.

Participant D stated that PPRs are stored in the company database and a shared drive. In addition, he noted that specific people such as managers, project control engineers, and planners access those reports by having a password authorized by the company. However, he believed everyone in the company should have access.

"Site teams are requested to capture knowledge, but there is little indication that they are helpful because they do not have access to the results, leading to the view that they provide little value."

Table 5.6 presents the summary of the participants' answers to the questions.

Table 5.6 Storing and Accessing PPRs

	Participant A	Participant B	Participant C	Participant D
Store				
Web portal		x		
Cloud storage			x	
Shared drive	x			x
Access				
Everyone in the company		x		
Managers			x	x
Technical Office	x			
IT department	x			
Project control engineers				x
Planners				x
Access based on permission	x		x	

Everyone should have access to the data, and it should be simple to trace. If a lesson contains personal or confidential material, the project leader should "lock" it and require authorization before anyone may access it. Additionally, the only people with authority to alter an existing Lesson will be the Project Leaders and a small number of their designated representatives. This may be carried out following a formal meeting or decision.

Question 7:

Do you use post-project reviews of previous projects to predict/manage risk in forthcoming projects?

- *Do you think use of post-project reviews in RM is beneficial?*

- *To what extent, has the use of post-project reviews in your organization resulted in project risk reduction/better performance? Could you please give us some examples?*

Participant A claimed that utilizing lessons learned besides effective communication, supervision, and meeting styles of the company has improved the company's learning culture. She added that the team used risk knowledge gained from earlier projects to provide an advance alert regarding technical problems, such as bringing staff to the site in time to make equipment ready. Additionally, she mentioned that their team uses lessons learned to set clear orders for the suppliers as well as the date and time the materials should arrive to avoid losing time. Another lesson learned that participant A mentioned was the first time their team ordered a specific material from a foreign country, and it was too late when the team realized that the supplier was on holiday for two weeks. As a result, the project didn't finish on time.

"It was a learned lesson that the team used to manage the same risk for our next project."

Participant B believes that lessons learned are valuable, mainly if project managers can use the results of project reviews for forthcoming projects. As she mentioned, by communicating with stakeholders, the project team builds on lessons learned from previous projects to improve communication and keep everyone up to date on the project's progress. She further mentioned that the team makes sure that the stakeholders are aware of the significance of controlling project risks. She believes that risk management is the most important LL from past projects to improve the success of future projects. Furthermore, she agreed that communicating the potential risks with stakeholders was essential to quickly implement the planned action to reduce or accept the risks. In conclusion, she stated that a similar new project could benefit from what worked well and not if lessons learned were recorded from previous projects.

Participant C noted that all of the projects have a start-up phase, and shortening the start-up phase of future similar projects using PPRs of completed projects is highly beneficial.

"It is a means of saving money, I would say; time is money."

However, he also thought that PPRs sometimes did not completely realize their potential for managing the risks of future projects.

"We haven't always had a good structure on how to use the evaluation results; I mean, it could stay on the bookshelf for ten years without being opened; that's the worst case, or individuals could take it out to use it for the next project."

Participant D acknowledged that using lessons learned from risks of completed projects for managing the risk of new projects was a substantial advantage of lessons learned. The project members are notified about the project's quality, risks, management, and the experience of the project participants and contractors from the PPR document of a similar completed project. He mentioned that the project team was prepared for possible safety problems the group might run across in the actual project by using lessons acquired from previous projects. He added that the group benefited from applying lessons gained to design and implementation standards that might have impacted the project's effectiveness. Additionally, the team used the time and scheduling principles they had learned, which benefited the projects.

In workplaces with significant staff turnover rates and where information is developed by adding blocks of experience, it is crucial to avoid losing vital information (Shokri-Ghasabeh & Chileshe, 2014). PPR is an effective method to learn from prior experiences and record this data. Risk management benefits from the information gained through PPR, particularly when it comes to detecting risks and creating response plans (Royer, 2000). Also people who feel their thoughts have been suppressed in the past find these documents as a confirmation of their opinions. Furthermore, they seem quite helpful when it comes to bringing up topics

that individuals want to discuss but haven't dared to bring up during a project. As well as generating a body of generalizable information about management—about what works and what doesn't (Carrillo, 2005)—they are successful at sharing knowledge from one area of an organization to another. It also reveals what kinds of risks are particular and what kinds are typical or systemic (Busby, 1999).

Question 8:

What are the barriers you may encounter during the use of post-project reviews for risk management?

Participant A acknowledged it could be challenging to conduct PPRs at the end of a project when everyone wants to start working on the next project, so project managers should always remind the team about recording risk knowledge. As she mentioned, in this process, another problem is internal competition between the project members, which results in keeping project knowledge, including risk knowledge, to themselves and unwillingness to receive advice from other departments or central office teams.

"People on the construction site think they are responsible for the whole project and do not listen to the people's comments and advice from the central team working at the main office. My colleagues and friends from other companies complained about similar sector problems."

She also noted that some project managers believe documenting lessons learned takes too much time. She assumed the reason could be project managers who had used LL from previous projects valued learning and were more prepared to take part in documenting what they had learned of earlier risks.

According to participant B, the most significant barrier to project closeouts and reusing them for new projects was time constraints in their organization years ago. Later, they included this procedure in the project life cycle to solve this problem. They recognized that stopping throughout a project to record LL or apply LL from

earlier projects to the current project allowed the team to preserve valuable knowledge and use it as the project moved forward rather than waiting until the end when the chance to improve or mitigate risks had already passed.

Participant C mentioned barriers to conducting PPRs in their organization as organizational leaders and blame culture. He expressed that organizational leaders and decision-makers did not build trust by encouraging participants to share their experiences about the risks they encountered or mistakes they have made.

"Mostly, I do not share risk knowledge. It might lead to criticism."

Regarding the critical role of organizational leaders, he declared:

"Managers should be given proper tools to ask questions of teams and gather feedback on project specifics, including risks and mistakes. Recording LL should be a mandatory deliverable after project completion."

Participant D mentioned time constraints as the most significant barrier to conducting PPRs. *"It depends on your time because things move quickly here, and everyone needs to be productive."*

The answer continued, *"The next project is already operating; you would like to have much more time to complete an evaluation, but if you don't, you have to find the most critical task and consider what will benefit you the most."*

He also declared that finding the appropriate PPR, which could help them during the risk assessment of the new projects, is another barrier in their organization. He believed the root causes of this problem are inadequate IT infrastructure, deficiency of an agreed standard for storing PPRs, and new employees being unfamiliar with the process.

Question 9:

How do you collate post-project reviews to be used for risk management? Do you use a particular format to make it easy to access? Is there a special software for this?

Participant A declared they have a particular format with heading structure and short, consistent texts for PPRs. Before PPRs are sent to the company database, the technical office team checks them to ensure everything is according to the format. She continued that the technical office team records the project name, country, client, project contract amount, project type, contract date, finish date, etc., in excel format. They also have a column representing the existence of PPR for each project. They note the document number of the PPR of that project so they can find it easily later.

Participant B stated that they include the recorded risk knowledge in the project closure report. The closeout report is concise, with clear lines or phrases and a specific format. However, as a limitation of their reports, she expressed that:

To be honest, although our closeout reports are clear, they might not be clear enough for someone who was not present in the meeting, making it hard to understand the report's context.

Participant C declared that in earlier projects he was involved, LL was mentioned in the "Areas of Concern" and "Areas of Improvement" at the end of the PPR. They listed the risks with a background and a ranking.

"The ranking was determined by the impact on the project's outcome and potential significance for upcoming projects. Then, the PPR on print and in a searchable electronic format were created to document these LL."

Participant D stated that each document has a different format and lacks unifying themes despite formal structures, locations, and rules for conducting PPRs. He claimed that the managers are not notified of the lessons learned or the measures done as a result of those reports, which restricts the learning process. In this case, the project manager produces LL to satisfy rules or regulations technically and does not perceive any benefit in doing so.

Question 10:

How you retrieve/search post-project reviews that are relevant for new projects?

As participant A mentioned in the previous question, they record the project name, country, client, project contract amount, project type, contract date, finish date, etc., so It is easy to search through the PPRs based on different filters.

Participant B stated that it is part of the risk management department's formal process to find the same cases after finishing the risk assessment phase to reapplication of best practices. However, other members also refer to project closeout when they need it.

"They can use a directory to look for similar projects or clients or a search engine to find PPRs based on keywords."

Participants C and D stated they could locate LL in paper versions of the PPRs or do an electronic document search. However, participant D claimed that while it is simple to search the database for the relevant risk information, doing so takes too much time because everyone doesn't adhere to the standards governing the format and structure of PPRs.

Question 11:

Do you provide a guideline to ensure that employees understand what post-project reviews are, what they aim to do, what are the preferred ways post-project reviews should be collected, stored, and used for risk management?

Participant A stated they do not provide established guidelines for their employees about PPRs and their use for RM. When further asked about the reason, she continued:

"Because we have a standard format, and people know how these reviews are undertaken. So, there is no need for guidelines, but we have a guideline for risk management. For newly attending employees, their teammates or managers teach the process."

Participants B, C, and D claimed that their companies had established formal guidelines on how PPRs were to be conducted. However, participant D stated:

"We have a guideline which we share with the related staff; however, most of the time, it is left unread."

Question 12:

Do you think that the way you are applying post-project reviews for risk management in your company has been successful? Can you please suggest any improvements?

According to participant A improving the organizational culture would be practical for project groups to share what they know and for project managers to be efficient and intelligent about managing the projects and ensure the groups do not repeat mistakes. In addition, participant A suggested that administrators should ensure that recording LL is part of the project life cycle and a requirement for project managers to carry out so that facilitate them well to conduct PPRs by allocating budget and time.

Participant B stated that although their current PPR process met their organization's needs, it might be improved.

"Despite the fact that things move quickly here, and we are constantly busy with projects, I believe it is effective and gives us ideas for the upcoming projects. However, I am confident we can do it much more thoroughly."

In order to get diverse viewpoints on the issue and ensure that the cause of problems is discussed freely and honestly, she proposed conducting PPRs with all team leaders.

According to participant C, project managers should include the conducting of PPR as a milestone and deliverable at the beginning of each project over a specific cost and time. Additionally, he thought that in order for project managers to assign resources for the procedure, organizational leaders needed to support the idea of

performing a PPR. He suggested that project managers examine ongoing projects and specify the PPR's expectations at the beginning of the project.

"Let's say organizational leaders are the ones who emphasize the need for PPRs. In that situation, it will be acceptable for the project managers to include the budget and plan the cost and time for capturing LL."

He concluded by pointing out that project managers may encourage team participation in PPRs by making the reviews brief and straightforward and by including events to celebrate the project's accomplishments.

According to participant D, PPRs should be documented using a similar template to preserve uniformity across all projects. Additionally, he recommended indexing and electronically archiving PPRs to enable easy access. He also suggested that construction companies should be in charge of educating personnel about the mental shift needed to execute knowledge management. Through training, staff members would acquire the most recent education, increasing their capacity to adapt to the constantly changing construction industry environment.

5.2 Findings from the Thematic Analysis

5.2.1 First Global Theme: Process Characteristics

This global theme represents the features of PPR practices noted in the interviews. The subject examines the "why" and "when" of a PPR, how it is transmitted, and whether it is systematized or documented. The first two knowledge management principles, "capture" and "disseminate," align with this cycle. In other words, it examines the methodology used to conduct a PPR and how its results are distributed once it has been carried out. To find logical answers to the research question ''how do construction companies use PPRs during risk-informed decision making?", it was essential first to find out how participants perceive the importance

of conducting PPRs, whether participants run PPRs in their organizations, whether there were formal procedures for conducting PPRs and what are the purposes of preparing PPRs before connecting it to risk management concept.

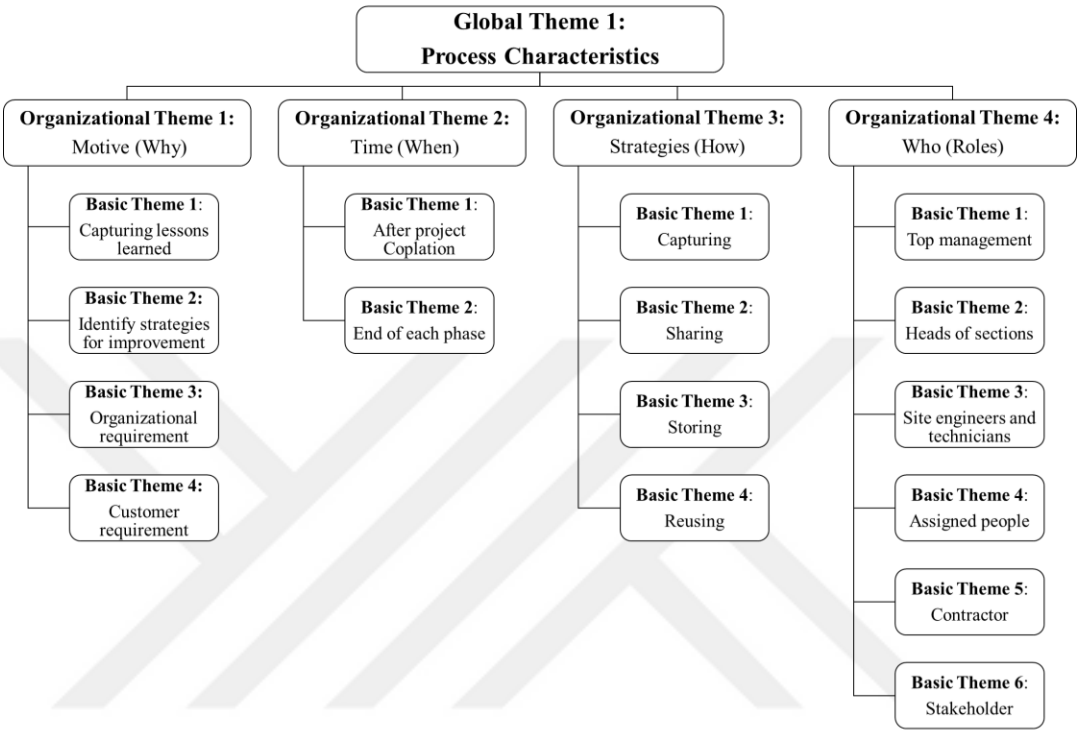

Figure 5.1 First Global Theme: Process Characteristics

5.2.1.1 Motive (Why)

When asked interviewees the purpose of conducting PPRs in their organization, most of them answered with "to know what went right" and "what went wrong," "to do it better in the future," and " need to evaluate performance" and "mainly to find lessons learned on what went well and what could be done better." The incentive to learn and improve through a PPR was evident across all respondents. Based on their type of work, each organization had its own goals to achieve by conducting PPRs. However, they all were trying to follow the same plan: learning

from completed projects. Most of the codes were collected around sharing best practices and repeating the successes of past projects, lessons from the failure, especially concerning a specific activity or a failure to complete a task or desired action, and to avoid making the same mistakes in the next projects. Lastly, to improve resource efficiency, customer satisfaction, and proposals for new projects.

The mentioned reasons were those that were frequently cited in the literature to support knowledge management initiatives in businesses, including to comply with the organization's knowledge and quality management procedures (Gibson et al., 2007); to avoid mistakes, and repeating successes of past projects (Caldas et al., 2009); to learn from similar projects in the future (Carrillo et al., 2011; Jugdev, 2012; Matthies & Coners, 2018); to learn lessons from successive stages of ongoing projects (Manotas-Niño et al., 2016; Matthies & Coners, 2018); and to give the business a competitive edge (Alhawari et al., 2012). All respondents showed interest in learning and growing through a PPR.

5.2.1.2 Time (When)

As for the PPR's timing, Participant A said to conduct the PPRs right after the project as it is officially scheduled for the project members. Participant B also explained that The project closure report is prepared when the construction site is finished however, some project members disband before the PPR occurs. Hence, their part in the review is captured before. Similarly, Participant D stated that in their organization, the PPR is integrated into the schedules of the project members but said that the PPR could either take place right after the project or "it can also take quite a long time before we come back to the evaluation of the project, and then we try to gather all the key personnel [..], it can vary a lot". When questioned about PPRs, Participant C frequently stated project monitoring evaluations. The PPR is carried out following the project, whereas the project monitoring assessment is carried out throughout the project. However, according to Eliufoo

(2017), no precise time has been established as suitable for PPRs because it varies on the project's scope, difficulty, and length. It can be done during and after a project's completion to determine whether the project is on track and evaluate both short- and long-term results.

5.2.1.3 Strategies (How)

Construction projects are carried out in various locations, by multiple parties, and with different goals, all of which make the knowledge capture and management process more challenging. Knowledge must be captured to avoid losing knowledge due to passing time, fading memories, and team members quitting projects. It should also be shared and documented in order to reuse it for future projects. The literature review revealed the importance of knowledge capturing, sharing, storing, and reusing, the areas that need to be captured, the time lag between the knowledge creation and capture, the format and content of the documented knowledge, etc., which are essential items in this process. The interview session aimed to discover how construction companies capture, share, store and reuse risk-related knowledge and how they include it in PPRs.

5.2.1.3.1 Capturing Knowledge

Reviewing a project for what went right and what didn't, what the project team could have done better to improve the project results, the risks of the project, and how those risks have been addressed is the process of capturing risk knowledge and lessons learned (Velandia-González et al., 2015). Based on the findings from the analysis results, the project team mainly records knowledge at the end of the projects. For large projects, all participants agreed that recording the LL and risk knowledge for each stage of the project is preferable. This is consistent with Sowards (2005) statement that reviews should be conducted during the course of the project rather than only at its conclusion. Participants are often sent a uniform

template for each phase of the process to let them know what went right or wrong and where there is room for improvement. One of the participants added that reviews should be done at the start of the project to evaluate how the team performed in the bidding and execution phases. The project team might later talk about the lessons discovered during project meetings, including a review after each phase and the project's completion. The interview session also focused on encouraging team members to record lessons learned throughout the course of the project rather than waiting until the finish because it is thought that the best time to record any learning is when serious problems arise and are noted.

5.2.1.3.2 Sharing Knowledge

Certain conditions must be met in order for knowledge sharing to take place and contribute and for people to share their expertise with others (Obrenovic & Qin, 2014). Milton (2010) observed that although businesses recognized and recorded lessons, they did not communicate them in order to bring about the desired changes in behavior, procedure, best practices, or standards. Recent research shows that manager support, ethics, motivations, and social power are important variables influencing the sharing of LL (Obrenovic & Qin, 2014). Interviews revealed that most of the time, information is communicated informally rather than formally, and factors influence the process. According to interviewees, time constraints, lack of management support, lack of motivation, fear of getting the blame, and workplace culture are the most likely to affect knowledge sharing in organizations.

5.2.1.3.3 Storing Knowledge

Recorded knowledge from earlier projects should be archived for usage in upcoming projects. IT is crucial in this situation for managing knowledge assets well (Kivrak et al., 2008). The interviewees were questioned regarding the existence of a database about previous projects in their organization. It was

discovered that three out of four companies use post-project evaluations to learn from previous projects and keep these documents in digital form. Based on participants' answers, these reports are stored in the shared drive, web portal, and cloud storage. Responses from interviewees revealed that three out of four companies have a particular format with heading structure and short, consistent texts for PPRs. One of the participants claimed that they check PPRs to ensure everything is according to the format before storing them. Additionally, in excel format, project name, country, client, project contract amount, project type, contract date, finish date, etc., are also recorded. However, despite the standard and clear format of PPRs, an interviewee explained that their reports might not be clear enough for someone who was not present in the meeting, making it hard to understand the report's context. One of the interviewees stated that their reports have a different format and lack unifying themes despite formal structures, locations, and rules for conducting PPRs. According to Carrillo et al. (2013), for LL to be reused, they must be documented in a format that is simple to find. The interrelation between storing and reusing knowledge will be more apparent in the next part.

5.2.1.3.4 Reusing Knowledge

The actual value of LL and PPRs is reached only if companies reuse them after documenting. It's essential for a practical PPR to provide valuable knowledge that facilitates the planning of upcoming projects, prevents repeating the same mistakes, and in our case, provides useful risk-related knowledge to manage risks in new projects. Participants' responses showed that we could not claim that these reports are frequently used in subsequent projects since certain factors are necessary for these reports to be useful. Project groups should access the appropriate risk lessons at the right time in the proper format. Therefore, preferred ways PPRs are reused in organizations, how they alert those who need these PPRs in case of a particular risk, who can access these reports, and how they search PPRs that are relevant for

new projects are essential questions which companies should answere. The format of PPR reports should make it easier to reuse them for new projects. By categorizing the reports according to various topics and the type of project, the reports' structure should also be considered. One of the drawbacks could be the report's length because long reports tend to include more unrelated information and make it hard to find the related risk knowledge. According to Choudhary et al. (2009), a successful PPR process should produce information that can be applied to other projects. However, efficient, and long-lasting exploitation and reuse can only be possible if relevant information can be found "fast" and "easy" without adding to the workload of new project teams. If finding or using knowledge requires too much time and effort, people are less inclined to reuse it, even if it is beneficial. Companies must have a systematic strategy for locating, exploiting, and sharing risk knowledge. Interviews indicate that some organizations do not give enough input on the outcomes of the review meeting for upcoming projects. Implementing feedback systems is necessary to ensure that appropriate individuals will see the review results. The companies must make more effort to guarantee that the PPR results are methodically evaluated and applied during risk assessment. According to answers to the interview questions, not all the staff in companies have access to these reports. Project managers, technical office personnel, and project control engineers were permitted to access PPRs. Everyone else had to request permission beforehand. Only one of the participants claimed that everyone in the company has access to PPRs. Participants had reasons for limiting access to PPRs, such as the financial information in the reports.

5.2.2 Second Global Theme: Benefits Realization

For new projects, captured learning offers a collection of data that acts as a historical baseline. Interviewees were asked to share how they benefited from using PPRs during risk management. The results showed that every participant is aware of the advantages of applying what they had learned, and each of them has

benefited by using PPRs for new projects in some ways. Participants from companies that conduct PPRs mentioned the benefits provided by PPRs as improved company learning culture, advanced alert regarding technical problems, improved quality and customer satisfaction, quick implementation of a planned action to reduce or accept the risks, saved time, prepared for possible safety problems, etc which collected under two organizing themes of "lerning from experience" and "improving areas of inefficiency" as presented in Figure 5.2.

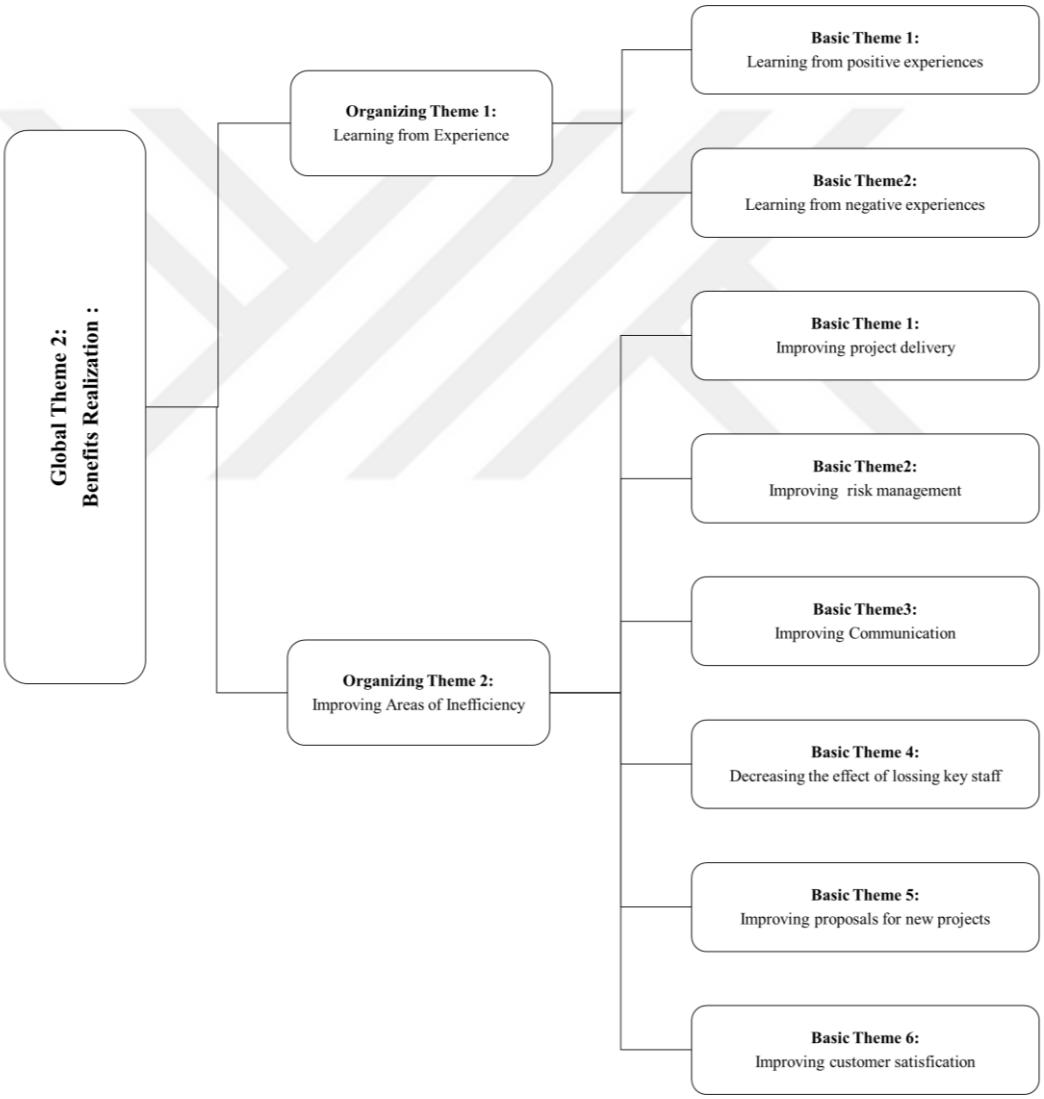

Figure 5.2 Second Global Theme: Benefits Realization

5.2.2.1 Learning from Experience

The most beneficial for conducting PPRs is cited several times in literature as learning from good and bad experiences. Participants also highlighted learning from past experiences as an important reason to conduct PPRs. It was revealed that learning was the most crucial thing they have benefited from conducting and reusing these reviews. Interviewees stated that mistakes and bad practices helped them to improve their process and decrease the number of mistakes. On the other hand, successful experiences also helped them to repeat the good practices for other projects.

5.2.2.2 Improving Areas of Inefficiency

As stated by one of the participants performing PPRs and implementing them for subsequent projects had increased quality and customer satisfaction in their company. The rest of the participants also emphasized improving project outcomes, communication, solution quality, and problem-solving time and expense which were in line with the benefits cited in literature (Ferrada et al., 2016; Kazi & Wolf, 2006; Leblanc et al., 2010).

5.2.3 Third Global Theme: Challenges

The fragmented character of construction projects and other limitations have prevented PPRs from reaching their full potential, even though PPR conduct has been widely disseminated in project management publications (Chin Bo Wei Andrew, Gao Shang, 2015). Insufficient support from upper management, time constraints, internal competition, the unwillingness of the staff to receive advice, blame game, and lack of professional software or IT-based tool are some of the barriers mentioned by participants, which is in line with the obstacles cited several

times in literature. Diffrent challenges collected under three organizing themes as presented in Figure 5.3.

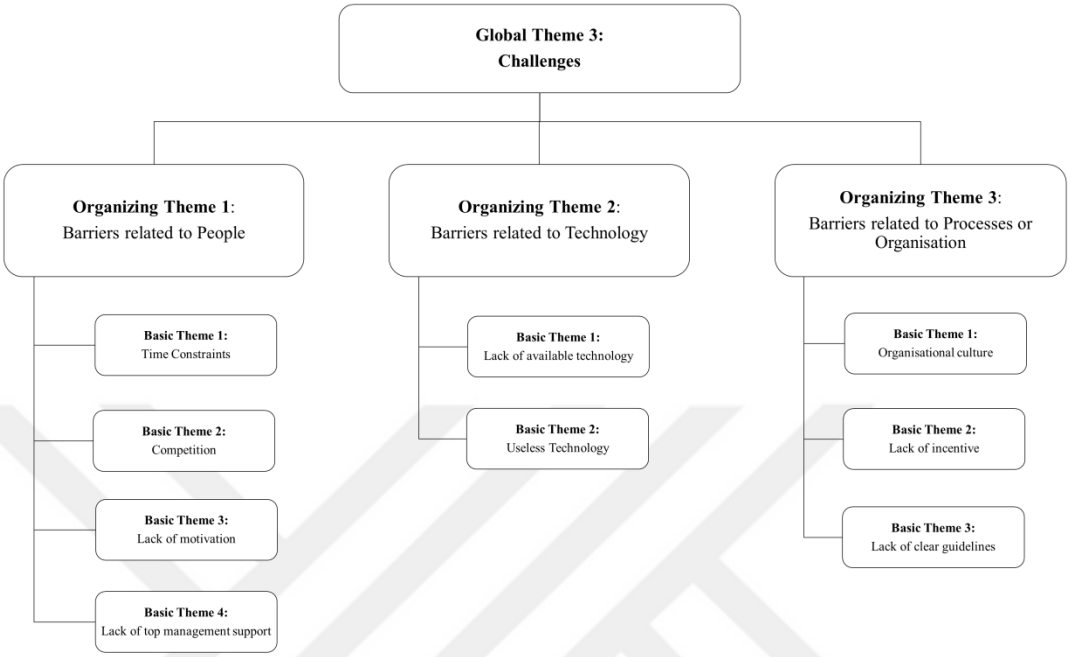

Figure 5.3 Third Global Theme: Challenges

5.2.3.1 Barriers related to People

5.2.3.1.1 Time Constraint

Time was cited by Participants A and D as the reason they were unable to commit to a more advantageous PPR procedure. This was further clarified by respondent D, who said, "[...] it is the ball between doing that and the next project because the next project is already running, you would like to have much more time to perform an evaluation, but if you don't, you have to find the most critical things [...]." Participant D said, "I am sure we can make it much bigger, but we don't have the resources and the time, and we have to think of what benefits us the best," as part of the closing remarks.

When asked whether the organization facilitates them well to engage with a PPR, participant D responded, "No, not really; the organization as a whole is always busy going forward, so they are not so happy to facilitate time and space for an evaluation procedure; you have to sort of pushing them, we have to push ourselves," She continued, "[...] I think it is always a problem to find time to have a good quality procedure when it comes to an evaluation." Participant D said that a contributing factor to the issue was a lack of desire to set priorities.

5.2.3.1.2 Competition

One of the important barriers which also mentioned by interviewees is internal competition between the project members, which results in keeping project knowledge, including risk knowledge, to themselves. Carrillo et al. (2013) also mentioned competition as a key barrier to KM.

5.2.3.1.3 Lack of Motivation

As mentioned by one interviewee, site teams are requested to capture knowledge, and there is little indication that they are helpful because they do not have access to the results, leading to the view that they provide little value.

5.2.3.1.4 Lack of Top Management Support

All participants agreed that post-project evaluations must be conducted and that organizational leaders must support and commit to doing so. The biggest obstacle to PPR is the absence of leadership engagement and commitment to the learning process. People are held responsible for adhering to disciplined procedures in applying lessons learned. Leading by example and being transparent about making mistakes or bad decisions are also essential components of effective learning.

5.2.3.2 Barriers related to Technology

By constructing knowledge repositories where employees can electronically contribute their expertise to the company in a form that other employees can access, many firms want to enhance knowledge sharing among their staff members. Implementing a successful knowledge management program and strategy depends mainly on technology. According to participant B, the major purpose of information technology in this situation is to facilitate complex knowledge transfer and cost-effective reuse of knowledge by assisting people in finding each other and communicating. Also, the contents of the acquired lessons are typically codified into clear and structured knowledge in textual forms like instances, reports, research studies, best practices, or guidelines available to their personnel to facilitate knowledge exchange and dissemination.

5.2.3.3 Barriers related to Processes or Organization

In addition to barriers related to the staff, some of the barriers occur due to some insufficiencies in the process or organization itself, which in this part will be further explained.

5.2.3.3.1 Organizational Culture

Culture is a barrier because it affects whether employees are willing to share their knowledge with their coworkers in the parent organization or other franchise organizations. Participant A mentioned one of the main barriers they encounter is internal competition between the project members, which results in keeping project knowledge to themselves and unwillingness to receive advice from other departments or central teams, especially on the construction site. She added that people on the construction site think they are responsible for the whole project and don’t listen to the people’s comments and advice from the central team working at

the main office. She claimed that her colleagues and friends from other companies complained about similar sector problems. Participant B shared that individual emotional trust manages the link between knowledge sharing and emotional commitment. Knowledge sharing is facilitated by the company culture, which promotes emotional-based trust between individuals.

5.2.3.3.2 Lack of Incentive

Some organizations' cultures may include a structure of incentives and rewards for knowledge creation and sharing. The results of the interviews show that respondents lack a reward system for sharing knowledge and that there are divergent opinions on reward systems and incentives. According to Wang & Noe (2010), reward systems are essential for motivating staff members to contribute to KM. However, even with a performance appraisal system, reward systems in the construction industry are challenging to manage. Given how much depends on cooperation and how difficult it is to separate the contributions of each team member to the collective knowledge, it is regarded as divisive. Additionally, financial incentives for information sharing may drive employees to create irrelevant and useless knowledge. It is important to consider the evaluation for reward based on group performance rather than individual performance. People may want to defend their knowledge power in the workplace due to an incentive structure that rewards individual achievement, which could result in personal knowledge hoarding.

5.2.3.3.3 Lack of Clear Guidelines

Construction companies' human resource departments should be in charge of educating employees about the mental shift needed to execute knowledge management and advance their knowledge. More training will foster employees' interest in and responsibility for maintaining their education. Through training, it is

hoped that staff members would acquire the most recent information on the market, increasing their capacity to adapt to the constantly changing construction industry environment. Applying a knowledge management approach and training could result in intriguing and pleasing outcomes. The most crucial human resources endeavor must include a knowledge management strategy because its effectiveness depends on being integrated into the hiring and selection process, staff training and development, performance management and incentives system, and mobility and reassignment. Participant D stated that *"we have a guideline which we share with related staff however most of the time it is left unread".*

CHAPTER 6

DISCUSSION AND CONCLUSIONS

6.1 Summary of Findings

This thesis presents exploratory research to derive how construction companies conduct PPRs to use later in the risk assessment of their forthcoming projects. Data was gathered through interviews with four experts from different Turkish construction companies. Data analysis was acquired through thematic analysis alongside a hybrid approach containing both inductive and deductive methods. Visual illustrations were added to the process data to improve it.

The data analysis revealed three global themes, including “process characteristics,” “benefits realization,” and “challenges.”

The emerging themes offered a thorough grasp of the value and advantages of PPR and lessons learned for risk management, the obstacles that prevent project managers from carrying out PPRs, and the techniques used by administrators to ensure project managers carry out PPRs and incorporate valuable risk knowledge in these reviews.

“Process characteristics” theme referenced participants' responses regarding how they perceive the importance of conducting PPRs, whether participants run PPRs in their organizations, whether there were formal procedures for conducting PPRs, and the purposes of preparing PPRs before connecting it to risk management concept. Based on their type of work, each organization had its own goals to achieve by conducting PPRs. However, they all tried to follow the same plan: learning from completed projects. Most of the codes were collected around the idea of sharing best practices and repeating the successes of past project and emphasize

on lessons learned from the failure, especially concerning a specific activity or a failure to complete a task or desired action, and to avoid making the same mistakes in the following projects. Lastly, improving resource efficiency, customer satisfaction, and proposals for new projects.

Finding answers to how PPRs are conducted, stored, and utilized for RM and who participates in this process in companies of the interview will reveal the company's strategies, strengths, and weaknesses and help us to find answers to our research questions.

“Benefits realization” theme referenced participant responses related to benefits they get by conducting and using PPRs in their organizations.

"Challenges" theme referenced participants' responses regarding problems the project team had during conducting and reusing PPRs.

These findings were supported and aligned with the literature. The literature review examines potential barriers to recording lessons learned and knowledge-based risk management through knowledge capturing, maintaining, and reusing. According to the literature review, recorded risk-related knowledge improves project performance by building organizational memory and preventing mistakes from being repeated.

This study's main research topic centers on how construction firms employ PPRs to evaluate project risks and stop repeating the same mistakes. According to the interview responses, some organizations use a standard format, and in some companies, recording the lessons learned before the project is completed is a mandatory process. The findings also included recommendations from each participant on different practical techniques organizations may use to ensure PPRs are carried out to record risk lessons learned.

As the participants recommend improving the process and ensuring that conducting PPRs is part of the project process, the project should not be finished without

incorporating the associated lessons learned, including risk knowledge. Also, project managers should be allowed to include time for PPRs in the project's initial budget and timeline. Furthermore, encouraging team members to capture lessons and take notes as the project develops.

6.2 Contributions to Practice

Effective project risk management will significantly increase the likelihood that a project will succeed. A justified activity is the identification of project risks and assumptions, their documentation, and inclusion in the entire project plan and processes. When a project is completed, the response's risks and learnings should be included in the organization's project management knowledge base. This knowledge base can be a jumping-off point for risk analysis and detection in upcoming initiatives. Both senior and junior project managers can use these prior real-world experiences to reduce risk and strain and raise the likelihood of success.

A company’s past is the best indicator of its future since, barring a significant organizational change, things often continue in the same direction. A more realistic appraisal of each new proposal might result from a review of previous projects, including an evaluation of similarities, differences, time constraints, costs, failures, and accomplishments. Therefore, analyzing historical data is the ideal place to start when quantifying and ranking risks, mainly if similar projects have been undertaken in the past.

Any organization's success depends on putting best company practices into action. The knowledge gained from participant responses regarding the significance of recording and using risk-based knowledge for risk assessment and methods organizations use to ensure project managers do not miss conducting PPRs is one of the contributions of this study's findings to practice.

These findings might make it possible for companies to recognize the critical contribution that risk knowledge from both successful and unsuccessful projects can make to project risk assessment. These findings may also help companies choose the best risk management methods, enhancing and benefiting project results.

In conclusion, risks have a significant role in post-project evaluations and vice versa. Risk issues make it simple to identify learning areas, and the risk management process results may reveal deficiencies in the project management procedures. Post-project evaluation helps build a knowledge database on possible risks to be used in risk management. The management of risk checklists and data generation for estimates and response plans may be aided by historical databases.

6.3 Limitations of the Research

It would have been more beneficial to do qualitative research on a smaller sample and then use a quantitative research strategy to confirm the results on a larger sample, known as a mixed method. However, the author was concerned that this would not have been possible due to time constraints. Also, it presents a chance to use the results as a starting point for future research.

REFERENCES

Adams, F. (2008). Construction contract risk management: a study of practices in the United Kingdom. *Cost Engineering*, *50*(1), 22–33.

Akintoye, A. S., & MacLeod, M. J. (1997). Risk analysis and management in construction. *International Journal of Project Management*, *15*(1), 31–38. https://doi.org/10.1016/S0263-7863(96)00035-X

Al-Ghassani, A. M., Anumba, C. J., Carrillo, P. M., & Robinson, H. S. (2005). Tools and Techniques for Knowledge Management. *Knowledge Management in Construction*, 83–102.

Alhawari, S., Karadsheh, L., Nehari Talet, A., & Mansour, E. (2012). Knowledge-Based Risk Management framework for Information Technology project. *International Journal of Information Management*, *32*(1), 50–65. https://doi.org/10.1016/j.ijinfomgt.2011.07.002

Alijoyo, F. A., Hendra, R., & Sirait, K. B. (2021). *The State-of-The-Art of Enterprise Risk Management Maturity Models: A Review*. *25*(2), 4005–4014. https://doi.org/10.1109/ICSRS48664.2019.8987615

Anbari, F. T. (1985). A systems approach to project evaluation. *Project Management Journal*, *3*, 21–26.

Association for Federal Enterprise Risk Management. (2020). *TSA ERM Capability Maturity Model*. https://www.aferm.org/resource/tsa-erm-capability-maturity/

Attride-Stirling, J. (2001). Thematic networks: an analytic tool for qualitative research. *Qualitative Research*, *1*(3), 385–405.

Audit Office Of New South Wales. (2019). *Risk Management Maturity Assessment Toolkit*. https://www.audit.nsw.gov.au/risk-assessment-tool

Banaitienė, N. (2011). *Risk management in projects : Peculiarities of Lithuanian construction companies*. *15*(1), 60–73. https://doi.org/10.3846/1648715X.2011.568675

Bazeley, P. (2013). *Qualitative data analysis: Practical strategies*. Western Sydney University, Australia.

Berkeley, D., Humphreys, P. C., & Thomas, R. D. (1991). Project risk action management. *Construction Management and Economics*, *9*(1), 3–17. https://doi.org/https://doi.org/10.1080/01446199100000002

Berry, A., & Phillips, J. (1998). Enterprise risk management: pulling it together. *Risk Management*, *45*(9).

Bing, B. L., & Robert L. K. Tiong. (1999). Risk management model for international construction joint ventures. *JOURNAL OF CONSTRUCTION ENGINEERING AND MANAGEMENT*.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Busby, J. S. (1999). *An Assessment of Post-Project Reviews*. 23–29.

Caldas, C. H., Gibson Jr, G. E., Weerasooriya, R., & Yohe, A. M. (2009). Identification of effective management practices and technologies for lessons learned programs in the construction industry. *Journal of Construction Engineering and Management*, *135*(6), 531–539.

Carrillo, P. (2005). Lessons learned practices in the engineering, procurement and construction sector. *Engineering, Construction and Architectural Management*, *12*(3), 236–250. https://doi.org/10.1108/09699980510600107

Carrillo, P., & Chinowsky, P. (2006). Exploiting Knowledge Management: The Engineering and Construction Perspective. *Journal of Management in*

Engineering, *22*(1), 2–10. https://doi.org/10.1061/(asce)0742-597x(2006)22:1(2)

Carrillo, P., Harding, J., & Choudhary, A. (2011). Knowledge discovery from post-project reviews. *Construction Management and Economics*, *29*(7), 713–723. https://doi.org/10.1080/01446193.2011.588953

Carrillo, P., Robinson, H., Al-Ghassani, A., & Anumba, C. (2004). Knowledge Management in UK Construction: Strategies, Resources and Barriers. *Project Management Journal*, *35*(1), 46–56. https://doi.org/https://doi.org/10.1177/875697280403500105

Carrillo, P., Ruikar, K., & Fuller, P. (2013). When will we learn? Improving lessons learned practice in construction. *International Journal of Project Management*, *31*(4), 567–578. https://doi.org/10.1016/j.ijproman.2012.10.005

CGMA. (2012). *How to Evaluate Enterprise Risk Management Maturity*. https://www.cgma.org/resources/tools/evaluate-enterprise-risk-management.html

Chapman, C., & Ward, S. (1997). *Project Risk Management: Processes, Techniques and Insights 2nd Edition*. Wiley; 2nd edition (December 1, 2003).

Chin Bo Wei Andrew , Gao Shang, L. S. P. (2015). An Institutional Approach to Understanding Post-Project Reviews in the Construction Industry. *International Surveying Research Journal*, *5*(1), 1–19. http://www.rism.org.my/wp-content/uploads/2015/08/ISrJ-5.1-Web.pdf#page=5

Choudhary, A. K., Oluikpe, P. I., Harding, J. A., & Carrillo, P. M. (2009). The needs and benefits of Text Mining applications on Post-Project Reviews. *Computers in Industry*, *60*(9), 728–740. https://doi.org/10.1016/j.compind.2009.05.006

Commission, C. of S. O. of the T. (2004). Enterprise Risk Management — Integrated Framework Executive Summary. *New York*, *3*(September), 1–16. http://www.coso.org/documents/COSO_ERM_ExecutiveSummary.pdf

Dandage, R. v., Mantha, S. S., Rane, S. B., & Bhoola, V. (2018). Analysis of interactions among barriers in project risk management. *Journal of Industrial Engineering International*, *14*(1), 153–169. https://doi.org/10.1007/s40092-017-0215-9

Davenport, T. H., & Prusak, L. (1998). *Working Knowledge: How Organizations Manage what They Know*. Harvard Business School Press.

del la Cruz, M. P., del Caño, A., & de la Cruz, E. (2006). Downside Risks in Construction Projects Developed by the Civil Service: The Case of Spain. *Journal of Construction Engineering and Management*, *132*(8), 844–852. https://doi.org/10.1061/(asce)0733-9364(2006)132:8(844)

Dikmen, I., Birgonul, M. T., Anac, C., Tah, J. H. M., & Aouad, G. (2008). Learning from risks: A tool for post-project risk assessment. *Automation in Construction*, *18*(1), 42–50. https://doi.org/10.1016/j.autcon.2008.04.008

Dikmen, I., Birgonul, M. T., Tah, J. H. M., & Ozer, A. H. (2012). Web-Based Risk Assessment Tool Using Integrated Duration–Cost Influence Network Model. *Journal of Construction Engineering and Management*, *138*(9), 1023–1034. https://doi.org/10.1061/(asce)co.1943-7862.0000547

Ding, L. Y., Zhong, B. T., Wu, S., & Luo, H. B. (2016). Construction risk knowledge management in BIM using ontology and semantic web technology. *Safety Science*, *87*, 202–213. https://doi.org/10.1016/j.ssci.2016.04.008

Egbu, C., Botterill, K., & Bates, M. (2001). The influence of knowledge management and intellectual capital on organisational innovations. *Proceedings of the 17th Annual Conference of the Association of Researchers in Construction Management (ARCOM)*, *1*(September), 5–7.

Egbu, C., & Robinson, H. S. (2005). Construction as a Knowledge- Based Industry. *Knowledge Management in Construction*, *4*, 31–49. https://doi.org/10.1002/9780470759554.ch3

Eken, G., Bilgin, G., Dikmen, I., & Birgonul, M. T. (2015). A Lessons Learned Database Structure for Construction Companies. *Procedia Engineering*, *123*, 135–144. https://doi.org/10.1016/j.proeng.2015.10.070

Eken, G., Bilgin, G., Dikmen, I., & Birgonul, M. T. (2020). A lessons-learned tool for organizational learning in construction. *Automation in Construction*, *110*(September 2019), 102977. https://doi.org/10.1016/j.autcon.2019.102977

Eliufoo, H. K. (2017). Post Project Review and Organizational Learning: A Reflection of Building Contractors Practices. *Management*, *7*(5), 161–167. https://doi.org/10.5923/j.mm.20170705.01

Fan, Z. P., Li, Y. H., & Zhang, Y. (2015). Generating project risk response strategies based on CBR: A case study. *Expert Systems with Applications*, *42*(6), 2870–2883. https://doi.org/10.1016/j.eswa.2014.11.034

Federico, A., Ferrada, X., Howard, R., & Rubio, L. (2014). Risk management in construction projects : a knowledge-based approach. *Procedia - Social and Behavioral Sciences*, *119*, 653–662. https://doi.org/10.1016/j.sbspro.2014.03.073

Fereday, J., & Muir-Cochrane, E. (2006). Demonstrating Rigor Using Thematic Analysis: A Hybrid Approach of Inductive and Deductive Coding and Theme Development. *International Journal of Qualitative Methods*, *5*(1), 80–92. https://doi.org/10.1177/160940690600500107

Ferrada, X., Núñez, D., Neyem, A., Serpell, A., & Sepúlveda, M. (2016). A Cloud-based Mobile System to Manage Lessons-learned in Construction Projects. *Procedia Engineering*, *164*(June), 135–142. https://doi.org/10.1016/j.proeng.2016.11.602

Gibson, G. E., Caldas, C. H., Yohe, A. M., & Weerasooriya, R. (2007). An analysis of lessons learned programs in the construction industry. *Texas: Construction Industry Institute*.

Godfrey, P. S. (1996). *Control Of Risk: a guide to the systematic management of risk from construction* (p. 71).

Graham, B., & Thomas, K. (2008). Building knowledge - developing a grounded theory of knowledge management for construction. *Electronic Journal of Business Research Methods*, *6*(2), 115–122.

Hallowell, M. R., Molenaar, K. R., & Fortunato, B. R. (2013). Enterprise Risk Management Strategies for State Departments of Transportation. *Journal of Management in Engineering*, *29*(2), 114–121. https://doi.org/10.1061/(asce)me.1943-5479.0000136

Han, S. H., Kim, D. Y., Kim, H., & Jang, W. S. (2008). A web-based integrated system for international project risk management. *Automation in Construction*, *17*(3), 342–356. https://doi.org/10.1016/j.autcon.2007.05.012

He, S., Chen, W., & Su, S. (2012). Risk knowledge integrated management for bridge and tunnel adjacent program. *Proceedings of the 2012 5th International Joint Conference on Computational Sciences and Optimization, CSO 2012*, 524–527. https://doi.org/10.1109/CSO.2012.119

Hoyt, R. E., & Liebenberg, A. P. (2011). The Value of Enterprise Risk Management. *Journal of Risk and Insurance*, *78*(4), 795–822. https://doi.org/10.1111/j.1539-6975.2011.01413.x

Ipe, M. (2003). Knowledge Sharing in Organizations: A Conceptual Framework. *Human Resource Development Review*, *2*(4), 337–359. https://doi.org/10.1177/1534484303257985

Jamal Al-Bahar, & Crandall, K. C. (1990). *SYSTEMATIC RISK MANAGEMENT APPROACH FOR CONSTRUCTION PROJECTS*.

Jannadi, O. A., & Almishari, S. (2003). Risk assessment in construction. *CONSTRUCTION ENGINEERING AND MANAGEMENT*, *129*, 492–500.

Jennex, M. E. (2005). Productivity impacts from using knowledge. *Case Studies in Knowledge Management*, *May*, 344–357. https://doi.org/10.4018/978-1-59140-351-7.ch020

Joseph HM, T. (2001). KNOWLEDGE-BASED APPROACH TO CONSTRUCTION PROJECT RISK MANAGEMENT. *Journal of Computing in Civil Engineering*, *15*(3), 170–177. https://doi.org/https://doi.org/10.1061/(ASCE)0887-3801(2001)15:3(170)

Jugdev, K. (2012). Learning from Lessons Learned: Project Management Research Program. *American Journal of Economics and Business Administration*, *4*(1), 13–22. https://doi.org/10.3844/ajebasp.2012.13.22

Kamara, J. M., Anumba, C. J., & Carrillo, P. M. (2003). Conceptual Framework for Live Capture and Reuse of project Knowledge. *CIB W078 International Conference on Information Technology for Construction – Construction IT: Bridging the Distance (Amor R, Ed)*, 178–185.

Kanapeckiene, L., Kaklauskas, A., Zavadskas, E. K., & Seniut, M. (2010). Integrated knowledge management model and system for construction projects. *Engineering Applications of Artificial Intelligence*, *23*(7), 1200–1215. https://doi.org/10.1016/j.engappai.2010.01.030

Kazi, A., & Wolf, P. (2006). *Real-life knowledge management: Lessons from the field* (Issue January 2007). http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Real-Life+Knowledge+Management+Lessons+from+the+Field#1

Kivrak, S., Arslan, G., Dikmen, I., & Birgonul, M. T. (2008). Capturing knowledge in construction projects: Knowledge platform for contractors. *Journal of*

Management in Engineering, *24*(2), 87–95. https://doi.org/10.1061/(ASCE)0742-597X(2008)24:2(87)

Koskinen, K. U., Pihlanto, P., & Vanharanta, H. (2003). Tacit knowledge acquisition and sharing in a project work context. *International Journal of Project Management*, *21*(4), 281–290. https://doi.org/10.1016/S0263-7863(02)00030-3

KPMG. (2000). Knowledge Management: Research Report 2000. *Journal of Knowledge Management*, *2*, 22. http://www.providersedge.com/docs/km_articles/kpmg_km_research_report_2000.pdf

Laslo, Z., & Goldberg, A. I. (2008). Resource allocation under uncertainty in a multi-project matrix environment: Is organizational conflict inevitable? *International Journal of Project Management*, *26*(8), 773–788. https://doi.org/10.1016/j.ijproman.2007.10.003

Leblanc, H., Nitithamyong, P., & Thomson, C. (2010). Information and Knowledge Management in Building. *Proceedings of the 18th CIB World Building Congress - W102 - Special Track, May*, 222–233.

Li, X., Zhu, R., Ye, H., Jiang, C., & Benslimane, A. (2021). MetaInjury: Meta-learning framework for reusing the risk knowledge of different construction accidents. *Safety Science*, *140*(May), 105315. https://doi.org/10.1016/j.ssci.2021.105315

Liebowitz, J., & Chen, Y. (2001). Developing knowledge-sharing proficiencies. *Knowledge Management Review*, *3*, 12–15.

Lin, Y. C. (2008). Developing construction assistant experience management system using people-based maps. *Automation in Construction*, *17*(8), 975–982. https://doi.org/10.1016/j.autcon.2008.04.004

Loosemore, M. , Raftery, J. , Reily, C. , & Higgon, D. (2005). *Risk Management in Projects* (1st Edition). https://doi.org/10.4324/9780203963708

Majchrzak, A., Cooper, L. P., & Neece, O. E. (2004). Knowledge Reuse for Innovation. *Management Science*, *50*(2), 174–188. https://doi.org/10.1287/mnsc.1030.0116

Manotas-Niño, V., Clermont, P., Geneste, L., & Halabi, A. X. (2016). Towards a model of integration between Risk Management and Lesson Learning system for Project Management. *Proceedings of 2015 International Conference on Industrial Engineering and Systems Management, IEEE IESM 2015, October*, 1179–1185. https://doi.org/10.1109/IESM.2015.7380302

Markus, M. L. (2001). Toward a theory of knowledge reuse: Types of knowledge reuse situations and factors in reuse success. *Journal of Management Information Systems*, *18*(1), 57–93. https://doi.org/10.1080/07421222.2001.11045671

Marty, L., O'Donnell, K., & Greene, A. (2020). Managing Knowledge and Risk-A Literature Review on the Interdependency of QRM and KM as ICH Q10 Enablers. *Journal of Validation Technology (JVT)*, *26*(4). https://www.researchgate.net/publication/353765090

Massingham, P. (2010). Knowledge risk management: A framework. *Journal of Knowledge Management*, *14*(3), 464–485. https://doi.org/10.1108/13673271011050166

Matthies, B., & Coners, A. (2018). Double-loop learning in project environments: An implementation approach. *Expert Systems with Applications*, *96*, 330–346. https://doi.org/10.1016/j.eswa.2017.12.012

Maxwell, J. A. (2012). *A realist approach for qualitative research*. SAGE Publications, Inc.

Mcadam, R., & Reid, R. (2001). SME and large organisation perceptions of knowledge management: Comparisons and contrasts. *Journal of Knowledge Management*, *5*(3), 231–241. https://doi.org/10.1108/13673270110400870

Miles, M. B., & Huberman, A. M. (1994). *Qualitative Data Analysis: An Expanded Sourcebook, 2nd Edition* (2nd ed.). SAGE Publications,edition.

Milton, N. (2010). *The lessons learned handbook: Practical approaches to learning from experience*. Elsevier.

Minassian, V. K., & Jergeas, G. F. (2009). A prototype risk analysis for determining contingency using approximate reasoning method. *Cost Engineering*, *51*(1), 26–33.

Neef, D. (2005). Managing corporate risk through better knowledge management. *The Learning Organization*, *12*(2), 112–124. https://doi.org/10.1108/09696470510583502

Neto, A., Perkusich, M., Dantas, E., Ramos, F., Costa, A., Almeida, H., & Perkusich, A. (2021). Knowledge-based Risk Management: A Systematic Literature Review. *Journal of Validation Technology (JVT), January 2022*, 320–329. https://doi.org/10.1145/3474624.3474635

New Zealand Government. (2020). *Enterprise risk maturity*. https://www.digital.govt.nz/standards-and-guidance/governance/system-assurance/enterprise-risk-maturity/

Newcomer, K. E., Hatry, H. P., & Wholey, J. S. (2015). *Handbook of Practical Program Evaluation* (4th ed.). John Wiley & Sons, 2015.

Nieto-Morote, A., & Ruz-Vila, F. (2011). A fuzzy approach to construction project risk assessment. *International Journal of Project Management*, *29*(2), 220–231. https://doi.org/10.1016/j.ijproman.2010.02.002

Nonaka, I., & Takeuchi, H. (1995). The Knowledge-creating company. *Oxford University Press, New York*.

Obrenovic, B., & Qin, Y. (2014). Understanding the concept of individual level knowledge sharing: A review of critical success factors. *Information and Knowledge Management*, *4*(4), 110–120. http://www.iiste.org/Journals/index.php/IKM/article/view/12258

Okudan, O., Budayan, C., & Dikmen, I. (2021). A knowledge-based risk management tool for construction projects using case-based reasoning. *Expert Systems with Applications*, *173*(January), 114776. https://doi.org/10.1016/j.eswa.2021.114776

Ozorhon, B., Dikmen, I., & Talat Birgonul, M. (2005). Organizational memory formation and its use in construction. *Building Research and Information*, *33*(1), 67–79. https://doi.org/10.1080/0961321042000329413

Öztürk, G. B., Arditi, D., Günaydın, H. M., & Yitmen, İ. (2016). Organizational Learning and Performance of Architectural Design Firms in Turkey. *Journal of Management in Engineering*, *32*(5), 05016015. https://doi.org/10.1061/(asce)me.1943-5479.0000455

Panthi, K., Ahmed, S. M., & Ogunlana, S. O. (2009). Contingency estimation for construction projects through risk analysis. *International Journal of Construction Education and Research*, *5*(2), 79–94. https://doi.org/10.1080/15578770902952181

Paranagamage, P., Carrillo, P., Ruikar, K., & Fuller, P. (2012). Lessons learned practices in the UK construction sector: current practice and proposed improvements. *Engineering Project Organization Journal*, *2*(4), 216–230. https://doi.org/10.1080/21573727.2012.681643

Park, M., Lee, H. S., & Kwon, S. (2010). Construction knowledge evaluation using expert index. *Journal of Civil Engineering and Management*, *16*(3), 401–411. https://doi.org/10.3846/jcem.2010.46

Pathirage, C. P., Amaratunga, D. G., & Haigh, R. P. (2007). Tacit knowledge and organisational performance: Construction industry perspective. *Journal of Knowledge Management*, *11*(1), 115–126. https://doi.org/10.1108/13673270710728277

Patton, M. Q. (2015). *Qualitative Research & Evaluation Methods* (4th ed.). SAGE Publications, Inc.

Perrott, B. E. (2007). A strategic risk approach to knowledge management. *Business Horizons*, *50*(6), 523–533. https://doi.org/10.1016/j.bushor.2007.08.002

Persson, M. (2006). *Lessons Learned in Knowledge Managment - the case of construction*. Lund University.

PMBOK. (2018). *A guide to the Project Management Body of Knowledge (PMBOK guide).* (6th Editio). Project Management Institute.

Polanyi, M. (1967). *The Tacit Dimension* (1st ed.). Routledge & Keegan Paul Ltd. London. https://www.worldcat.org/title/tacit-dimension/oclc/718091

Project Management Institute. (2008). *A guide to the project management body of knowledge (PMBOK Guide).* Project Management Institute.

Ramaprasad, A., & Prakash, A. N. (2003). Emergent project management: How foreign managers can leverage local knowledge. *International Journal of Project Management*, *21*(3), 199–205. https://doi.org/10.1016/S0263-7863(02)00094-7

Renault, B. Y., & Agumba, J. N. (2016). Risk management in the construction industry: A new literature review. *MATEC Web of Conferences*, *66*, 6–11. https://doi.org/10.1051/matecconf/20166600008

Rezgui, Y., Hopfe, C. J., & Vorakulpipat, C. (2010). Generations of knowledge management in the architecture, engineering and construction industry: An evolutionary perspective. *Advanced Engineering Informatics*, *24*(2), 219–228. https://doi.org/10.1016/j.aei.2009.12.001

Robinson, H. S., Carrillo, P. M., Anumba, C. J., & Al-Ghassani, A. M. (2005). Knowledge management practices in large construction organisations. *Engineering, Construction and Architectural Management*, *12*(5), 431–445. https://doi.org/10.1108/09699980510627135

Rollett, H. (2012). *Knowledge Management: Processes and Technologies*. Springer Science & Business Media.

Royer, P. S. (2000). Risk Management: The Undiscovered Dimension of Project Management. *Project Management Journal*, *31*(1), 6–13. https://doi.org/10.1177/875697280003100103

Schaufelberger, J. (2008). *Construction Business Management*. Pearson Prentice Hall, Upper Saddle River, NJHall.

Sharan B., M., & J.Tisdell, E. (2015). *Qualitative research: A guide to design and implementation*. John Wiley & Sons, 2015.

Shokri-Ghasabeh, M., & Chileshe, N. (2014). Knowledge management: Barriers to capturing lessons learned from Australian construction contractors perspective. *Construction Innovation*, *14*(1), 108–134. https://doi.org/10.1108/CI-06-2013-0026

Sowards, D. (2005). The value of post-project reviews. *Contractor Magazine*, *52*(8), 35–36.

Spiegler, I. (2000). Knowledge Management: A New Idea Or a Recycled Concept? *Communications of the Association for Information Systems*, *3*(June). https://doi.org/10.17705/1cais.00314

Tan, H. C., Carrillo, P., Anumba, C., Kamara, J. M., Bouchlaghem, D., & Udeaja, C. (2006). Live capture and reuse of project knowledge in construction organisations. *Knowledge Management Research and Practice*, *4*(2), 149–161. https://doi.org/10.1057/palgrave.kmrp.8500097

Tan, H. C., Carrillo, P. M., Anumba, C. J., Bouchlaghem, N. (Dino), Kamara, J. M., & Udeaja, C. E. (2007). Development of a Methodology for Live Capture and Reuse of Project Knowledge in Construction. *Journal of Management in Engineering*, *23*(1), 18–26. https://doi.org/10.1061/(asce)0742-597x(2007)23:1(18)

Thevendran, V., & Mawdesley, M. J. (2004). Perception of human risk factors in construction projects: An exploratory study. *International Journal of Project Management*, *22*(2), 131–137. https://doi.org/10.1016/S0263-7863(03)00063-2

Tserng, H. P., Yin, S. Y. L., Dzeng, R. J., Wou, B., Tsai, M. D., & Chen, W. Y. (2009). A study of ontology-based risk management framework of construction projects through project life cycle. *Automation in Construction*, *18*(7), 994–1008. https://doi.org/10.1016/j.autcon.2009.05.005

Uher, T. (2003). *Programming and scheduling techniques*. University of New South Wales Press.

Velandia-González, M., Trumbo, S. P., Díaz-Ortega, J. L., Bravo-Alcántara, P., Danovaro-Holliday, M. C., Dietz, V., & Ruiz-Matus, C. (2015). Lessons learned from the development of a new methodology to assess missed opportunities for vaccination in Latin America and the Caribbean. *BMC*

International Health and Human Rights, *15*(1), 1–8. https://doi.org/10.1186/s12914-015-0043-1

von Krogh, G. (2002). The communal resource and information systems. *Journal of Strategic Information Systems*, *11*(2), 85–107. https://doi.org/10.1016/S0963-8687(02)00006-9

von Zedtwitz, M. (2002). Organizational learning through post-project reviews in R & D. *R and D Management*, *32*(3), 255–268. https://doi.org/10.1111/1467-9310.00258

von Zedtwitz, Max. (2003). Post-project reviews in R&D. *Research, Technology Management*, *46*(5), 43–49.

Wang, S., & Noe, R. A. (2010). Knowledge sharing: A review and directions for future research. *Human Resource Management Review*, *20*(2), 115–131. https://doi.org/10.1016/j.hrmr.2009.10.001

Wang, S. Q., Dulaimi, M. F., & Aguria, M. Y. (2004). Risk management framework for construction projects in developing countries. *Construction Management and Economics*, *22*(3), 237–252. https://doi.org/10.1080/0144619032000124689

Webb, J. (2007). Risk Management Report and Tool Kit. *Free Pint Ltd*, 40.

Wiewiora, A., & Murphy, G. (2015). Unpacking "lessons learned": Investigating failures and considering alternative solutions. *Knowledge Management Research and Practice*, *13*(1), 17–30. https://doi.org/10.1057/kmrp.2013.26

Wiig, K. M. (1997). Integrating intellectual capital and knowledge management. *Long Range Planning*, *30*(3), 399–405. https://doi.org/10.1016/s0024-6301(97)90256-9

Wolcott, H. F. (1994). *Transforming qualitative data: Description, analysis, and interpretation*. SAGE Publications, Inc.

Yildiz, A. E., Dikmen, I., Birgonul, M. T., Ercoskun, K., & Alten, S. (2014). A knowledge-based risk mapping tool for cost estimation of international construction projects. *Automation in Construction*, *43*, 144–155. https://doi.org/10.1016/j.autcon.2014.03.010

Zhang, X., Mao, X., & Abourizk, S. M. (2009). Developing a knowledge management system for improved value engineering practices in the construction industry. *Automation in Construction*, *18*(6), 777–789. https://doi.org/10.1016/j.autcon.2009.03.004

Zhao, X., Hwang, B.-G., & Low, S. P. (2013). Developing Fuzzy Enterprise Risk Management Maturity Model for Construction Firms. *Journal of Construction Engineering and Management*, *139*(9), 1179–1189. https://doi.org/10.1061/(asce)co.1943-7862.0000712

Zhao, X., Hwang, B.-G., & Low, S. P. (2014). Investigating Enterprise Risk Management Maturity in Construction Firms. *Journal of Construction Engineering and Management*, *140*(8), 05014006. https://doi.org/10.1061/(asce)co.1943-7862.0000873

Zou, P. X. W., Zhang, G., & Wang, J. (2006). Identifying Key Risks in Construction Projects : Life Cycle and Stakeholder Perspectives Related Past Research and Risk Classification. *Architecture*, 1–14. http://www.prres.net/papers/Zou_risks_in_construction_projects.pdf

Zou, Y., Kiviniemi, A., & Jones, S. W. (2017). Retrieving similar cases for construction project risk management using Natural Language Processing techniques. *Automation in Construction*, *80*(April), 66–76. https://doi.org/10.1016/j.autcon.2017.04.003

Zoysa, S., & Russell, A. D. (2003). Knowledge-based risk identification in infrastructure projects. *Canadian Journal of Civil Engineering*, *30*(3), 511–522. https://doi.org/10.1139/l03-001

APPENDICES

A. Interview format

Using post-project reviews for risk management of construction projects

M / F:

Name:

Company / Organization:

Age:

1. Qualitative interview introduction

Expected duration of the interview is 1 hour.

Primary goal: A conversation with a focus on experience, opinions and what interviewee thinks or feels about post-project reviews and their utilization for risk management.

Thank you for accepting this invitation to the interview. I'm interviewing you to understand post-project appraisal practices in your company, types of knowledge retained by these reports, and particularly investigate how these reports are utilized during risk-informed decision-making. I'm interested in your experiences, so any answers to each of the questions aren't right or wrong. Participation in this study is optional. I think the interview will take approximately one hour, depending on how much information you would share with us. If you don't mind, I will record the conversation to avoid missing any of your words. All responses will be kept private and only will be shared with research team members. I will ensure that any information we include in our report does not identify you as the respondent. You

are allowed to decline to answer or stop the conversation for any reason at any time. Are there any questions about what I have just explained? May I turn on the recorder?

2. Verbal Consent

Would you like to participate in this interview?

Verbal Consent was obtained from the study participant

Verbal Consent was NOT obtained from the study participant