A Holistic View of Factors Impacting the Adoption of Lessons Learned Management Systems

by

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Abstract

The benefits of a lessons learned (LL) program are widely recognized. A lesson learned management system (LLMS) is the software designed to support the LL program and is essential to the program's value delivery. The need for knowledge management (KM) in the energy sector appears to increase as energy companies focus on the energy transition while continuing digital transformation, performance improvement, and decarbonization of conventional energy production. Digital transformation has increased the accessibility to intelligent, well-designed lessons learned management systems (LLMS). However, there remain challenges to adoption. This study aims to explore factors impacting the adoption of LLMSs within the context of the upstream oil and gas sector. First, a comprehensive literature review is conducted to understand existing barriers and enablers. Semi-structured interviews are then conducted with employees from a large global oil and gas company to uncover existing barriers and factors leading to the adoption of an LLMS. The thematic analysis method was used to analyze the interview data, in which five themes are presented: understand existing barriers, incorporate enabling processes and governance, facilitate the people element supporting the LL programs, satisfy users with important LLMS characteristics, and improve the LL process with an LLMS. Finally, practical recommendations for organizations to increase the adoption of an LLMS are summarized.

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1 Introduction

Learning from experience is part of basic human instinct. It is an activity that all humans perform. However, organizations can also learn from experience, and successful ones know how to enable learning at all organizational levels (Senge, 2006). Many organizations have lesson-learning processes to learn from experience – past successes and failures (Levy, 2018). Similar to any process, technology may enhance the efficacy and efficiency of the learning process. This thesis seeks to comprehend the elements influencing the adoption of technologies that might facilitate the learning process. Chapter 1 includes the background of the study, motivation, research aim and questions, approach, scope, and thesis structure.

1.1 Background

Knowledge Management (KM) is a management discipline that systematically manages organizational knowledge and learning to create value (Milton & Lambe, 2019; O'Dell & Hubert, 2011). An organization skilled in KM will have a competitive advantage over its competitors (Davenport & Prusak, 1998; Grant, 2013). There is no hard definition of what KM is (Milton & Lambe, 2019). However, it is widely recognized that KM is a discipline that involves integrating people, processes, and technology (Gorelick et al., 2004; Liebowitz, 2012). O'Dell and Hubert (2011) categorized KM into four categories: Self-Service, Lessons Learned, Communities, and Transfer of Best Practices. Most organizations will likely require a combination of these four approaches to fit the culture and best manage critical knowledge assets.

Lessons learned (LL) is one of the proven KM approaches. By learning from the execution of projects and tasks, employees will capture, share, and reuse lessons to improve performance and prevent relearning from the same mistakes (O'Dell & Hubert, 2011). The learning process could yield significant value, especially for capital-intensive industries such as upstream oil and

gas (Milton, 2010). Furthermore, a deliberate and systematic approach to learning from lessons can accelerate value creation or steepen the learning curve (Milton, 2010). Since LL is a component of KM, LL initiatives must integrate people, processes, and technology to support learning. In this study, the term LL program will refer to the integration of all three main components – people, processes, and technology.

Organizations use information technology as part of this systematic LL approach. Lessons learned systems or lessons learned management systems (LLMS) refer to software systems designed to support the LL process by means of collecting, verifying, storing, disseminating, and reusing (Weber, Breslow, et al., 2001). They are structured in the form of a repository of LL (Weber & Aha, 2003). While there are obvious benefits to having an LLMS, organizations usually struggle to generate desirable positive impacts from such systems. A study by Milton (2010) shows that many employees are unsatisfied with their organization's LL process.

The concept of LLMS has been around since the 1980s, and significant investment has been made to develop the systems, but their ability to support the LL process is still limited (Weber, Aha, et al., 2001). An excellent software system that makes knowledge readily available to employees does not mean that the knowledge will be accessed and used (Miller & Steinke, 2002). It is the user's accountability and responsibility to make such a system work. O'Dell and Hubert (2011) believe that people, not technology, are the key success factor to KM and the LL process. They believe that gaining employees' participation and contribution in capturing and reusing captured knowledge are the two most challenging aspects of KM (O'Dell & Hubert, 2011). Since LLMS is part of the KM and LL processes, they share similar barriers and failures. Many studies have addressed the barriers to KM (Braganza & Möllenkramer, 2002; Chua & Lam, 2005; Ranjbarfard et al., 2014; Wall, 2020; Weber, 2007).

Together, the LL process and LLMS must meet the expectations of all stakeholders, such as senior leadership and end-users. Therefore, the use context of LLMS will likely differ between industries due to the nature of work. Factors impacting the success of LLMS in one industry may not hold true for another. Even within the same organization, it is known that different functions or departments perform work differently, and one LLMS design may not fit all. The researcher has spent professional career time in a large global oil and gas (O&G) company, specifically in the Wells department. This department performs all the engineering and operations related to a hydrocarbon well, such as drilling an O&G well, well completion, intervention, suspension, and abandonment. Performance improvement is one of the critical successes of the Wells department due to its capital-intensive projects and high operating costs. Thus, the Wells department could gain substantial value from having an effective LL process (Milton, 2010). However, although the LL process is taken seriously, the Wells department that the researcher was part of does not have an LLMS. The lack of an effective tool may impact the performance of the LL program.

Based on the researcher's initial review of related literature, there remain research opportunities within the field of KM and LL. First, the researcher found that most studies address the bigger picture of KM or LL, not specifically LLMS. Thus, research opportunities exist to explore the success and failure factors directly related to LLMS. Second, most studies discuss KM practices from the perspective of senior leadership and not the end-users. This one-sided perspective may paint an incomplete picture of the enablers and barriers of KM and its approaches. Third, none of the literature found has discussed barriers and enablers of LLMS within the context of the Wells department. The way operations are conducted within a O&G company varies between business units and even the same departments. The factors impacting the successful deployment of LLMS will likely depend on the nature of the work. For these reasons, the unique

nature of operations within the Wells department and its relationship with the LLMS have not been explored.

1.1.1 The Wells Department in the Upstream Oil and Gas Industry

The O&G industry is generally divided into three sectors: upstream, midstream, and downstream. The upstream sector involves the exploration and production (E&P) of fossil fuels by performing a series of activities such as seismic surveys, drilling and completions, and initial production to bring fossil fuels to the surface. The midstream sector involves the storage and transportation of crude oil, while the downstream sector includes refining, selling, and distributing petroleum products (Hayes, 2021).

The upstream sector is highly complex and requires effort in planning and collaboration to succeed. The E&P activity is known for having a deterministic input but a probabilistic output. Due to the uncertainty in exploration, an investment in E&P with a sound execution strategy may not return a profit. As a result, the E&P phase is expensive and risky (Chowdhury, 2016).

The Wells department belongs to the upstream sector and performs all E&P operations to a hydrocarbon well, such as drilling a well, well completion, intervention, suspension, and abandonment. These operations are very dynamic, and unplanned events occur frequently. Due to high operating costs, the operations are often carried out 24 hours. This continuous operation limits the practicality of night shift frontline supervisors to seek information and guidance from subject matter experts (SMEs) every time a decision must be made.

A working unit called a rig is often used to carry out operations. These rigs' rental rate is very high, making non-productive time (NPT) highly undesirable. There are many causes of NPT, for example, equipment malfunction and well problems. After-action reviews or debriefs are usually performed to learn from the event and take corrective actions to prevent future NPT. By

learning from experience, the Wells department can gain tremendous value from performance improvement and mistakes avoidance.

Enterprise-wide knowledge sharing could significantly improve performance, reduce costs, and retain knowledge. Many lessons and best practices could positively impact different operating locations. However, global O&G companies tend to struggle with enterprise-wide knowledge sharing. A global O&G company usually consists of multiple business units that are decentralized, and each unit has its own culture and work practices. Furthermore, time zone and language differences add to the knowledge-sharing barriers (Milton & Lambe, 2019).

The upstream sector is capital-intensive, making it more sensitive to the fluctuating oil price. The low oil price creates a hiring gap as aging workers retire or are laid off to preserve cash flow for the business. This talent gap significantly impacts organizational knowledge loss, especially if no knowledge retention strategy exists (Sumbal et al., 2017). It is critical because E&P activities are becoming more costly, risky, and technologically intensive. Existing oil and gas reserves are depleting, and new reserves are more challenging and complex to develop. As a result, to improve and optimize company performance, oil and gas firms will need greater knowledge, creativity, and a multidisciplinary approach. (Chowdhury, 2016). Obviously, KM, and therefore the LL process, plays a significant role in this improvement effort.

1.1.2 Digital Transformation in the Oil and Gas Industry

Increasing capabilities of digital technologies and the falling cost of digitalization are changing many industries, including O&G. Many O&G companies have adopted digital tools and developed strategies to use these tools to increase productivity, save costs, improve performance, and improve safety (Mittal et al., 2017). Digital transformation has become a term embedded in most O&G companies' strategies. Investments have been made in technologies such as cloud

computing, artificial intelligence (AI), Machine Learning, and Big Data to support the digital transformation. However, these technologies also positively impact the effectiveness of KM and its processes.

In turn, KM is required for effective digital transformation initiatives. Digital transformation and KM have many things in common. Both are concerned with how knowledge and information can improve organizational performance. In addition, they both promote organizational learning, agility, and innovation. KM helps organizations on their digital transformation journey by fostering the development of new capabilities and knowledge (Milton & Lambe, 2019). Successful KM necessitates the integration of sharing culture with technology, and one such technology is the LLMS (Grant, 2013).

The increasing adoption of new digital technologies has altered the nature of work and employees' work behavior. Employees are becoming more familiar with collaboration software and cloud computing. Additionally, the COVID-19 pandemic has accelerated this transformation (McKinsey, 2020; World Health Organization, 2020). For this reason, the researcher believes the digital transformation has impacted the factors influencing the success of LLMS and the LL process. And as described above, the Wells department may greatly benefit from having an effective LLMS to support KM.

Hence, in this context, the researcher aims to determine the enablers and barriers to deploying and sustaining LLMS. By understanding these factors directly from the employees, the researcher hopes to provide meaningful recommendations.

1.2 Motivation

The researcher has eight years of experience in the Wells department as a frontline supervisor on offshore drilling rigs. This role requires good decision-making skills to prevent loss

of well or NPT events. Due to the high operating cost of drilling rigs and the high expenses of oil and gas well development, a problem resulting from poor decision-making could cost the company millions of dollars.

Rig site supervisor relies on experience and knowledge to troubleshoot problems. The researcher believes that having a centralized knowledge storage system could support decision-making. A system such as the LLMS could help the rig site supervisor easily refer to lessons learned and use the context of those lessons to impact operations in real-time. However, the researcher has never been exposed to such a system. Digital transformation has introduced many cloud-based software solutions within the company, but LLMS has not been part of the roll-out at the researcher's organization. Lessons were generated after executing the projects, but there was no single repository or systematic process to handle them. Unless they were immediately applicable, LLs were stored away in Word documents or Excel sheets without any structured database. This could lead to loss of valuable knowledge, and LL never applied to future operations. Moreover, it was extremely difficult for frontline supervisors to find LL unless it was given by the project engineers. The researcher believes that providing frontline supervisors with all the knowledge is crucial to operation success, especially in troubleshooting problems.

The O&G companies, now generally referred to as energy companies, are in a state where KM appears to be increasingly vital to business success. The industry is going through a digital transformation, but now it faces the energy transition. Energy companies are expanding their portfolio to include green, renewable energy. Additionally, the energy transition aims to decarbonize existing operations. To do this, energy companies will require new expertise, new knowledge, and new capabilities. Efficient knowledge circulation within the organization will

allow the company to have a competitive advantage in this new landscape. KM is critical for this paradigm change.

There are many apparent barriers to having an effective LLMS, making these systems hard to sustain, but many have been successful. The researcher believes that an LLMS is a critical part of KM and, therefore, would like to understand what is holding organizations back in terms of adoption.

1.3 Research Aim and Questions

Many studies have been done to address the barriers and enablers of KM and LLMS, but not specifically in the context of the Wells department in the upstream O&G sector. Therefore, this research aims to explore factors impacting the adoption of an LLMS within this context. The researcher hopes to provide meaningful recommendations to this issue by learning about the barriers and enablers directly from employees or end-users. Additionally, the researcher intends to validate existing studies on this topic by comparing the findings to those studies. The following questions are guidelines to fulfill the research aim.

1. What barriers are employees facing concerning LL programs?
2. What factors would lead employees to adopt an LLMS?
3. How could an LLMS facilitate and streamline the LL process?

1.4 Approach

A qualitative method is used for this research. A literature review of KM, LL, and LLMS is conducted to understand the field and create an interview protocol. Participants from the Wells department of a global O&G company are selected using purposive sampling. Semi-structured interviews are conducted to understand the end-users of LLMS. The interviews are analyzed based on the thematic analysis method with the help of the software NVivo. The thematic analysis

method is selected due to its flexibility and is suitable for people with no experience with qualitative studies (Braun & Clarke, 2013). From this analysis, themes are generated and cross-checked with current studies. Finally, recommendations are proposed based on the insights.

1.5 Research Scope

This study focuses on factors impacting the adoption of LLMS from the perspective of the Wells employees in a global O&G company that operates at diverse geographic locations. There is no restriction to participants' working locations as long as they are within the Wells department from that company. However, this study is restricted to employees that will likely be using the LLMS, wherein the opinions of 10 Wells employees are studied in interview sessions. Due to the decentralized nature of the organization, participants have different experiences related to the LL process and systems. Some participants have experience using a database for LL, while others do not.

This study does not cover the perspectives of any senior leadership and management. Furthermore, this study does not cover employees' views from other departments in the upstream sector. This may limit the applicability of the recommendations to other departments, companies, or industries.

1.6 Thesis Structure

This thesis is organized into six chapters. Chapter 1 introduces the current challenges of KM and LLMS and the context concerning the Wells department. Chapter 2 provides a review of literature related to KM, LL, LLMS, and the impact of digital transformation on KM. Chapter 3 describes the methodology of this qualitative study. Chapter 4 presents the findings and the discussion of the findings. Finally, Chapter 5 summarizes the study and discusses proposed recommendations for future research opportunities.

2 Literature Review

This chapter introduces the knowledge creation theory, KM, and the connection between KM and LL. The importance of understanding the interconnection of people, processes, and technology from a holistic perspective is highlighted, and each entity is discussed. The chapter then discusses the review of literature on barriers and enablers of LL initiatives, highlighting prominent factors. Lastly, the chapter discusses the reciprocal relationship between KM and digital transformation and explores the possible future of KM.

2.1 Knowledge Creation and Knowledge Management

It is important to comprehend how organizational knowledge is created before managing knowledge. A well-known knowledge creation model is the knowledge spiral model presented in the book *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation* by Nonaka and Takeuchi (1995). The popularity of this book introduced the two forms of human knowledge – explicit and tacit – to the business world (Gorelick et al., 2004). According to Nonaka and Takeuchi (Nonaka & Takeuchi, 1995), explicit knowledge is systematic, can be codified, and is easy to articulate. On the other hand, tacit knowledge refers to subjective, personal knowledge embedded in experience, context-specific, that is difficult to codify and communicate. The social interaction between these two forms of knowledge creates what Nonaka and Takeuchi call the four modes of knowledge conversion:

a) Socialization (from tacit to tacit) is a process of sharing experience, resulting in shared mental models, technical skills, and expertise.
b) Externalization (from tacit to explicit) is a process of explicitly articulating or representing tacit knowledge, typically in the form of concepts but can also be

analogies, metaphors, hypotheses, or models. Creating new explicit concepts from tacit knowledge is a key to knowledge creation.

c) Combination (from explicit to explicit) is a process of systematically combining different bodies of explicit knowledge or concepts to generate new knowledge.

d) Internalization (from explicit to tacit) is a process of learning through practice, allowing the individual to gain tacit knowledge.

Nonaka and Takeuchi call knowledge created from each mode: sympathized knowledge, conceptualized knowledge, operational knowledge, and systemic knowledge. The continuous and dynamic interaction between each type of knowledge is a spiral of knowledge creation, as shown in Figure 1. Two other dimensions exist for the spiral: the interaction between individuals within the organization and time. Thus, the spiral can be thought of as rising upwards through time, starting at the individual level and spiraling up, while expanding as knowledge is amplified through the four modes of knowledge conversion, reaching groups at different organization levels. Nonaka and Takeuchi call this the spiral of organizational knowledge creation.

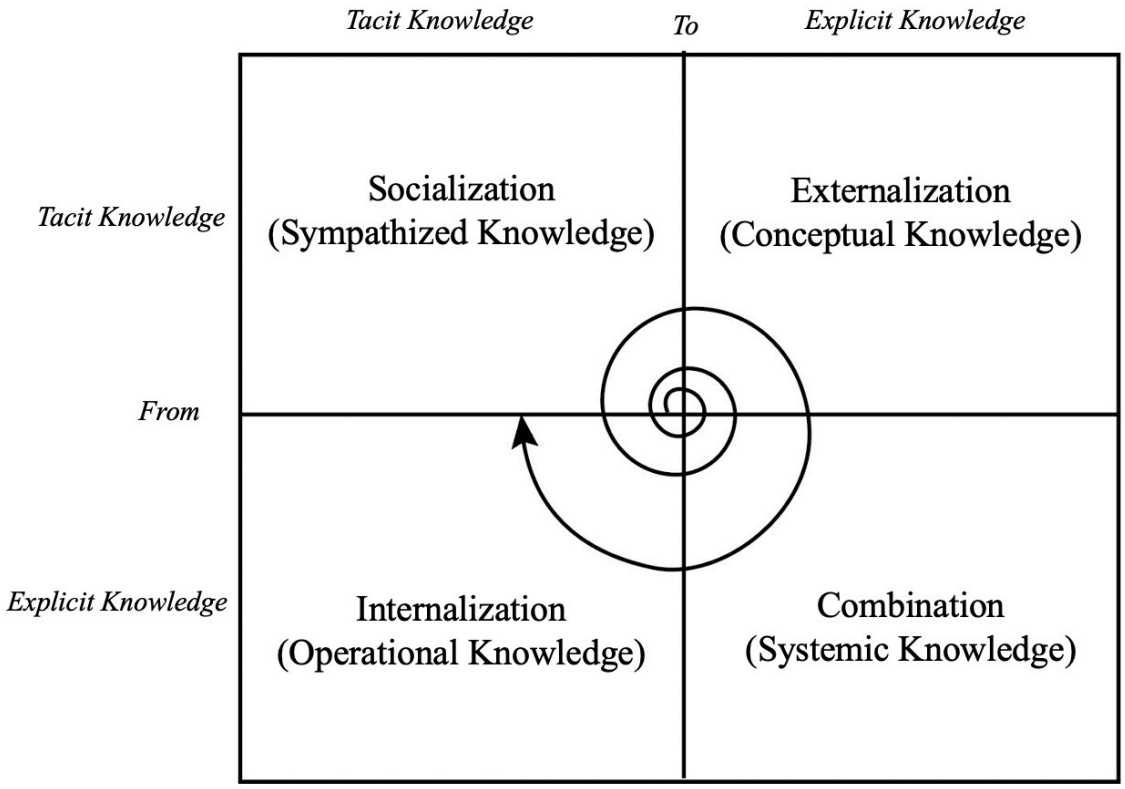

Figure 1: SECI Model and the Knowledge Spiral (adapted from Nonaka & Takeuchi, 1995)

Experiences, best practices, or lessons learned must be facilitated through the processes of socialization, externalization, combination, and internalization in order for them to become valuable assets to the individual and the organization (Dalkir, 2011). This knowledge-creating process is widely known as the SECI model (Nonaka & Takeuchi, 2020). It is recognized that tacit knowledge is difficult to quantify; thus, it is harder to manage (Ichijo & Nonaka, 2007). However, the value of knowledge is typically higher when knowledge is more tacit (Dalkir, 2011). The field of KM attempts to efficiently gain value by addressing both forms of knowledge, and the four modes of knowledge conversion, along the knowledge spiral (Dalkir, 2011; Gorelick et al., 2004).

Due to the multidisciplinary nature of KM, there is no hard definition of what KM is (Dalkir, 2011; Milton & Lambe, 2019). Gorelick et al. (2004) define KM as "a systematic approach

for optimizing the access, for individuals and teams within an organization, to relevant actionable advice, knowledge and experience from elsewhere" (p.3). According to Dalkir (2011), KM is "the deliberate and systematic coordination of an organization's people, technology, processes, and organizational structure in order to add value through reuse and innovation" (p.469). Milton and Lambe (2019) view KM as "intangible asset management with knowledge as a focus" (p.9). They suggest that organizations should establish a unified definition of KM in relation to their business objectives and organizational context. In general, KM is a management discipline that systematically manages organizational knowledge and learning to create value from these intangible assets (Liebowitz, 2000; Milton & Lambe, 2019; O'Dell & Hubert, 2011). KM focuses on how organizations can gain a competitive advantage by effectively capturing, sharing, applying, and using knowledge (Liebowitz, 2012).

Studies have recognized that KM is a discipline that integrates people, processes, and technology (Gorelick et al., 2004; Liebowitz, 2012). Milton and Lambe (2019) add governance as another element required for KM. They note that each element is interdependent, and they all enable KM to the same degree. O'Dell and Hubert (2011) argue that some KM approaches are people-intensive while others are technology-intensive. They point out that most KM approaches fit into four categories, distinguished by the level of human interaction and forms of knowledge – tacit and explicit. The four categories are: (a) Self-Service, which enables self-access to mostly explicit knowledge; (b) Lessons Learned, which enables employees to capture, share, and reuse lessons from experience; (c) Communities, which refer to communities of practice or networks that enable the sharing of knowledge between one another; and (d) Transfer of Best Practices, which typically involves systematic processes and formal facilitation and coaching to transfer successful practices that are highly tacit. O'Dell and Hubert argue that most organizations will

likely require a combination of these four approaches to fit the culture and best manage critical knowledge assets. To determine the KM approach that best fits organizational behaviors, O'Dell and Hubert recommend that organizations should consider the nature of knowledge conversion required.

KM is crucial for reducing complexity and gaining competitive advantages for global organizations (Ichijo & Nonaka, 2007). According to Dalkir (2011), primary business drivers for KM in today's increasingly complex and dynamic business environment are (a) globalization of business, (b) leaner organizations, (c) corporate amnesia, and (d) technical improvements. Along the same line, Milton and Lambe (2019) determine four main business drivers: operational excellence, customer knowledge, innovation, and growth and change. Considering these business drivers, it seems that they emphasize the organizational need to adapt to changes. In order to successfully respond to external dynamic environments, Lee (2022) points out that organizations must change their behaviors through the process of learning. Additionally, the speed of learning should be adequate to adjust to the speed of change; otherwise, the organization will not survive. For learning to be effective, the learning process should be spontaneous, continuous, and dynamic, adapting to changes in the environment that are often complex and unpredictable (Lee, 2022).

2.2 Lessons Learned

Lessons Learned (LL) is one component of KM that may be viewed as a KM process or initiative (Weber & Aha, 2003). It is an approach that provides a means for organizations to learn from experience. By doing so, organizations can gain substantial benefits from performance improvement and cost savings. There are numerous definitions of LL, all of which allude to learning through experience.

Weber and Aha (2003) define LL as "knowledge artifacts that convey experiential knowledge that is applicable to a task, decision, or process such that, when reused, this knowledge positively impacts an organization's results" (p. 287). They point out that this is the reason LL initiatives are prevalent in organizations with high consequential risks.

Another definition is from *The Lessons Learned Handbook: Practical Approaches to Learning from Experience* (Milton, 2010). In the book, Milton defines a LL as "a change in personal or organizational behavior, as a result of learning from experience" (p. 16). Things must change to consider that a lesson has been learned; otherwise, it is just a lesson identified, not a LL. The changes may be in the form of procedural changes, document updates, or equipment repair. Moreover, organizations require a process to support the changes (Milton, 2010).

The next definition is from the National Aeronautics and Space Administration (NASA), well-known for KM and LL. NASA defines LL as "the significant knowledge or understanding gained through past or current programs and projects that is documented and collected to benefit current and future programs and projects" (NPR 7120.7A, 2020, p.37). Another NASA policy directive (NPD) differentiates LL from best practices by stating that "unlike a best practice, lessons learned describes a specific event that occurred and provides recommendations for obtaining a repeat of success or for avoiding reoccurrence of an adverse work practice or experience" (NPD 7120.6A, 2019).

The last example of LL definition is from the Project Management Institute (2021), which defines LL in the Project Management Body of Knowledge (PMBOK) as "the knowledge gained during a project, which shows how project events were addressed or should be addressed in the future, for the purpose of improving future performance" (p. 242). These are only a few instances

of LL. According to Levy (2018), lessons and LL are occasionally used interchangeably in KM literature.

All these LL definitions infer that captured knowledge from experience leads to changes, and changes lead to various types of improvement. This knowledge capturing is typically facilitated through activities such as after-action reviews, post-mortems, debriefs, or project reviews (O'Dell & Hubert, 2011). Milton (2010) notes that factors leading to changes include documented processes and procedures, owners of the processes and procedures, and the owners' engagement with the learning process.

The term LL program in this study refers to aspects of LL related to people, processes, and technology. Understanding the nature of each component to adopt a holistic view of LL is critical in developing a matured LL program. Milton (2012) identifies three maturity levels of LL initiative:

- Level 1 – Reactive capture, capturing lessons for information. This level is to capture lessons reactively and document them in a specified location. People need to read the lessons to gain knowledge. They also need to search for lessons or self-nominate to receive automatic notifications.
- Level 2 – Reactive change, capturing lessons for action. The captured lessons at this level lead to changes and are embedded into practice and processes. Individuals can access knowledge without reading the lesson. They can just follow updated procedures and processes.
- Level 3 – Proactive change, lesson-hunting. This level differentiates from level 2 by proactively seeking out lessons everywhere within the organization. As part of a KM

plan, learning areas may be prioritized and selected. A team can investigate themes and trends that operational lessons may obscure.

Milton finds that most organizations are trapped at level 1 maturity, which provides little benefit. According to Milton, organizations should aim for at least level 2 for the LL program to be a powerful learning method.

2.3 Lessons Learned Process

The LL process occurs at any given time during the project or operation, depending on the criticality and complexity. Critical times are at the end of important activities or the end of the project. However, if waiting too long, organizations may miss valuable lessons. Additionally, LL can help improve future activities of ongoing projects, not just improve future projects (Rowe & Sikes, 2006). Many steps in the LL process have been proposed in various publications. Table 1 provides a summary of LL processes from several authors. Although each LL process appears different, the steps are similar. Moreover, each step can be grouped for further elaboration.

Table 1: Comparison of Lessons Learned Process

Author	Lessons learned process
Baird et al. (1997)	Review, analyze, capture, and apply
Weber, Aha, and Becerra-Fernandez (2001)	Collect, verify, store, disseminate, and reuse
Row and Sikes (2006)	Identify, document, analyze, store, and retrieve
Trevino and Anantatmula (2008)	Collect, analyze, store, disseminate, and make effective use of data
Jeon (2009)	Acquisition, Evaluation, Storing, Dissemination
Chaves and Veronese (2013)	Capture, storage, share and verify, distribute, apply, withdraw
Milton (2010)	Identification, action, and institutionalization
Center for Army Lessons Learned (2011)	Collect, Analyze, Share, Archive, Resolve, Assess
White and Cohan (2016)	Define the project, collect, verify and synthesize, store, and disseminate
Dülgerler and Negri (2016)	Collection, prioritization, documentation, communication, and assimilation
Al-Mansour (2020)	Collect, review, implement, and track

2.3.1 Identify, Capture, and Collect

The first step is to capture knowledge or lessons through structured and unstructured processes (White & Cohan, 2016). Milton (2010) distinguishes a lesson learned from a lesson identified, which is just a recommendation based on positive or negative experiences. A lesson identified needs to be associated with follow-up action, and that action must be acted upon to be considered a lesson learned (Milton, 2010). Knowledge must be transformed into action to improve performance (Levy, 2018). However, Levy (2018) argues that not all lessons or knowledge can turn into action. It is possible that the specified action does not fit within a procedure or is not currently actionable. Moreover, there may be processes that do not have procedures or processes that organizations want to loosen formal instructions due to regulatory audits. Nevertheless, Levy recommends identifying and collecting all these lessons even if there is currently no change to implement since they can become important in the future.

APQC or The American Productivity and Quality Center (2021d) suggests that lessons can be captured through facilitated discussions or self-submission processes. Organizations should provide both options as part of the LL program (APQC, 2021d). The facilitated discussions are typically debriefing sessions or after-action reviews held at the end of major activities or post-project reviews at the end of projects (Milton, 2010). The discussion leading to the lessons would start around questions that describe the work, processes, objectives, key challenges, and success factors. Following that, open questions will be used to highlight key learning points. The learnings are then analyzed, and recommendations are made using 'what' queries, leading to follow-up actions (Milton, 2010). On the other hand, self-submissions or "self-service" allows employees to capture lessons at their convenience using tools and templates (APQC, 2021d). Weber, Aha, and Becerra-Fernandez (2001) further categorize the collection step into six approaches:

- Passive collection, in which individuals submit their lessons using some type of form
- Reactive collection, in which lessons are collected by interviewing individuals
- After-action collection, in which lessons are collected after missions or projects
- Proactive collection, in which lessons are collected during problem solving
- Active collection, in which methods and processes are used to find lessons
- Interactive collection, in which Weber et al. (2000) presented an intelligent elicitation system that interacts with the lesson's author and relevant information sources in real-time.

The captured lessons must be specific enough to enable learning. Moreover, lessons need to be captured in the form of a recommendation, not an observation. This will lead to actionable items for future improvement (Milton, 2010). In addition, Levy (2018) suggests that lessons should be captured from additional sources like quality-based processes in project management such as quality audits, customer feedback, or Plan-Do-Check-Act (PDCA) model.

2.3.2 Verify, Analyze, and Prioritize

This step involves validating lessons for accuracy, redundancy, consistency, and applicability (Weber, Aha, et al., 2001). The analysis focuses on the "who, what, when, where, and why" to discover the root causes of the lesson (Center for Army Lessons Learned, 2011). This step is usually performed by or with the support from domain or subject matter experts (Weber, Aha, et al., 2001; White & Cohan, 2016). The lessons should be further organized according to their applicability while ensuring consistency in processes and forms (Rowe & Sikes, 2006). A team consisting of key project members may be assigned to prioritize the lessons to prevent information overload, which could reduce the effectiveness of the LL process (Dülgerler & Negri, 2016).

A lesson review team may evaluate the value of LL to future projects. Furthermore, depending on the review result, lessons identified may be accepted, merged, forwarded, or archived (Al-Mansour, 2020). Milton (2010) states that "the exact nature of the validation and quality assurance process is not as important as actually having a validation and quality assurance process in the first place" (p.72). This LL sub-process requires time and resources.

2.3.3 Store and Document

The verified lessons from the previous step will be stored in an electronic repository or a database system if they are available. Otherwise, the lessons are usually stored in a shared drive along with other project documents (Rowe & Sikes, 2006). A systematic approach with standardized formats and indexing is essential for future reference and retrieval from the LL repository (Dülgerler & Negri, 2016; Rowe & Sikes, 2006; Weber, Aha, et al., 2001; White & Cohan, 2016). Each lesson is stored and managed independently to enable efficient retrieval (Levy, 2018; Milton, 2010). Actions may be assigned to the lessons if not previously done. The lessons must be documented in a way that leads to action and results in change (Dülgerler & Negri, 2016; Levy, 2018; Milton, 2010). Milton (2010) defines six types of actions from LL:

- Fixing a problem
- Further investigation
- Procedure or process documentation
- Procedure or process update
- Training program update
- Passing lessons to others to identify actions

If all actions have been successfully implemented, resulting in a process update, LL may not need to be in a database (Levy, 2018; Milton, 2010). However, Levy (2018) argues that there are lessons

that, for the time being, no concrete actions can be assigned, or the actions are not straightforward. Moreover, some processes do not have specific procedures to incorporate the lessons. These lessons may remain in the form of valuable recommendations or ideas and must be documented for future action to realize their value (Levy, 2018). Therefore, the LL store and document sub-process should also be structured to consider these types of lessons.

2.3.4 Disseminate and Communicate

The dissemination step may be the most crucial in terms of encouraging lesson reuse (Weber, Aha, et al., 2001; White & Cohan, 2016). Dissemination of lessons will be easier if they are well categorized and indexed during the documentation step. Lessons can be automatically delivered to users (push) or searched by users (pull) (White & Cohan, 2016). Milton and Lambe (2019) use the market supply and demand analogy to represent push as knowledge dissemination driven by suppler and pull driven by demand. They suggest that for knowledge to flow, the organization requires both push and pull to function, the same way that a market requires demand and supply. Weber, Aha, and Becerra-Fernandez (2001) further categorize dissemination into six methods:

- Passive dissemination, in which users search for LL from a passive system
- Active casting, in which lessons are broadcast to targeted users
- Broadcasting, in which lessons are sent to everyone in the organization
- Active dissemination, in which users are dynamically informed of lessons that are pertinent to their decision-making
- Proactive dissemination, in which the system anticipates when users should be prompted with relevant lessons

- Reactive dissemination, in which users request the system for assistance in obtaining relevant knowledge

Any process updates or improvements must be communicated to various stakeholders, especially the process owners. They must be able to refer to, review, and comprehend the knowledge. One method to achieve this is by updating training programs to reflect the LL. Another way of LL dissemination is through process reviews such as before-action reviews and peer reviews. Discussions can lead to a greater understanding of LL, increasing the possibility that it will be used for future activities and, as a result, performance will improve. The lessons in a database will not impact performance unless applied (Milton, 2010).

2.3.5 Retrieve, Reuse, Implement, and Assimilation

The last step involves applying LL retrieved from a repository to help projects and operations avoid repeated problems and improve performance (Al-Mansour, 2020). This step is the actual learning of the lessons (Levy, 2018; Milton, 2010; Pearce, 2020). Existing LL, applicable to specific projects, can be searched or identified. The team should develop a LL implementation plan and ensure team members understand the impact before applying LL (Al-Mansour, 2020).

To implement or embed lessons into the organization, Levy (2018) suggests embedding lessons into templates and forms, training programs, checklists, online help, processes, and work procedures. Lessons reuse requires domain-specific knowledge and understanding of the problem context to successfully implement the learnings (Weber, Aha, et al., 2001). This step is one of the biggest challenges of the LL process (O'Dell & Hubert, 2011). An additional step may be to track the impact and benefit of applying LL or any pending action that has not been closed out (Al-Mansour, 2020). The process of embedding lessons into the organizational environment and

raising awareness of the LL closes the learning loop, forming complete life-cycle management of LL (Levy, 2018; Milton, 2010).

2.4 Lessons Learned Approaches

O'Dell and Hubert (2011) introduce two strategic paths for the LL program. Path A entails incorporating a LL process into the project or work processes, allowing team members to adapt and apply LL to the current project. Employees are more likely to recognize the value of the LL process since there can be immediate benefits from using LL. Path B encourages future LL reuse by capturing LL throughout the project and then developing a system for making those lessons available to future projects. This approach is more difficult since processes, people, and context may have changed. However, organizations deal with both strategic paths. To support path B and every step of the LL process, a well-designed database or LLMS is required.

LL approaches may not require an LL database but use other means to transfer and store lessons. Milton (2010) defines four different approaches or systems that support the LL process: informal connect systems, formal connect systems, informal collect systems, and formal collect systems. These systems originate from the interplay of connect-collect and formal-informal, producing four quadrants as illustrated in Figure 2.

- **Informal connect systems** are informal networks, such as popular social networks like LinkedIn and Facebook, in which knowledge is shared through group discussions emerging from bottom-up interest. These systems are easy to use and can foster discussion-oriented culture, opening the opportunity for unusual sources of learning. However, due to the unstructured network, people may give opinions instead of proper knowledge, and learning experience may not be exchanged. Informal connect systems

may be suitable for initiating a sharing culture but is unlikely to support a systematic approach to knowledge transfer.

- **Informal collect systems** are "the voluntary, ad hoc and self-organizing community tools such as Wikipedia" (p. 29). An advantage of the wiki model is that it is easy for users to create content and share knowledge. This can result in continuous knowledge emerging from employees. The wiki approach may be suitable for complex learning where risks and costs of not learning are low, and actions can be left ad hoc. However, since this system is voluntary, there is no guarantee that critical lessons will enter the system or reach critical stakeholders.
- **Formal connect systems** are formal networks that "allow members to use each other as a resource and repository of unwritten knowledge" (p.30). Lessons are exchanged through discussions within a formal network of people or at a formal meeting. This approach is suitable for sharing complex and context-specific lessons and rapidly changing topics where new problems are frequent. It is less suitable for standardized processes where lessons can be incorporated into standards and guidelines.
- **Formal collect systems** are well-managed systems for collecting lessons. These are formal LL repositories or databases. They allow for easy lesson management with the ability to perform functions such as search, sort, organize, and track. A formal collect system can follow through with action items, which increases the chance of lesson dissemination to targeted stakeholders. However, the challenge of such a system is the difficulty or effort of inputting lessons into the system.

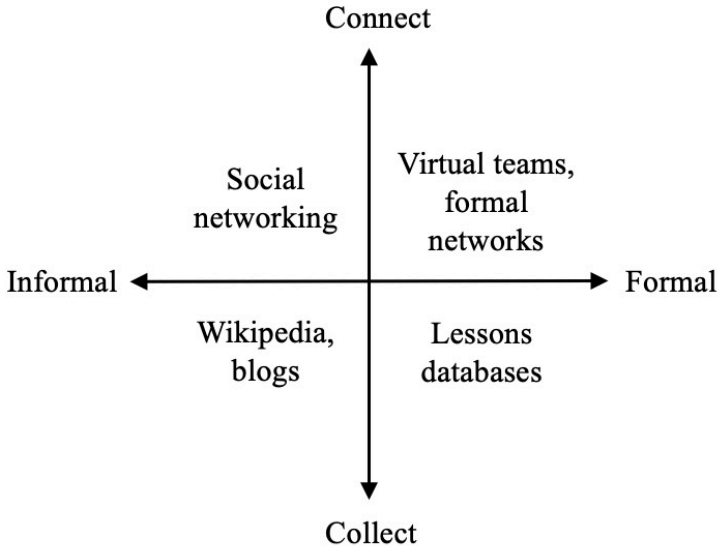

Figure 2: The Four Quadrants of Learning Approaches (adapted from Milton, 2010)

Milton (2010) suggests that a blended approach between connect and collect is required, while organizations must find the right balance between informal and formal systems. Milton and Lambe (2019) stress that any KM initiative must cover both elements of connecting people and collecting content. They are both important because conversations are an effective method of passing on knowledge, but the contents are more efficient at knowledge dissemination. The LLMS falls under the formal collect system but will also require the ability to connect for it to facilitate an effective LL process.

2.5 Lessons Learned Management Systems

Since LL programs are part of KM, LLMS can be considered an instance of knowledge management systems (KMS) – IT systems supporting all types of KM initiatives. The term lessons learned management system (LLMS) in this study refers to information technology in the form of a structured database specifically designed to support the LL process. This technology assists the LL process by recording lessons in a standardized format, searching for and retrieving lessons,

assigning actions to lessons, tracking the status of lessons, and forwarding lessons to targeted users (Milton, 2010). The ability to support the LL process distinguishes LLMS from libraries, document management systems, or portals (Levy, 2018). According to Levy (2018), the structure of an LLMS has four main components: (1) the lesson's body, (2) context-based attributes, (3) fixed attributes, and (4) hyperlinks and attachments. The specifics of each component will vary between organizations. The inputs from the users within the organization and the nature of work should dictate the detailed design of the LLMS (Garfield, 2017; Weber, 2007). To determine the effectiveness of an LLMS, Liebowitz (2012) suggests using these metrics:

- Ability to quickly capture LL in the system
- Ability to improve performance and decision making through the embedded LL process
- Quality of the knowledge captured
- Amount of knowledge captured
- Ease of use in both incorporating LL into the process, as well as in accessing the LL
- Adaptability of the approach in terms of how generic is the methodology as applied to other domains
- Ease of archival and maintenance of the LL process
- Flexibility of the approach in terms of getting LL to the right user at the right time and in terms of searchability of the LL

Due to the justifications mentioned earlier, LLMS should contain features to connect people and collect knowledge. An LLMS can provide the ability to route lessons and associated actions to responsible individuals, allowing the actions to be closed out by embedding lessons into processes and procedures (Milton & Lambe, 2019). Milton (2010) notes that LLMS can be used for a single project, to manage lessons within the project, or set up as an enterprise-wide system to

manage lessons of multiple projects within the organization. By using an enterprise-wide LLMS, lessons from various projects can be captured and systematically stored for future reuse, where they will be compared, searched, and transferred to other projects (Milton & Lambe, 2019).

The LLMS itself can be a standalone tool or embedded into other suites of tools. Organizations that can quickly incorporate lessons into their processes may not need to maintain a permanent database since lessons have already been learned or reused. In contrast, rigid organizations, such as military organizations, will likely need to maintain a database since it may take a long time before lessons will be integrated into processes and procedures (Weber, Aha, et al., 2001).

An LLMS can efficiently provide beneficial lessons to employees who will encounter situations similar to previous experiences. This allows organizations to systematically retain their knowledge even though subject matter experts become unavailable through job changes or retirement (Weber, Aha, et al., 2001). The LLMS must be designed to support "lessons for action," not designed to function merely as a lessons database where lessons become lost in a "lesson graveyard" and not learned (Milton, 2019). However, LLMS by itself is insufficient. Organizations should consider setting up Communities of Practice to facilitate conversations and enhance the knowledge-sharing culture (Liebowitz, 2011). An LLMS must also facilitate the people component of the LL program.

2.6 Roles and Responsibilities Supporting Lessons Learned Programs

To ensure any type of KM initiative prosper, the organization must address the people component of the LL program by dedicating roles and skills to perform the work of KM (Davenport & Prusak, 1998). Well-defined roles and responsibilities are vital to having a practical LL program. Responsibilities and expectations must be clearly defined and documented for both

process managers and participants in the LL process (Trees & APQC, 2010). As with any other new initiative, leadership support is essential. Milton and Lambe (2019) believe that senior management support is recognized as “the single most important enabler” of any KM initiative, including LL.

Davenport and Prusak (1998) point out that, ultimately, organizations successful in KM are those in which managing knowledge is everyone's business. However, they recognize that “it is unrealistic to assume that a company can simply throw knowledge management activities on top of its existing positions” (p.107). Similarly, Levy (2018) notes that several processes are too complex for employees to handle alone. In addition, no individual doing after-action reviews should be responsible for activities such as verifying and validating lessons and managing changes. Therefore, dedicated roles with specific responsibilities to support the LL program are crucial.

In order to initiate change, there must be roles that are accountable for the change process, which Milton (2010) calls the process owners. Actions from lessons will require changes, such as updating standards and procedures. The process owners are responsible for reviewing the actions and updating the changes; these owners might be subject matter experts, technical authorities, or R&D staff. This will depend on the maturity of the LL process and the organizational structure (Milton, 2010). Apart from process owners, Levy (2018) suggests additional roles to support the LL process, such as lessons manager and knowledgebase (LLMS) manager. These roles could be thought of as a learning team accountable for facilitating the LL process and maintaining the LLMS, monitoring and measuring its use (Milton, 2010). They will be responsible for activities such as assisting in complex debriefing sessions, training personnel, designing the structure of the LLMS, reviewing lessons and good practices, and finding ways to embed them into the organizational environment (Levy, 2018).

The learning team structure will differ between organizations, depending on the nature of work and the organizational structure. The key point is that it is unlikely that a LL program can naturally grow without intentional support, as O'Dell and Hubert (2011) emphasize that people are critical to the success of any kind of KM initiative.

2.7 Value of Learning

Learning from experience has many business implications. Knowledge is vital to achieving success in the twenty-first century, which has become increasingly complicated (Levy, 2018). A competitive advantage gained through knowledge is a sustainable advantage (Davenport & Prusak, 1998). Consequently, organizations that fail to learn are at a disadvantage in increasingly competitive markets (Robertson et al., 2008). Lessons are evidence-based improvement opportunities generated within the organization. Thus, they are less risky than external improvement recommendations and should be a priority in terms of implementation (Fry, 2021). The probability that a project will be completed successfully increases when the team focuses on learning from experience (Bost, 2018). Maier and Reimer (2018) conducted a survey to understand how managers perceive the importance of experience. The survey results indicated that experience is considered valuable, and the areas or activities where experience is seen as very important are shown in Figure 3.

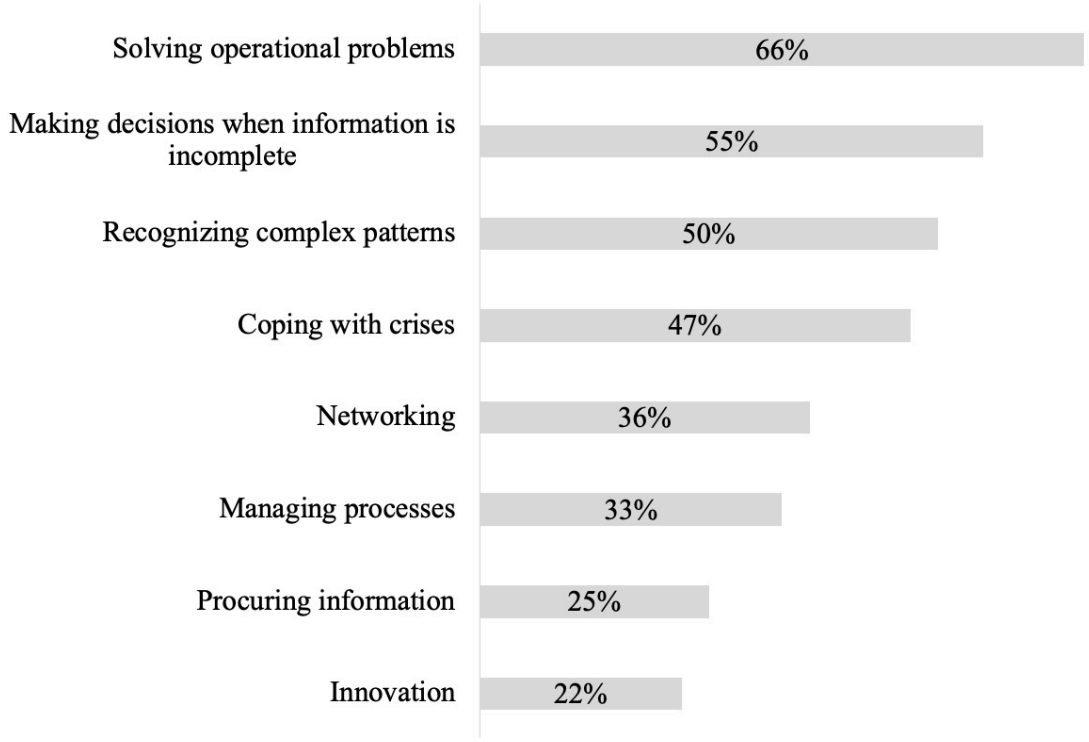

Figure 3: Areas and Activities Where Experience Is Very Important (adapted from Maier & Reimer, 2018)

Milton and Lambe (2019) list five topics that the LL program can address:

- Speeding up the learning curve – learning can help bring teams up to speed quickly when working in a new environment.
- Continuous improvement – ensures mistakes are not being repeated and success is being replicated. New learning is infused into organizations' processes and procedures to improve performance.
- Standardization – learning from experience allows organizations to define best practices.
- Business intelligence and decision support – learning can support decision making, strategies, and plans.

- Development of breakthrough products and services – learning can lead to new ways of doing things and business approaches.

Similarly, O'Dell and Hubert (2011) state that the LL program can:

- Avoid redundancy and reinvention
- Improve performance while reducing errors
- Standardize best practices
- Enhance learning proficiency and professional development
- Build a knowledge-sharing culture.

The learning process could yield significant value, especially for capital-intensive industries such as upstream oil and gas (Milton, 2010). In an analysis comparing well intervention operations with and without LL, Oughton (2021) demonstrates that by establishing a systematic LL process with the assistance of an online tool, the organization realized a 32% decrease in non-productive time (NPT) and a cost savings of $10.2 million. Oughton concludes that, apart from reducing NPT and saving costs, effective LL management can improve operational efficiency and increase the accuracy of time and cost estimates.

2.8 Barriers to Lessons Learned Programs

The notable benefits highlight the significance of incorporating a LL program within the organization's KM strategy. However, there are numerous reasons why organizations are failing to implement and sustain LL programs. Davenport and Prusak (1998) emphasize the need to "take a hard look at your culture before launching a knowledge initiative" (p.172). In general, KM and LL share similar, if not the same, barriers since LL is part of KM. This section discusses barriers to having an effective LL program and factors preventing the adoption of LLMS.

2.8.1 Barriers Related to the Lessons Learned Process

The LL process does not come naturally. Suppose it is not integrated into the work process; many may overlook the value of learning and see the LL process as unnecessary (additional workload) since the company can continue to function (Fry, 2021; Levy, 2018). In a survey by Trevino and Anantatmula (2008), every respondent felt they could learn from past successes and failures. However, only 60% indicated that lessons learned are occasionally used. According to Williams (2008), project managers believe the LL process is essential, but there is a significant gap between what is done and what they believe should be done. A recent case study by El Khatib et al. (2021) found that all project managers agree that LL will eliminate repeating mistakes. However, some could not even remember the last time they used or reviewed project lessons. Newell et al. (2006) highlight a critical point that project teams typically focus on the results rather than the process. This paradigm can lead to neglecting the time to reflect on the learnings.

A common pitfall during the LL identify, capture, and collect sub-process is coming up with general conclusions that are abstract, devoid of context, devoid of practical instruction, and non-actionable (Dülgerler & Negri, 2016; Levy, 2018). However, Levy (2018) points out that organizations can also become overwhelmed with actions and suggestions after lessons capturing activities. Furthermore, organizations might see the need to have flexibility in their procedures due to regulations. There is tension between regulations against organization best practices. Organizations need to ensure that no issues arise during regulatory audits on compliance in execution procedures. Lessons may not be a good fit into procedures in this scenario. If the LL capturing activities do not take every type of lesson into account, it may negatively impact employees' participation in identifying lessons or knowledge since less value is seen from such activity (Levy, 2018). Another scenario impacting lesson identification is the case where people

believe that the lesson is common knowledge and is not worth the effort to share or capture (O'Dell & Hubert, 2011).

Duffield and Whitty (2015) identified that if merely the capturing and storing processes are functioning, without the dissemination and implementation, it may create a misleading impression that the organization is learning from experience. Lesson dissemination is known to be a challenging aspect of the LL process (Fry, 2021; Weber, Aha, et al., 2001; Williams, 2008). Employees may not look for lessons if there is no means of effective searching (Levy, 2018). Fry (2021) notes that lessons are often left in spreadsheets if there is no governing process for reuse. The process of reviewing LL is frequently neglected since it is time-consuming to locate relevant lessons (Dülgerler & Negri, 2016). In terms of lesson implementation, Levy (2018) points out that merely embedding lessons into work procedures and guidelines can be ineffective since some employees may not refer to these important documents even though they are required to do so.

To date, numerous studies have identified barriers to an effective LL process. These barriers might differ depending on the organizational context. This literature review aims to provide a broad range of possible barriers to LL programs and KM as a whole. Table 2 summarizes the findings from several studies concerning barriers to the LL process. Some prominent barriers are further discussed in detail.

2.8.1.1 Time Barriers

A common barrier is related to time. Many studies have reported that lack of time or time pressure is a barrier to the LL process (APQC, 2021d; Levy, 2018; Wiewiora & Murphy, 2015; Williams, 2008). Pausing to look back and learn how to improve future projects seems rational. Nevertheless, many people will move on to the next endeavor, assuming they do not have time for the perceived added work of learning from lessons (Levy, 2018). Even with after-action reviews

being performed, the team may not have sufficient time to cover every identified lesson in full detail (Fry, 2021). Generally, the LL process is not seen as important enough to be given time (Garfield, 2017).

The time required to complete each LL sub-process affects the time barrier perception. If lessons are difficult to document and locate, project managers may be under time pressures, limiting their use of LL (Wiewiora & Murphy, 2015). Additionally, manually managing the LL process without the aid of technology is time-consuming for project managers (El Khatib et al., 2021).

The time barrier might be a result of insufficient resources. Especially if learning is not a management priority, organizations may lack the resources necessary to implement actions based on lessons (Fry, 2021). The actions owners might be overloaded and unable to apply all the actions from the learning (Levy, 2018). This could lead to the loss of valuable learnings and recommendations, preventing lessons from being learned.

2.8.1.2 Motivation and Incentive Barriers

Several survey participants cited employee motivation as a critical barrier in their case study in a survey conducted by Rhodes & Dawson (2013). Wiewiora and Murphy (2015) found that employees' motivation to engage in the LL process is negatively impacted by time pressure from project execution. Due to the time-sensitive nature of projects and the difficulty accessing LL, project managers forego the chance to search for LL. The late timing of lesson-capturing activities, such as end-of-project reviews, could also impact employees' motivation since the team may have disbanded (Newell et al., 2006). In addition, it is naturally more difficult to recall events that occurred in the distant past.

If employees do not perceive the benefit of contributing, KM efforts may fail (Weber, 2007). Both extrinsic (monetary) and intrinsic (recognition) rewards can positively influence the LL process (Abdelwhab Ali et al., 2019). However, in a case study of eight leading Canadian O&G companies, Carrillo (2004) found that financial incentive has a short-term influence, whereas peer recognition has a long-term impact. Milton (2020c) expands this distinction with data from Knoco (www.knoco.com) KM surveys conducted with approximately 700 respondents. He found that monetary or other extrinsic rewards are the least powerful incentive. In addition, the survey reveals that incentives that are not embedded as part of the work behavior tend to lose their effectiveness as the maturity of KM initiatives increases within the organization. These non-embedded incentives are monetary rewards, gamification of KM, and a centrally organized recognition scheme (Milton, 2020c).

2.8.1.3 Leadership Barriers

Davenport and Prusak (1998) have stated that KM cannot transform a company unless "the CEO and his or her management team is standing on the front lines of knowledge management with you" (p.177). Almost every study in Table 2 includes a leadership aspect, with lack of leadership support as a prominent barrier. For example, Carrillo (2004) agrees that KM should be pushed by senior leadership for it to be successful. Without leadership support, it is unlikely that any type of KM initiative will thrive. Managers should define, communicate, and enforce the guidelines, while offering guidance and support to improve the LL process (Weber, Breslow, et al., 2001).

2.8.1.4 Lack of Systematic LL Process or Clear Direction

In a survey conducted by Trevino and Anantatmula (2008), respondents indicated that their organization lacks processes and governance for each sub-process of the LL approach. Wiewiora

and Murphy (2015) carried out a multi-case study and found that respondents from four different industries recognized the lack of a systematic LL process in their organization. There is no assurance that lessons will be captured, stored, and reused without such a process. A common issue is the lack of a dedicated storage location for LL, leading to difficulty in finding information. However, Wiewiora and Murphy also noted that a LL process that is overly structured and systematic might diminish the value and depth of knowledge (Wiewiora & Murphy, 2015). Abdelwhab Ali et al. (2019) support this view by reporting that an informal setting can increase knowledge sharing between employees.

2.8.1.5 Culture Barriers

A common barrier in the literature is that organizational culture does not facilitate learning and the LL process. Culture is part of the people component within the LL program. Duffield and Whitty (2015) point out that people and culture substantially affect the LL process. To examine this issue, Milton (2020b) conducted a survey and ranked common cultural barriers as:

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

Milton (2020b) describes short-term thinking, the highest-ranked cultural barrier, as not taking the time to learn before, during, and after the projects or tasks. This cultural barrier overlaps with the time barriers previously discussed. The second most common cultural barrier – lack of openness to sharing knowledge – can be related to trust issues.

O'Dell and Hubert (2011) point out that people tend to absorb knowledge from other people they know, respect, and like. Therefore, a lack of trust within the organization will lead to fewer interactions among employees, resulting in less knowledge sharing.

Another factor affecting knowledge sharing is a prominent blaming culture within the organization. This will create reluctance to share problems or failures (Newell et al., 2006). Apart from the fear of being blamed, there is fear that sharing mistakes may lead to humiliation (North Atlantic Treaty Organization, 2011). The LL process involves learning from positive and negative experiences, including mistakes. However, developing an open and transparent dialogue about one's shortcomings is difficult for most people (Levy, 2018).

Fry (2021) believes that a significant cultural problem is failing to prioritize addressing actions from captured lessons. This leads to an organizational structure that lacks capacity and resources. Since most organizations have entirely different cultures, it is safe to assume that the culture barrier can differ based on the organizational context, and cultures that interfere with any sub-process of the LL process will diminish the effectiveness of the LL program.

Table 2: Barriers to Lessons Learned (LL) and Knowledge Management (KM)

Authors	Barrier or problem
Williams (2007)	• Lack of employee time • Lack of management support • Lack of incentive • Lack of resources • Lack of clear guidelines • Lack of support from others in the organization • Our processes do not capture useful lessons • Data repository too hard to search • Lessons are not transferable • Wrong people are involved • We already put in enough effort
Weber (2007)	KM approaches may fail when: • they attempt to create a monolithic organizational memory • they do not integrate humans, processes, and technology • they are designed without input from all stakeholders • contributors do not know the ideal specificity of knowledge • lack of leadership support • users are afraid of the consequences of their contributions • they store knowledge in unrestricted textual representations • they rely on inadequate technology • they are outside the process context • they ignore impediments to knowledge transfer • they do not enforce managerial responsibilities • they do not properly oversee the quality of stored knowledge • they do not promote collaboration • they are not able to show measurable benefits • users do not perceive value in contributing
Trevino and Anantatmula (2008)	• Lack of time • Lack of resources • Lack of clear guidelines • Lack of incentive • Lack of management support

Authors	Barrier or problem
Milton (2010)	• Lack of follow-through and application • Lack of leadership support • Wrong culture • Lack of time
Rhodes and Dawson (2013)	• Lack of time to search for or record lessons • Lack of learning culture • Lack of process • Lack of a searchable, indexed repository • Lack of clear intent from the organization
Grant (2013)	• Information overload • No time to share knowledge • Not using technology to share knowledge effectively • Difficulty capturing tacit knowledge
Carrillo et al. (2013)	• Inadequate communication • Silo environment • Little value added • Time constraints • Too process driven • Culture • Reluctance to obtain external advice • Duplication of work • Lack of perceived value • Internal competition • Legal issues
Ranjbarfard et al. (2014)	• Lack of an appropriate reward • Lack of technical support of integrated technology to support KM tools requirements • Lack of formal authority on the part of the innovator • Lack of fitness between knowledge and important organizational goals

Authors	Barrier or problem
Wiewiora & Murphy (2015)	• Lack of consistent set of structure to produce LL • Only some project managers update LL documents • Captured and stored in a way that is not conducive to sharing • LL are not stored in a concise location • Lack of visibility to see how LL are progressing • Lack of LL ownership – a person or group responsible for implementing changes and following up • Lack of process to ensure LL are captured throughout the project • Lack of process that would require searching through LL documents – only an individual's initiative
Le et al. (2018)	• Lack of effective information management system • Lack of instructions and processes • Lack of background and skills • Perceived competitiveness of LL • Underestimating the value of LL
Oughton (2021)	• Lack of searchability making the information difficult to find when and where needed. • Ineffective data management, resulting in stale or non-value adding data. • Loss of learnings when a rig was laid down or project completed. • Lack of process to institutionalize learnings into a document and/or procedure that drove adoption

Authors	Barrier or problem
APQC (2021e)	• Employees are overworked and think they don't have time for KM • Leaders are focused on (what they see as) more urgent problems or opportunities • Organizational culture does not incentivize knowledge sharing and reuse • Organizations have too many disconnected technologies in place to support KM • KM's impact is hard to measure, which complicates funding and buy-in • KM may get lost in broader digital transformation/workplace strategies

2.8.2 Barriers Related to Lessons Learned Management Systems

Complexity is inherent in large-scale LLMS (Thomas, 2015). Organizations must determine what technology solutions fit their nature of work and culture (Edwards et al., 2005). Many organizations have been fixated on deploying new digital technologies without questioning why (Garfield, 2017). Technologies such as LLMS will not gain adoption if employees do not consider them useful (Talukder, 2012). Therefore, several impediments exist within the LLMS's architecture and functionalities; and how they holistically assist the LL process. Table 3 presents barriers related to LLMS and its adoption within the organization.

Weber, Aha, and Becca-Fernandez (2001) recognize that if there is no standardized format for capturing lessons into the LLMS, the lessons will be difficult to verify, retrieve, interpret, and reuse. Similarly, Newell et al. (2006) determined that an important barrier to knowledge database usage emerges from lessons not being captured in an actionable manner; and the contexts behind the learning are incomplete. However, even with a well-structured database and embedded LL

activities, it does not imply that people will search for lessons. Therefore, the system should be able to forward lessons to stakeholders such as action owners (Milton, 2010).

The lack of this function is one disadvantage of using spreadsheets instead of specialized software. Furthermore, when a database expands, spreadsheet databases can quickly become unmanageable (North Atlantic Treaty Organization, 2011). Technology should be used to help create useful knowledge, not just to collect more "unfocused data" (Edwards et al., 2005). Spreadsheets are commonly used as a LL database since many employees already use the spreadsheet software for other tasks. This commonality highlights a challenge that if LLMS is a standalone tool, it may create problems with dissemination; thus, lessons might not be reused (Weber, Aha, et al., 2001).

Table 3: Barriers Related to Lessons Learned Management Systems

Author	LLMS and KMS barriers
Liebowitz (2011)	• The system is only capable of passive analysis and dissemination of lessons • The lessons in the system are outdated • Lack of effective search capability
NASA Office of Inspector General (2012)	• Managers are not using LLIS because: – LLIS is outdated – Not user friendly – Not operating as originally designed – It does not contain relevant information • Policy requirements weakened over time • Inconsistent policy direction and implementation • Disparate funding support • Lack of monitoring • Lack of a comprehensive strategy for knowledge management

Author	LLMS and KMS barriers
Milton (2018)	• Poor database • Poor notification mechanism • No support • No training • No incentives • No governance • No checking on actions
Wall (2020)	• Lack of training • Cumbersome to use • Lack of rewards • Lack of management support/budget • Employees are overworked • Small companies do not need a KMS • When not kept up to date, KMSs are not useful • Does not fit with the organization

A survey conducted by the NASA Office of Inspector General (2012) found that NASA's LLMS, which is called Lessons Learned Information System (LLIS), is underutilized. Despite NASA requirements and guidance, project and program managers seldom use or contribute to the LLIS. Reasons for the underutilization are listed in Table 3. The audit report concludes that the LLIS was not currently configured to be an effective instrument for capturing and disseminating lessons. Additionally, the report recommends developing and implementing a strategic plan for how the LLIS can better support the LL process within NASA.

According to Davenport and Prusak (1998), developing or buying a well-designed LLMS does not imply that employees will use or gain value from the system. It is easy to divert to focus on technology since it is easy to buy, implement, and measure. However, spending too much effort on technology might neglect other critical factors such as organizational culture and motivation. It

is crucial to remember that an LLMS is only a tool for the LL process and, by itself, does not create knowledge or a knowledge-sharing culture (Davenport & Prusak, 1998). Organizations often overlook the fact that technology will always require support from people and processes (Garfield, 2017).

2.9 Enablers of Lessons Learned Programs

Before starting KM initiatives, it is vital to have well-defined corporate objectives, vision, strategies, and use cases to achieve success (Garfield, 2017). Weber (2007) states that an organization in which employees have "the same technical goals, are motivated by a common interest, are organized on a flat hierarchy, and are receptive to innovation" (p.344) will likely succeed in implementing KM programs. People within the organization must realize the value derived from using the LL process and its supporting technologies and procedures (Atwood, 2002; Weber, 2007). If no LL program exists, an organization will require an implementation plan before rollout. Milton and Lambe (2019) recommend using an iterative approach to develop a pilot framework that meets business objectives and provides opportunities to deliver quick wins. This iterative process continues until the framework is robust enough to be deployed. Table 4 summarizes some of the enablers and recommendations reported to facilitate LL programs. The following sections discuss each enabler of the LL program: processes, technology, people, and governance.

Table 4: Enablers and Recommendations for LL Programs

Authors	Lessons learned enablers and recommendations
Weber (2007)	KM approaches [or LL programs] should: • be designed to support communities of practice • integrate humans, processes, and technology • be designed in collaboration with different stakeholders • identify an adequate level of specificity • be strongly supported by the leaders of their target communities • be adopted by communities that encourage innovation • adopt representations with set of specific fields • adopt technology only when it is suitable for a task • be integrated into the context of target organizational processes • include methods to overcome impediments to knowledge transfer • incorporate means of enforcing managerial responsibilities • include verification methods • include measures to promote collaboration • demonstrate how contributors can benefit from KM • allow for the measurement of their effectiveness
Milton (2010)	• Actions defined arising from the lessons • Clear high-level expectations from senior management that the lessons learned process will be applied • A method to measure whether actions have been completed and lessons closed out • A process for validating or agreeing on the actions • An accountable person or people being assigned to complete the actions • A defined process for identifying lessons from activity

Authors	Lessons learned enablers and recommendations
Trees and APQC (2010)	• Determine the strategic objectives of the lessons learned process • Ensure that lessons can be adapted and applied to support current project and process teams • Foster reuse in other projects and domains where sources and recipients of lessons are not the same • Create governance and clearly defined roles • Establish an integrated, timely process to capture and share lessons learned • Ensure participation • Measure the impact of the lessons learned process
Rhodes and Dawson (2013)	• Remove all redundant systems • Introduce an official software tool • Introduce an official lessons-learned process • Define lessons learned intent • Market the chosen process • Overcome time barriers • Highlight success stories • Motivate employees to engage with lessons learned • Allocate employee time to maintain the system • Incorporate into training
Duffield & Whitty (2015)	• Learning • Culture • Social • Technology • Process • Infrastructure
Le et al. (2018)	• Altruism for organization • Effective work habits • Positive attitude towards sharing • Intrinsic motivation to learn • Sharing as an opportunity for learning

Authors	Lessons learned enablers and recommendations
(APQC, 2021b)	• Build capture, transfer, and reuse into work processes • Offer self-service and facilitated options • Verify and institutionalize outcomes • Capture and demonstrate value

2.9.1 Lessons Learned Process Enablers

There is consensus that organizations must integrate the LL process into standard work processes (Abdelwhab Ali et al., 2019; APQC, 2021d; Liebowitz, 2011; Maier & Reimer, 2018; O'Dell & Hubert, 2011; Trees & APQC, 2010). Incorporating the LL process into roles and responsibilities helps facilitate the LL program by instructing employees when to capture, review, or reuse lessons (APQC, 2021d). A typical example includes embedding the LL framework into project management processes such as planning and operations (APQC, 2021b).

O'Dell and Hubert (2011) believe that the best LL programs balance the speed of LL publishing with the quality of LL. The LL process must be monitored to assess gaps and identify process improvement opportunities throughout the learning loop. Streamlining the process will facilitate employees' participation in the LL process (APQC, 2021d). Although some LL sub-processes may have a greater influence on the success of the LL program, it is essential to examine each sub-process.

2.9.1.1 Enablers of Identify and Collect

A standardized format or template must be in place for capturing lessons (Liebowitz, 2011; Milton, 2010; Weber, Aha, et al., 2001). Ideally, an LLMS should support this standardization. Furthermore, the lessons must be captured in a format that allows for actions and future usage (Fry, 2021; Milton, 2010; Weber, Aha, et al., 2001).

The process should allow for lessons to be captured at any given point during a project or operation. Identifying LL at certain intervals throughout a project will help the project team to reflect on and evaluate their assumptions in light of reality (Bost, 2018). APQC (2021b, 2021d) reports that the LL process should allow for self-facilitated lesson capturing (individual submission) in addition to a facilitated capturing approach (after-action reviews or retrospects). Milton (2010) believes that the self-facilitated approach can only capture a small fraction of the learning because people are unaware of the knowledge they possess. With a facilitated LL capturing activity, a facilitator can help employees capture these "unknown knowns" by asking the right questions (APQC, 2021b; Milton, 2010).

In contrast to Milton, Fry (2021) argues that a voluntarily captured lesson will provide more information and context than lessons captured from a scheduled process, such as after-action reviews. Moreover, this self-submission option enables individuals to capture knowledge whenever it occurs to them or whenever they have the opportunity or time (APQC, 2021b). Levy (2018) elaborates on this by proposing that debrief sessions should be performed whenever an event is unexpected – both positive and negative. The flexibility also addresses the time barrier previously discussed. This contrast highlights the need for the LL process and system to accommodate both capturing approaches, an option based on the circumstances. Additionally, Jeon (2009) points out that the capturing method or system should support offline activities to accommodate employees at the work sites without internet access.

2.9.1.2 Enablers of Verify, Analyze, and Prioritize

APQC (2021d) suggests that there could be several tiers of lesson severity, and the formal review and verification of every submitted lesson should be an option. This prioritization can help prevent overloading the subject matter experts that review the lessons (APQC, 2021d). Moreover,

making the formal review process optional will encourage employees to share knowledge such as tips and tricks (APQC, 2021b). These types of knowledge may be low on the lesson severity scale, yet they may still lead to performance improvement. In addition, capturing more lessons will foster a knowledge-sharing culture. However, quality assurance and quality control processes are still essential enablers of the LL process (Milton, 2010). Organizations can improve the quality of LL by dedicating personnel to manage the contents (Wiewiora & Murphy, 2015). Additionally, organizations can incorporate an endorsement process in which lessons are approved by authorized decision makers, similar to the NATO LL approach (North Atlantic Treaty Organization, 2011).

2.9.1.3 Enablers of Store and Document

Lessons should be stored and managed as an individual entity to increase retrieval efficiency and accuracy (Levy, 2018). Each lesson must be documented in a manner that is easy to understand, specific, and beneficial to the reader (Levy, 2018). Moreover, it is important to provide adequate context to each lesson in order for them to be understood in isolation, without the need to understand the entire project in which the lesson is derived (Levy, 2018; Milton, 2010).

Jeon (2009) suggests a periodic review of stored LL to ensure their relevancy. Lessons may be deleted or updated to maximize the benefits of LL and prevent any undesirable consequences from applying outdated lessons.

2.9.1.4 Enablers of Disseminate and Communicate

There must be an effective method to distribute or push captured lessons to targeted individuals to either complete action items or comprehend the knowledge (APQC, 2021d; Milton, 2010). Organizations can support the dissemination by using a system like an LLMS to push lessons to targeted stakeholders with features such as alerts and notifications (Levy, 2018; Milton, 2010). In their research, Weber and Aha (2003) conclude that knowledge dissemination must be

closely integrated with the processes in which the knowledge will be immediately valuable. This integration prevents unnecessary interruptions to the users. This topic is further discussed in section 2.9.2 below.

2.9.1.5 Enablers of Retrieve, Reuse, Implement, and Assimilation

Accessibility to the LL is critical to promoting reuse. Organizations must facilitate employees' requests for knowledge. Organizations can embed the LL review activity in a before-action review (pre-mortem or briefing) process. Doing so can trigger team members to incorporate lessons that have been learned from previous situations (Levy, 2018).

Pearce (2020) points out that the learning process has to be voluntary for individuals to learn truly. The LL program can be designed to support voluntary learning by using techniques such as stories to illustrate lessons, case studies to make lessons more meaningful, project phase gates incorporated with lessons and actions, and changing processes or systems. Pearce argues that changing processes or systems ensures that at least the organization has learned, even though the individual may have not. To support individual learning, the LL system of records must have the capability for users to search (Center for Army Lessons Learned, 2011).

Through a comprehensive literature study, Duffield and Whitty (2015) developed a conceptual model illustrating the essential elements necessary for the LL process. They propose that essential organizational components must exist, align, and complement one another, to promote the dissemination and implementation of LL. These components include learning, culture, social, technology, process, and infrastructure. The LL process will be effective when the facilitators of these components align (Duffield & Whitty, 2015).

2.9.2 LLMS Enablers

Like the LL process, users of an LLMS must see that they obtain benefits from using the system. An LLMS must fulfill its intended purpose to facilitate the reuse and sharing of knowledge (Weber & Aha, 2003). The LLMS can only be successful if it is adopted and utilized by intended users; otherwise, organizations may abandon its use since value cannot be realized (Frambach & Schillewaert, 2002). Organizations must comprehend the nature of their activities to assess whether the implementation of new technological tools will be successful (Edwards et al., 2005). The needs of the organization and users will dictate the tool required to provide solutions, not vice versa (Garfield, 2017). Understanding the users' requirements is vital in selecting the appropriate digital solutions to ensure adoption. The organization should seek input from all stakeholders to prevent unnecessary adoption resistance and lessen the likelihood of LLMS failure due to misaligned objectives, non-use, or inappropriate design (Liebowitz, 2011; Weber, 2007).

Periyasamy (2022) differentiates software usage and adoption by stating that software usage is merely the interaction between users and software, whereas software adoption is the use of the software to obtain value; thus, the organization must aim to increase adoption. During the initial deployment of an LLMS within an organization, employees may face a learning curve similar to that of other enterprise software. Organizations can increase software adoption by providing employees with training and support while promoting a feedback culture (Periyasamy, 2022). Table 5 presents examples of important factors that positively impact the adoption rate of LLMS.

Ideally, the LLMS should be integrated or interoperable with existing technology within the organization (Haamann & Basten, 2019). Studies suggest that LLMS usage should be an integral element of work processes or the workflow, just like the LL process (Liebowitz, 2011;

O'Dell & Hubert, 2011; Wiewiora & Murphy, 2015). Employees must not feel that using the tool is additional work. Organizations must provide training programs, materials, and technical support to facilitate the use of LLMS (Talukder, 2012). By understanding the system requirements and essential features, the organization can increase employees' adoption and usage.

2.9.2.1 Structured Capture and Storage

A standardized, structured format for capturing lessons will enhance the LL process. Users will be well-guided during the capturing process resulting in a clearly defined lesson and appropriate actions, facilitating further LL sub-processes such as verification (Milton, 2010; Weber, Aha, et al., 2001). The stored lessons must be organized in a way that is visible, discoverable, and easily accessible by employees (Wiewiora & Murphy, 2015). Lessons should be stored and organized with metadata and indexing options based on particular work activities or processes, not projects. The usage of metadata will facilitate the retrieval of lessons (Milton, 2010). Furthermore, stored lessons in the LLMS should be concise and easily guide targeted users to the required actions (Weber, Aha, et al., 2001). However, Jeon (2009) found that an overly rigid structure did not seem to positively affect employees' contribution and proposed allowing some flexibility during the capturing and storing processes, such as flexibility in creating new lesson categories.

The lessons must be presented in an appealing and user-friendly format. A user-centric format that can show overviews and highlights, with the option to request further details, could improve the user experience. Additionally, permitting multimedia attachments, such as photographs or videos, may facilitate learning (Milton, 2010).

2.9.2.2 Pull and Push Knowledge

A practical, intelligent search engine and filter function are critical LLMS features reported in many studies (El Khatib et al., 2021; Liebowitz, 2011; Milton, 2010; Oughton, 2021; Wiewiora & Murphy, 2015). Apart from providing the users with the ability to find specific knowledge quickly, the search capability allows the action owners to be aware of any pending actions and allows the LL process owner to track metrics related to learning (Milton, 2010). The LLMS should also be able to automatically notify intended users with information concerning the LL process, such as new submissions or pending reviews (Milton, 2010). Some users may prefer the information push, while others prefer the pull; thus, the LLMS should be effective at providing both knowledge push and pull (APQC, 2021d; Thomas, 2015).

A central LLMS accessible by everyone within the organization will promote LLMS usage, collaborations between different teams, and LL reuse (Oughton, 2021). Additionally, the system should be able to connect users to subject matter experts in the case of complex and challenging situations (Abdelwhab Ali et al., 2019). Facilitating collaboration is important since collaboration is required for learning and sharing lessons (Weber, 2007). Consequently, a global multinational firm will necessitate a more advanced LLMS design with well-defined processes (Milton, 2010).

Table 5: Factors Supporting the Adoption of LLMS

Author	Factors or features that support the adoption of LLMS
Jeon (2009)	Technological success factors • Designing project-oriented system architecture • Networking all possible participants • Maintaining content integrity • Ensuring ease of interface • Allowing flexibility and expandability of the system Managerial success factors • Systematic LL process management • Promotion of end-user participation • Integration with offline LL efforts • Continuous investments in training • Repetitive requests for contributions are identified Strategic success factors • Include continuous and visible commitments from the top management • The need for long-term plans to become a knowledge-enabled organization
Milton (2010)	• A lessons-learned database, which can hold lessons from multiple projects or units • A search function within the lesson database
Liebowitz (2011)	• Capturing, sharing, and accessing lessons learned in a lesson learned information system (LLIS) must be embedded within the normal activities of the employee • Incorporating a recognition and reward system • Design a system that is capable of a proactive dissemination • Dedicate people to review, maintain, and update LLMS • There should be a unified template for entering LL • Include an excellent search capability
Wiewiora & Murphy (2015)	• User-friendly and intelligible • Search capability • Integration with project management process

Author	Factors or features that support the adoption of LLMS
APQC (2021b)	• Embedding KM directly into work processes and applications • Making the KM user experience less confusing and more intuitive • Proactively delivering or recommending knowledge to users without their having to search • Incorporating tacit knowledge and expertise, as well as content and information • Customizing the knowledge and experience to each user
Oughton (2021)	• Web-based software • User-friendly • Efficient data entry (5-10 minutes) • Drop-down menus to improve accuracy and quality • Effective search and filter function

2.9.3 People Factors Enabling Lessons Learned Programs

O'Dell and Hubert (2011) believe that the key to an effective LL program is people, not technology. They gave three reasons to support this statement:

1. The LL process is a social activity since the process requires interactions between employees.
2. People can convey complex contextual components within the lessons.
3. Connecting people is an effective way to share complex and complicated knowledge.

Knowledge reciprocity among employees is a potent facilitator of a knowledge-sharing culture (Abdelwhab Ali et al., 2019; O'Dell & Hubert, 2011). Abdelwhab Ali et al. (2019) reported that, from an individual standpoint, key factors positively impacting knowledge sharing are intention, trust, reciprocity, and motivation. This culture will build the LL program and is crucial to the program's success (O'Dell & Hubert, 2011).

In most cases, culture change results from knowledge sharing, not a precondition. Leadership must nurture this culture by engaging with employees, developing their skills, communicating with them, and rewarding them. Leadership support is known as an essential facilitator of knowledge sharing. Managers and supervisors play an important role in promoting employees' engagement in the LL process by emphasizing the value of sharing lessons and offering guidance and encouragement (Abdelwhab Ali et al., 2019). Besides facilitating the LL process, leadership support is also crucial to adopting technology such as the LLMS. Technological adoption will be stagnant in the absence of leadership support (Roberts et al., 2021; Roberts & Flin, 2020). People's adoption of an LLMS is essential to promote the LL process, creating knowledge dissemination.

For employees to learn and share their experiences, mistakes must be acceptable within the organization. This no-blame culture will foster creativity and promote new ways of work, expanding learning (Abdelwhab Ali et al., 2019). A no-blame culture starts with a no-blame process, achievable by not including the 'who' question in processes like after-action reviews (Milton, 2020a). However, even though it is designed without the blaming component, activities such as debriefing can easily pinpoint a responsible person, usually as a follow-up action (Levy, 2018). Organizations must handle these processes with care. Trust must be the foundation of the LL program (Grant, 2013).

In addition to trust, appropriate incentives must underpin the LL program (Grant, 2013). organizations could determine the impact of the LL and provide appropriate incentives by developing a systematic LL evaluation process (Jeon, 2009). Intrinsic incentives were reported to have more impact and are more sustainable than extrinsic incentives (Garfield, 2017; Milton,

2020c). By surveying KM professionals, Milton (2020c) identified that the most effective incentives to promote KM activities are:

- clear management directive for KM,
- KM embedded within normal job descriptions,
- a centrally organized recognition scheme, and
- peer recognition schemes.

Milton points out that effective incentives are incorporated as part of the work behaviors; to recognize employees for their performance. However, Garfield (2017) argues that offering employees monetary awards as part of the LL efforts might emphasize the significance of the LL process to the organization.

The majority of employees recognize the benefits of the LL process. Nonetheless, APQC (2021d) reports that it is essential to articulate the value and intent of the LL program to employees within the organization for the program to be effective. APQC believes that analyzing and showcasing business value from learning, albeit being an additional task, is the best way to empower engagement and advocacy of the LL process. This extra step demonstrates that the effort employees put into the LL process is time well spent (APQC, 2021b).

2.9.4 Governance for Lessons Learned Programs

Effective LL programs need formal governance. Governance provides organizations with a systematic framework for managing LL resources and processes (Trees & APQC, 2010). Jeon (2009) points out that the LL process needs to be managed to achieve the desired outcomes. Furthermore, without formal governance, the LL program will not be sustainable (APQC, 2020; Milton, 2010).

Milton (2010) proposes a governance framework to sustain the LL program consisting of three main elements – leadership expectation, learning system, and monitoring and measurement – as shown in Figure 4. Milton states that the three elements are "the interlocked pieces of a jigsaw" and that all three must be present for the LL program to work. Clear corporate leadership expectations will allow employees to understand their role in the LL process and what to focus on. The expectations must be clearly communicated and written down with related roles and accountabilities. This document will guide employees on who owns what LL sub-processes and who will be accountable for maintaining, monitoring, and measuring the LL process and LLMS. Structured LL sub-processes will let people know how they should be capturing, reviewing, or reusing lessons. At the same time, technology will enhance the LL process, enabling employees to store, find, or track lessons efficiently. Monitoring the LL process will assist leaders in determining whether the LL program is effective and what kind of support they must offer to maintain the LL program. Metrics that could be measured include the degree of compliance with the organization's LL standard, the amount of active LL activity, and the impact of the lessons (Milton, 2010).

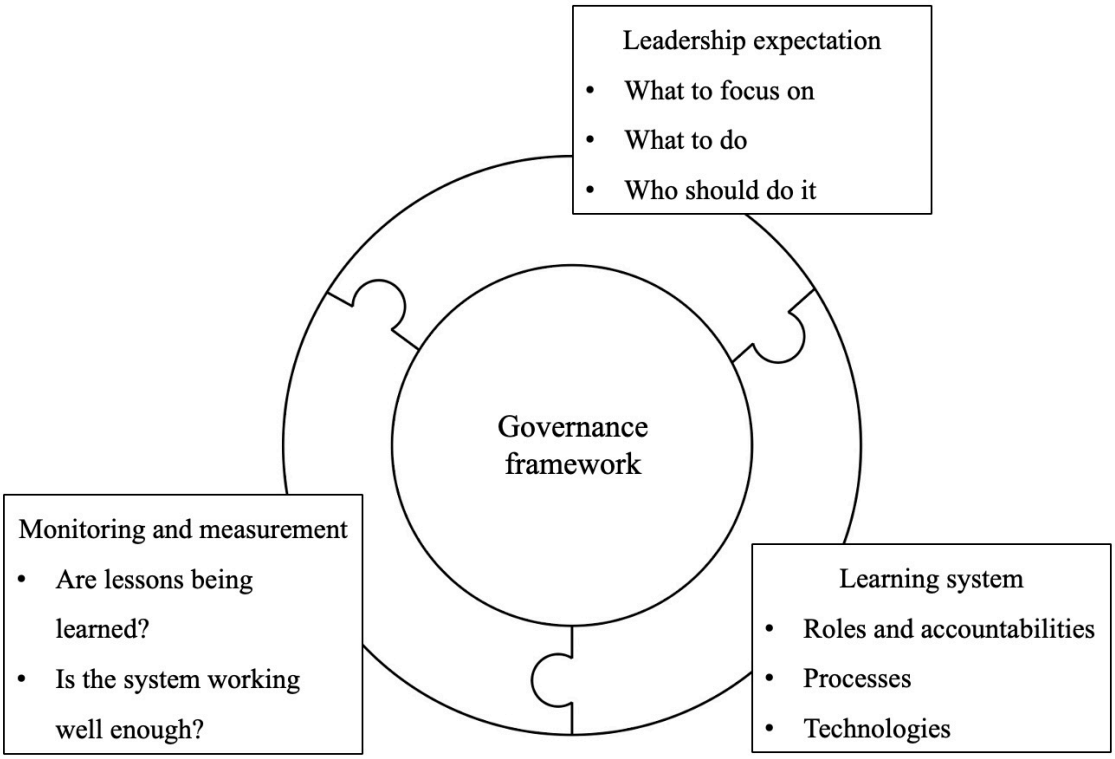

Figure 4: Lessons Learned Governance Framework (adapted from Milton, 2010)

2.10 Digital Transformation and the Future of Knowledge Management

The increasing adoption of technologies, such as cloud computing, big data, and machine learning, presents new tools and opportunities for KM through digital transformation. In turn, KM supports digital transformation with processes and capabilities and is considered a vital transformation driver (Alvarenga et al., 2020; Milton & Lambe, 2019). KM can facilitate the efficient use of digital tools to support new ways of work (Marchegiani, 2021). Milton and Lambe (2019) point out that four opportunities for KM to facilitate effective digital transformation are:

- using knowledge organization skills to manage data quality;
- discriminating the types of expertise that can be modeled by AI from those that cannot;
- creating and managing the knowledge bases;

- managing the change to new capabilities and skills in staff. (Milton & Lambe, 2019)

Both KM and digital transformation are centered on assisting organizations to remain adaptable, agile, innovative, and constantly learning. Consequently, they share similar enablers and barriers (Milton & Lambe, 2019).

In the digital era, tacit knowledge creation expands into human-computer interaction. Consequently, KM initiatives and enabling technology should be developed to allow this interaction in which knowledge is created more rapidly and dynamically (Dong & Yu, 2022).

In terms of technological impact on KM, APQC conducted a survey of KM experts in 2019 and identified five technologies in which KM programs are investing. The most popular technology from the survey is the integrated digital cloud platform, as shown in Figure 5.

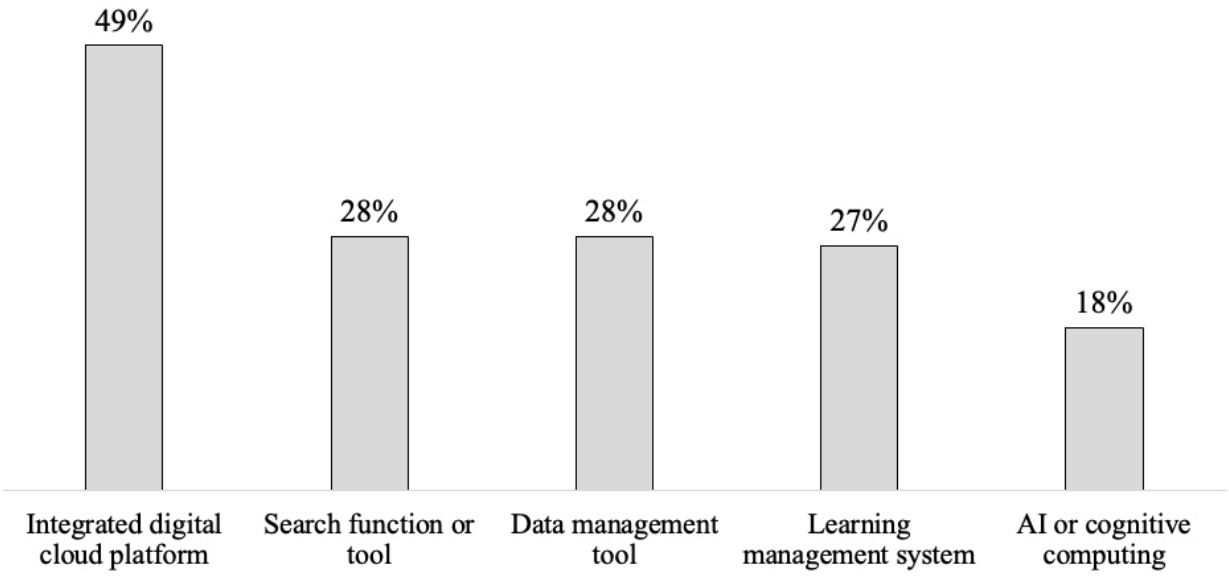

Figure 5: Technologies KM programs are investing in (adapted from APQC, 2019)

Another recent survey by APQC (2021c) indicated three technologies that KM professionals believe should be adopted now are:

- **Team collaboration and digital workplace apps**, which are cloud-based tools to help people share and discover knowledge
- **Intelligent search**, in which AI-powered search engines improve users' search experience
- **Knowledge graphs and relational databases**, which are data management approaches to help KM users uncover patterns and insights, improving knowledge flow.

The survey further identified three technologies that organizations should adopt within the next three years are:

- **AI-enabled content and recommendations**, which refers to the use of AI to proactively deliver useful knowledge to the users; helping with knowledge dissemination and assimilation
- **Robotic process automation (RPA)**, which is the automation of process workflow related to KM to increase productivity
- **AI to identify and surface expertise**, which means using AI to connect relevant stakeholders across the enterprise, reducing people's time to find experts. (APQC, 2021c)

All these technologies will change the process of KM. In the survey, half of the respondents believe that KM is gaining traction, with two-thirds expecting their organization to increase investment in KM. However, the top KM priority reported is identifying, mapping, or prioritizing critical knowledge, which refers to valuable knowledge that can provide sustainable competitive advantages that justify the cost of retention and transfer (APQC, 2021a; Harper, 2020).

Dong and Yu (2022) concur with APQC's survey that AI-enabled solutions will become ubiquitous. They point out that the rapid development of machine learning and natural language processing (NPL) will enable the automation processes of unstructured content analysis, making KM technologies, such as LLMS, more intelligent and powerful. Dong and Yu also note knowledge graph as a KM development trend. Knowledge graphs represent integrated knowledge and context via semantic metadata, providing a framework for data integration, unification, analytics, and sharing. They believe that knowledge graphs facilitate the externalization of tacit knowledge, which will help organizations realize their knowledge assets.

Another example of using digital technology to enhance KM is process mining. An emerging discipline, process mining is a discipline of data science and process science with the aim to "discover, monitor and improve processes by extracting knowledge from event logs readily available in today's systems" (van der Aalst, 2016, p. 31).

Maier and Reimer (2018) propose using process mining to partly automate the extraction of LL and best practices from event logs to reduce the effort of LL capture and reuse. By analyzing the activity patterns that contribute to problems, one can get insight into how to prevent similar problems from reoccurring. Likewise, organizations can use process mining to derive good practices from activity patterns. Additionally, Maier and Reimer believe that process mining may provide users with practical knowledge when they need it by predicting upcoming actions. However, this is only possible if there are models that can identify the sort of knowledge necessary for a specific knowledge-intensive task. Nevertheless, Davenport and Spanyi (2019) state that organizations have successfully used process mining to understand current performance status, identify improvement opportunities, and evaluate the outcome of process improvements. They

believe that process mining benefits large, complex organizations interested in internal benchmarking and process management.

Regardless of which digital solutions are deployed, in the digital era, organizations' competitive advantages are derived from knowledge assets and how they are implemented (Marchegiani, 2021). It is important to keep in mind that technology alone is not enough to drive KM (Milton & Lambe, 2019). As a result of digital transformation, the paradigm shift also introduces aspects of agile methodology and design thinking, influencing KM approaches and development (APQC, 2019). The organization's KM team must be proactive in developing new capabilities to embrace the changes and support business stakeholders toward a successful digital transformation (Trees & Harper, 2019).

3 Methodology

This chapter discusses the research design and methodology used to investigate the research question: what factors impact the adoption of an LLMS within large O&G organizations. Additionally, research quality criteria and ethical considerations are discussed.

3.1 Research Design

Implementing LL programs relies on the interactions between humans and technologies to succeed, as previously discussed. To achieve adoption and success for an LLMS, organizations must consider the social environment in which it operates, not merely see an LLMS as a technical artifact; therefore, a sociotechnical perspective is required for joint optimization of technology and people to improve organizational performance (Coakes, 2002).

Conducting the research through a constructivist paradigm was appropriate because it allows the researcher to explore people's engagement and experience with the LL process, aiding researchers in comprehending the intricacy and phenomena of LL programs (Adom, 2016; Leavy, 2017). Therefore, a qualitative research approach was suitable for this thesis because it aims to explore and understand human-related problems (Creswell & Creswell, 2018).

Qualitative methods offer an effective way to reveal the complexity of peoples' experiences and retain people's own framing of issues related to LL programs, allowing for a deeper understanding of related barriers and enablers. The flexibility of the qualitative approach allowed the researcher to accommodate unanticipated ideas from the participants and adjust the scope accordingly (Braun & Clarke, 2013).

The chosen field of research is the upstream oil and gas sector – specifically, the Wells department. This research aims to use a holistic view to explore how a highly operationally dynamic organization like the Wells department would gain employees' contributions in adopting

and sustaining LLMSs. Therefore, a large multinational O&G company was selected for this study to understand the factors impacting the adoption. Due to the limited time frame, only one company was selected. Additionally, the interdependencies between LLMS adoption factors and the cultural environment within organizations are multifaceted. Given this complexity, a multi-organization study was not suitable as a starting point for the scope of this research, which lacks supporting literature.

The case company, now referred to as Company X to preserve anonymity, is a large, integrated energy company with independent business units (BU) in several countries. Company X has over 10,000 employees operating businesses encompassing upstream, midstream, downstream, and renewable energy. Company X does not have a standardized LL program. Each BU has its own LL approach. The decentralized structure of the BUs and the difference in operation characteristics may account for this inconsistency. However, there are similarities in the nature of work between each BU. Only some BUs employ technology to assist the LL process systematically based on initial data collected. However, this technology or software is not specifically designed for the LL process.

3.2 Participants

Participants from the Wells department of Company X were selected using a purposive sampling strategy. This strategy was selected since it can facilitate the researcher's understanding of the challenge by selecting people with relevant backgrounds and expertise (Creswell & Creswell, 2018). Additionally, a purposive sampling strategy allowed the research to be within scope, focusing on the perspectives of end-users and supporting teams, not managers and senior leaders.

The participants were recruited via email with an attached summary of the research, including the question list. Each participant was requested to allocate one hour of interview time. All participants were Wells employees from four different BUs, as shown in Table 6. The diverse BU selection was attempted to reflect the different nature of operations within the same company. All participants had 8-12 years of industry experience supporting engineering and operations in various roles within the Wells department. Every participant was familiar with the LL process, but few had used technology to facilitate the process.

3.3 Data Collection

This study used semi-structured interviews for the data collection method, which is suitable for researchers trying to understand influencing factors. The semi-structured interview is the most commonly-used interview method for collecting data in which an interview guide with a set of open-ended questions will be prepared ahead of time, but the researcher does not strictly follow it. This approach was chosen because of its flexibility, allowing the participants to discuss what is important to them and the interviewer to follow up with unplanned questions (Braun & Clarke, 2013).

The researcher developed an interview guide (Appendix A) based on the research questions and literature review. The interview guide was not used as a scripted list of questions. It served as a conceptual framework to remind the researcher to cover topics related to the research questions (Yin, 2016). The researcher used the interview guide during the interviews of each participant and revised the guide based on the feedback from a pilot interview test – three revisions were made.

Table 6: List of Participants

Participant	Business Unit
1	A
2	A
3	B
4	C
5	B
6	D
7	B
8	A
9	C
10	B

The researcher conducted ten interviews with employees from the Wells department of Company X, as in Table 6. All the interviews were conducted virtually due to the difference in geographic location between the researcher and the participants. Additionally, virtual interviews can be more convenient and empowering for participants (Braun & Clarke, 2013). The virtual setting allowed the researcher to reach geographically dispersed participants from different time zones, such as North America and Asia. The researcher used Zoom and Microsoft Teams video conferencing software to conduct the interviews, with permission from participants to record. Researchers must receive permission from relevant persons before any kind of recording (Yin, 2016). Participants were informed at the outset of the interviews that their identities would be kept confidential, and the recordings would not be shared with any third parties. The interviews lasted between 45-60 minutes.

During the interview sessions, the researcher used active listening skills and paid close attention to avoid asking leading questions, closed-ended questions, and interrupting the

participants (Seidman, 2006). To prevent participants from being interrupted, the researcher took notes of topics and questions to follow up and waited for the participants to finish talking. These practices allowed the participants to fully express their own perspectives of LL programs (Yin, 2016).

Nine out of ten interviews were conducted with the video camera, allowing the researcher to interpret facial expressions and body language. The one interview without video was due to the participant's slow internet connection. Recording the video interviews can increase the quality of research. For instance, the researcher may be reminded of body language or facial expression that was not visible in a transcript (Yin, 2016). Using video recording allowed the researcher to fully focus on the conversation during the interviews, taking only notes related to the conversation without worrying about writing down the main points. The recorded interviews were automatically saved on cloud storage servers of Zoom and Microsoft Teams. These cloud servers and the researcher's personal computer are password-protected, ensuring data security. All the interview notes were in electronic form and password protected.

3.4 Data Analysis

For data analysis, this study followed the thematic analysis (TA) method popularized by Braun and Clarke (Braun & Clarke, 2013). Braun and Clarke define TA as "a method for identifying, analyzing and reporting patterns (themes) within data" (Braun & Clarke, 2006, p. 79). The TA method was selected due to its flexibility in selecting a theoretical framework, research questions, and data collection method, allowing the researcher – who has no experience in qualitative research – to acquire qualitative skills without delving into theoretical constructs (Braun & Clarke, 2013). The six-phase process of TA, according to Braun and Clarke (2006), is shown in Table 7.

Table 7: Phases of Thematic Analysis (adapted from Braun & Clarke, 2006, 2021b)

Phase	Description of the process
Phase 1: Familiarizing yourself with the dataset	Transcribing data (if necessary), reading and re-reading the data, noting down initial ideas.
Phase 2: Coding	Coding interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code.
Phase 3: Generating initial themes	Collating codes into potential themes, gathering all data relevant to each potential theme.
Phase 4: Developing and reviewing themes	Checking if the themes work in relation to the coded extracts (Level 1) and the entire data set (Level 2), generating a thematic 'map' of the analysis.
Phase 5: Refining, defining, and naming themes	Ongoing analysis to refine the specifics of each theme, and the overall story the analysis tells, generating clear definitions and names for each theme.
Phase 6: Writing up	The final opportunity for analysis. Selection of vivid, compelling extract examples, final analysis of selected extracts, relating back of the analysis to the research question and literature, producing a scholarly report of the analysis.

Braun and Clarke (2021a) later define this process as reflexive thematic analysis to capture the practice of critical reflection on the role of the researcher and the research practice and process. Additionally, they use the term to differentiate this method from other TA methods: coding reliability TA and codebook TA.

Braun and Clarke (2021b) state that reflexive TA is a recursive process with no fixed end point between phases. Therefore, the interpretive process can continue ad infinitum, unlikely to meet the popular data saturation concept. Moreover, they point out that the concept of saturation

may not be theoretically coherent with reflexive TA and suggest a pragmatic approach to determine sample size. The researcher settled on ten participants as a practical number within the time constraint of this research.

3.4.1 Phase 1: Familiarizing with the Dataset

In qualitative research, data analysis can begin even though data collection has not been completed. Data transcription is often considered part of the data analysis process since the transcription process forces the researcher to become familiar with the collected data. The transcripts must be thorough and of high quality for data analysis. For the purposes of this study, the participants' actual words mattered more than how they expressed them. The researcher ensured the anonymity of participants and the case company by anonymizing the transcripts (Braun & Clarke, 2013).

To transcribe the interviews, the researcher downloaded the interview files from the respective cloud server and uploaded them to Otter.ai (www.otter.ai), an automatic speech-to-text transcription software website. The auto-generated transcripts required correction since the software's accuracy is not 100%. The researcher used Otter's web-based editing tool to edit the transcripts manually. The tool provided the replaying of recordings and line-by-line editing. The transcripts were exported from Otter.ai as Microsoft Word documents.

The transcription process corresponds to phase one of reflexive TA. The researcher went through the data provided by the participants at least three times through interviewing, transcribing, reading, and re-reading. This data immersion allowed the researcher to be critical of the data and think through each participant's meaning, sense-making process, and assumptions (Braun & Clarke, 2021a).

3.4.2 Phase 2: Coding

The researcher used NVivo software (www.qsrinternational.com) to support the remaining phases of reflexive TA. NVivo is a qualitative data analysis software that allows the researcher to conveniently import transcripts, code data, and organize the codes, facilitating data analysis to generate themes. The researcher began the initial coding – phase two of reflexive TA – after completing four transcripts. This early start allowed the researcher to spend time understanding the process.

The coding process is a systematic process of reading the transcript and tagging all text segments relevant to the research questions with code labels. The outputs of the coding process are codes, which are the "building blocks of analysis in reflexive TA" (Braun & Clarke, 2021, p. 52) in which themes are generated. Codes are used to parse out the diversity of meanings from the data. Therefore, a text segment can have multiple codes, but a code should not have multiple meanings (Braun & Clarke, 2021a).

The researcher used an inductive approach during the coding process, focusing on the experience and perspectives of the participants (Braun & Clarke, 2021a). The transcripts were imported into NVivo as cases, where each case referred to a participant. NVivo allowed coding by highlighting a text segment and assigning it to a code. The software automatically collated the data extracts for each code corresponding to each participant, streamlining the data analysis process. The researcher created 145 initial codes from the ten transcripts. The coding approach used was complete coding, where the researcher coded "anything and everything of interest or relevance" to the research questions throughout the entire data (Braun & Clarke, 2013, p. 206). The researcher found that initial codes were too granular and renamed or merged codes with similar meanings to manage the clustering. The number of codes was reduced to 122. Data extracts in each code were

checked to ensure they represented the codes. Two rounds of coding were performed in different orders to refine and finalize the codes before moving on to the next phase (Braun & Clarke, 2021a).

3.4.3 Phase 3: Generating Initial Themes

Phase three involved generating initial themes by clustering codes with similar meanings and patterns across the dataset. In reflexive TA, it is important to differentiate a topic summary from a theme. A theme is "a pattern of shared meaning organized around a central concept," not merely codes around a topic (Braun & Clarke, 2021a, p. 77). NVivo was used to cluster the codes into initial themes. The researcher generated eight code clusters and identified shared meanings across codes within and across clusters. After the clustering process, the researcher noted that some clusters were topic summaries, lacking a unifying concept. The codes were then rearranged, and five initial themes were created. Codes irrelevant to the research questions were discarded.

3.4.4 Phase 4: Developing and Reviewing Themes

Phase four continued the development of the themes from phase three. The themes were reviewed concerning the viability of the clustering by reviewing coded data within each theme. To avoid decontextualization of data content, the original data from which the codes were generated were re-read (Braun & Clarke, 2021a). The researcher reviewed that each theme and subtheme shared a central organizing concept while being individually discrete. After reading the codes and data extract, the researcher rearranged some codes to make themes and subthemes more coherent and meaningful.

3.4.5 Phase 5: Refining, Defining, and Naming Themes

Phase five started with refining and defining themes around the central organizing concept, boundary, uniqueness, and contribution to the overall analysis of each theme (Braun & Clarke, 2021a). The researcher renamed themes to capture meanings and analytic direction while

attempting to make theme names easy to understand. During this phase, the researcher merged several subthemes that had excessive overlap.

3.4.6 Phase 6: Writing Up

The last phase involved producing the report and writing the analysis, an integral part of the analytic process for TA. The data must be analyzed and interpreted, not merely quoting or paraphrasing the data extracts (Braun & Clarke, 2021a). Sufficient evidence must be provided in the findings to support the themes while making the report concise, coherent, logical, and engaging (Braun & Clarke, 2006). The researcher reviewed data extracts and selected the ones that could support the importance and meaning of each theme. Theme names continued to be refined during this phase. Throughout the analysis write-up, the researcher reflected on whether the codes and extracts contain a shared meaning with the theme.

3.5 Research Quality

The researcher followed the reflexive TA quality criteria checklist presented by Braun and Clarke (2006) to ensure quality analysis. The criteria are categorized according to the analytical processes shown in Table 8.

The researcher ensured the correctness of the transcripts by thorough transcribing using software to assist. The transcripts were neither altered nor interpreted while transcribing, confirming their authenticity. By reviewing the transcript twice, the researcher gained confidence in its accuracy. Each dataset received equal consideration during the coding process. The researcher used complete coding and coded the entire dataset. NVivo was used to support collating data extracts, and each code was reviewed to ensure consistency between extracts and code meaning. The researcher was critical throughout the formulation of themes and performed many iterations to maintain coherence with the practices of reflexive TA.

During the analysis write-up, the researcher carefully noted checklist items seven and onwards. The researcher was cautious not to paraphrase data extracts. In addition, data extracts were consistently checked to verify that they aligned with and supported the report's structure.

3.6 Ethical Considerations

Prior to research commencement, the researcher completed the Collaborative Institutional Training Initiative (CITI) online human subjects research course for social and behavioral research investigators. The training was required to obtain approval from MIT's institutional review board (IRB) to undertake human subject research. This research received approval and was granted exempt status for the IRB review. This study involved benign behavioral interventions with adults only, and disclosing any information would not harm the participants.

As part of the recruitment email, participants received information about the purpose of the study, a general question list, and privacy and consent. The participants were informed that the interview sessions would be recorded for the sole purpose of creating transcripts and that only the researcher would have access to the recordings. The researcher guaranteed the confidentiality of the participants. This anonymity was accomplished by omitting personally identifiable information in research documents and not sharing data with any individual. Any names or information that could identify the case company were also removed. In addition, the participants were advised that no confidential information regarding their respective organizations was anticipated.

The processes of data collection and data analysis were described to each participant. The researcher clarified that participation in the study is entirely voluntary and that participants may withdraw anytime. Furthermore, the researcher advised the participants that they may refuse to answer any questions. All participants gave verbal consent prior to the interview sessions.

Table 8: A 15-point Checklist of Criteria for Good Thematic Analysis (adapted from Braun & Clarke, 2006)

Process	No.	Criteria
Transcription	1	The data have been transcribed to an appropriate level of detail, and the transcripts have been checked against the tapes for 'accuracy.'
Coding	2	Each data item has been given equal attention in the coding process.
	3	Themes have not been generated from a few vivid examples (an anecdotal approach), but instead, the coding process has been thorough, inclusive and comprehensive.
	4	All relevant extracts for each theme have been collated.
	5	Themes have been checked against each other and back to the original data set.
	6	Themes are internally coherent, consistent, and distinctive.
Analysis	7	Data have been analyzed – interpreted, made sense of – rather than just paraphrased or described.
	8	Analysis and data match each other – the extracts illustrate the analytic claims.
	9	Analysis tells a convincing and well-organized story about the data and topic.
	10	A good balance between analytic narrative and illustrative extracts is provided.
Overall	11	Enough time has been allocated to complete all phases of the analysis adequately, without rushing a phase or giving it a once-over-lightly.
Written report	12	The assumptions about, and specific approach to, thematic analysis are clearly explicated.
	13	There is a good fit between what you claim you do, and what you show you have done – i.e., described method and reported analysis are consistent.
	14	The language and concepts used in the report are consistent with the epistemological position of the analysis.
	15	The researcher is positioned as active in the research process; themes do not just 'emerge.'

4 Results and Discussions

This chapter presents the findings from the data analysis and interpretation of the findings in relation to the literature review. Five themes were generated based on the data collected from Wells employees concerning the factors impacting the adoption of an LLMS. The themes are summarized in Table 9.

Table 9: Theme Summary

Theme	Description
Theme 1: Understand Existing Barriers	There exist barriers related to the LL program that the organization should address. Otherwise, these impediments would, in turn, hinder the LLMS adoption.
Theme 2: Incorporate Enabling Processes and Governance	This theme highlights the processes and governance framework that could support the LL program and the LLMS adoption.
Theme 3: Facilitate the People Element Supporting LL Programs	The dynamics of people within the organization significantly impact the success of the LL program and LLMS. This theme is about the different facets of people's behavior and interactions.
Theme 4: Satisfy Users with Important LLMS Characteristics	Certain LLMS characteristics and features affect the LLMS adoption. Participants reported users' needs and software characteristics related to flexibility, usability, and how the LLMS must be effective for lesson discovery.
Theme 5: Improve the LL Process with an LLMS	This theme concerns how an LLMS can be used to improve the LL process. The benefit that an LLMS can provide over using commonly available software. Two subthemes discuss how the LLMS can: (1) provide a structured system of records to facilitate both collection and dissemination of LL and (2) allow for effective management of action items and changes by facilitating the knowledge workflow.

4.1 Theme 1: Understand Existing Barriers

Data collected from Wells employees revealed barriers within the Wells department of Company X concerning LL programs. If these barriers are not addressed, the organization may struggle with a low contribution to the LL program and a lack of LLMS adoption. Within this theme, four subthemes were generated to capture the nuances: difficult to manage, lack of a systematic approach, requiring too much effort, and ineffective software.

4.1.1 Difficult to Manage

Participants described LL program characteristics that suggest the program is difficult to manage. One of the most frequently cited reasons is that the lessons and their application rely on the operating context, such as the operating area and environment, rig types, equipment, and even personnel. If the lessons did not come from a similar operational setting, they would likely be irrelevant to that area. For example, Participant 1 mentioned asking for "information about similar projects, … and see what lessons learned they gathered." Similarly, Participant 2 noted the context-dependent nature of LL by stating that:

> *When we listen to some lesson learned, it does not tell us that we need to do it this way. We just take it into our consideration, and we have to do our own risk assessment again. Because different conditions, different operations, sometimes it is not the same.*

The unique character of operations is the fundamental reason that LLs within Wells are highly reliant on context. For instance, geology can vary drastically between operating areas, and different rigs have different capabilities. Participant 5 pointed out that:

> *There is a lot of stuff in Wells being pushed to … be globally more consistent on things and operations. I will say that that probably would work to some extent. But being in Wells, as we deal with Mother Nature, there is going to be things and geology and mother nature*

and different equipment that's going to drive you to do some different things and different operations as much as you try to standardize.

Additionally, the differences in geology impact the level of activity within each business unit. For example, an oil well in one area may take one week to drill and complete, whereas it can take two months in another. Participant 4 pointed out that the frequency of creating LL can vary between different BUs. Consequently, one LL program structure and content may apply to one BU and not others since the operations are highly dynamic. In addition, these distinctions prompted the BUs to conduct business differently. Therefore, each Wells function in each BU has its LL program, as confirmed by the participants. The decentralized nature of the BUs highlights the fact that an enterprise-wide LL system would be a large and complex system to manage. Furthermore, the participants pointed out that LL programs continue to change as BUs attempt to find a system design that works. This barrier may be one of the unique characteristics within the upstream O&G sector, specifically related to Wells operation.

4.1.2 Lack of a Systematic Approach

The data from every participant suggested a lack of systematic approaches as an impediment to a successful LL program. Lacking a systematic approach means no clear standards or guidelines to address each LL subprocess and no governance around the LL process. This unstructured approach to LL can create inconsistency within each subprocess, impacting the quality of LL and the value of learning. The absence of a standardized LL process may result in divergent conceptions of a LL, negatively affecting the LL program. For example, Participant 10 stated:

Depending on who you are, what your lived experiences are, you may or may not consider something a lesson learned. And so that was a challenge to really understand.

Was it a lesson learned? Had we already learned that lesson before, and we just forgot? Are you new to the business unit, and you did not know? And how, how do you build out that kind of shared learning together? I would say that's one of the challenges.

The definition of LL varies, as discussed in the literature study. Employees may therefore be misguided in the absence of alignment.

Many participants recognized that capturing lessons without a structured format can result in a poorly documented LL – lacking detail, context, and useable information. The lack of a standardized format is a key issue recognized by many authors, including Liebowitz (2011), Milton (2010), and Weber, Aha, and Becerra-Fernandez (2001). This lack of quality makes the lessons unactionable and unapplicable. For example, Participant 6 pointed out the inconsistency of LL as:

The one frustration that we do have … is that a lot of the field entered, lessons learned, maybe aren't lessons learned, but more so notes as a reminder. … So, I find a lot of the engineers maybe get frustrated with the quality of the lessons learned. So, maybe a better definition of what a lesson learned actually is, needs to be communicated.

Organizations should set clear expectations around the LL process, and some form of quality assurance should be in place. However, it might not be easy to clearly define what makes a good LL, as pointed out by Participant 4:

But just because the sky is blue when the sun is out … does that make it a good lesson learned? It's true; it's factual but is it something that's important for the situation? That's a difficult question.

For this reason, Participant 5 stated, “I think we probably ought to get rid of a third of our lessons learned. I don't know if there's enough critical thought that went in that somebody can actually use

it later on." Ensuring LL quality is critical to the perceived value of the LL program. The process should be systematically embedded into the LL process design.

The lack of clear guidelines around the LL process can result in employees neglecting to capture lessons that are minor but valuable or assumed to be common knowledge. Additionally, Participant 4 raised the point that unclear guidelines around the LL process could lead to a lack of LL ownership, such as whether the LL belongs to the engineering or the operations team. This hesitancy may lead to a loss of opportunities to capture LL or implement actions.

Although lessons have been captured, they may not be shared with others if no dissemination protocol exists. This issue can create knowledge silos, especially for a decentralized operating environment and organizational structure such as various remote drilling sites and geographically-diverse BUs. This barrier to LL adds to the finding reported by Carrillo et al. (2013) concerning silo environments created by site teams operating in remote areas with little or no interactions amongst the teams. Participant 3 illustrated this point by saying:

> *They're tracking them [lessons learned] on each one of their own individual Excel sheets. So, it's not great for sharing lessons learned, I guess, between rigs because everyone's doing their own. So, it doesn't, in my mind, it's not facilitating as good of a sharing opportunity, and it's very manual.*

Without a deliberate process, it is difficult for lessons to be shared. Many studies recognize the issue of lesson dissemination as one of the most challenging aspects of the LL process (Fry, 2021; Weber, Aha, et al., 2001; Williams, 2008).

Participants noted that, in the absence of a well-defined LL process, too much emphasis is typically focused on lesson capture instead of the applications. Participant 9 illustrated this point by stating, "we record them, and we may or may not look at them in the future, and then it just

dies." Consequently, lessons are recorded, but no value is created since nothing changes as a result. Another example was given by Participant 7:

> *The heart of it needs to be 'how does lesson get applied.' And I feel like right now, people go look at it and say, 'how is the lesson going to be entered into the program?' The question needs to be how's the lesson going to come out of the program and get into a well design or a completion, design and save us money.*

These comments are congruent with Milton (2010), who stresses that lessons identified without follow-up actions will end up in a "lessons graveyard," and nothing improves.

Without a systematic approach to LL, there will be a lack of guidance, lack of ownership, and missed opportunities to capture and share knowledge. Consequently, the LL cycle is unlikely to be completed. This finding is consistent with that of Williams (2007), Trevino and Anantatmula (2008), and Wiewiora and Murphy (2015), where all these studies reported a lack of clear guidelines and a systematic approach as a barrier to an effective LL process.

4.1.3 Requiring Too Much Effort

Another reported problem was that the LL process requires excessive workload and effort to capture, share, search for, and initiate change. The participants shared a sense that the LL process should be streamlined and made more efficient. As indicated by the participants, the highest effort required is around the capturing subprocess. Participant 9 said that:

> *So historically, with lessons learned, people feel like you need to spend a lot of time to formulate the lesson, what the lesson looks like, trying to understand what the action is, and really make sure that's clear. But that hinders progress because you spent so much time on that that you might give up, or you may not really know what it is, and you don't know how to flush it out, and you don't know yourself.*

Employees may feel they lack support and guidance. While Milton (2010) stresses that lessons need to be assigned actions for it to be considered as learned, too much upfront emphasis could lead employees to see the process as excessively time-consuming and forgo collecting LL altogether.

Another aspect of too much effort is in accessing data. About half of the participants indicated difficulties accessing captured lessons when they needed to work on assigned actions or learn from them. Participant 7 expressed an experience working with a poorly-designed system by saying that "the problem … is it was terrible to try and search. Once I put that lesson learned in, I'd never be able to find it again unless I knew the exact reference ID number of that entry." Two participants from BU A indicated they need to search for LL in files stored in shared folders, which are often unorganized, requiring time and effort to access. Furthermore, the lack of structure around systems of records could result in employees not knowing where to start looking for lessons and abandoning the learning process.

Unlike the time barriers discussed in the literature review, participants did not report a lack of time to perform LL activities. The participants viewed the learning process as part of their work responsibilities and believed that learning from experience is beneficial. However, they considered that the process should be improved to maximize employees' productivity. According to Jeon (2009), participation level will be lower when too much effort is required during lesson acquisition.

4.1.4 Ineffective Software

Participants indicated that there is an existing LL repository designed for the Wells department of every BU within Company X. However, only the Wells engineering teams have access to this LL repository. Participants explained that the system received some attention during the initial rollout but lacked current usage due to indicated reasons such as slow response time,

cumbersome to use, and lack of clear governance. As a result, each BU developed its strategy for utilizing technology to support the LL process, which differs in each BU.

Most participants described using Microsoft Excel for storing LL and how the limitations of Excel hinder the LL program's effectiveness. For example, Participant 5 discussed the limited search capability of Excel by stating, "I think a database system could provide better search opportunities for lessons learned. I think that's probably where the drawback of Excel is from using it." Similarly, Participant 6 said:

> *I know you can filter in Excel, and it's really easy to do that. But it's not entirely user-friendly for people that are maybe less familiar with Excel. ... We don't have the granularity of the search capability in Excel to properly segment the different operations that lessons learned belong to.*

These constraints led participants to believe that it is challenging to keep track of LL. Moreover, the locations of LL differed significantly between teams and BUs, resulting in poor LL dissemination since people are unaware that lessons exist. Consequently, participants raised the issue of not having an effective central LL database to store and search for LL. Participant 7 illustrated the importance of having an LLMS with a good searching capability by stating that:

> *If I spend 20 minutes just trying to search and find one usable piece of information, that's kind of sunk-in cost to me. Where in 20 minutes, I can write up an email or pick up the phone and call a colleague that may be able to get me the information I need right away. The problem implies when you run out of those colleagues, right. I mean, that's why you need a different system.*

This comment illustrated the ineffectiveness of the current system in place at Company X. According to Williams (2007), an LLMS lacking an effective search engine will become a barrier

instead of facilitating the LL process. In addition, the lack of an effective LLMS could impact the reuse of LL because it is more difficult to follow up on actions, as Participant 1 pointed out:

> *We just use the Excel file or Word file to track. We don't really have the system to track it. … So, we don't really follow up or regularly look at it, except if it is very critical to the current operation.*

Similarly, Participant 9 described how a system – currently inactive for LL – did not work out:

> *We had no ability to [perform] action. So, what we found is it still became a recording system. It became a database, which is a problem. Because if you have a database, and it doesn't allow you to move them forward, it just allows you to look back, there's no forward element.*

The LL cycle will not be completed without a means to pass actions or recommendations to responsible parties. As discussed previously, an ineffective system could create a "lessons graveyard" (Milton, 2010).

All participants believed that the LL program should be supported by capable technology to be effective. The lack of an effective information management system is one of the top five barriers to LL identified by Le et al. (2018). As Edwards et al. (2005) have pointed out, "organizations need to find the solution that is right for their context." Thus, the system needs to meet users' requirements stemming from the LL process design and the nature of work.

4.2 Theme 2: Incorporate Enabling Processes and Governance

As discussed in chapter 2, the LL program must integrate people, processes, and technology to succeed (Gorelick et al., 2004; Liebowitz, 2012). This theme concerns the processes and governance supporting the LL program, which increases the likelihood of LLMS adoption since technology alone is insufficient. In the data collected from the participants, there was a close

relationship between processes and governance. Three subthemes were generated: standardizing the LL process and governance, ensuring the validity of LL, and following through with LL.

4.2.1 Standardizing the LL Process and Governance

Theme 1 discussed participants' views concerning the lack of a systematic approach to the LL program as a whole and why it is critical to address this issue. This subtheme focuses on the initiatives to standardize the LL process and establish the LL program governance, as interpreted based on the data provided by the participants. Participants believe a systematic approach is required. For example, when Participant 6 was asked what might be done to increase the participant's contributions to the LL process, the following response was given:

> *So, a more structured approach on when we review the lessons learned, how we review them, and what information we enter would be beneficial to the business unit. So that's what I mean by a structured approach. It is just having similar frequencies and information that we gather for those lessons learned.*

This systematic approach is a method to incorporate the LL process into normal work activities; a factor widely reported to be crucial to any LL program's success (Abdelwhab Ali et al., 2019; APQC, 2021d; Liebowitz, 2011; Maier & Reimer, 2018; O'Dell & Hubert, 2011; Trees & APQC, 2010). While a structured approach is essential, Participant 6 further commented that the structure should not be overly rigid; otherwise, it could impact employees' engagement with the LL process. For example, it should not discourage employees from entering LL by strictly accepting specific criteria. Participant 8 highlighted why this might be true:

> *I think for the lessons learned module, you have to undergo action items and have to specify close-out dates and things like that. If we just have an open whiteboard to capture and share lessons learned, that would be great. … Somethings don't need action items. We just*

want to share what we learned from the project and the things that the team did good. We can capture it in here so other people can refer back to it.

However, Participant 9 argued that a true LL should lead to actions. Participant 9 pointed out that:

Every lesson learned – if it's a true lesson learned – needs that action because there should be something that we did wrong or we want to do differently. So there needs to be an action to close it out. What we tell our group is if you can't come up with an action or that action isn't evident, is it really a lesson learned?

Participant 9 acknowledged the increased effort necessary to correlate actions with lessons but suggested the establishment of processes to assist action development, such as consulting with the team in a weekly performance meeting to identify actions from a lesson. Organizations could incorporate processes and resources as part of the standard LL process design to support action identification and development and not set up barriers to knowledge flow. Levy (2018) recommends capturing lessons even though no evident change or action could be presently developed because these lessons could become valuable in the future.

Most participants recognized that the employees should be encouraged to input any lessons regardless of their impact or value, and this aspect should be embedded into the standardized process. For instance, Participant 6 said, "if we discourage people from putting the lessons learned of what they think, then we might not get valuable lessons learned for the future." Participant 9 agreed with this notion by highlighting the need to ensure actions were carried out and that "it's important for us to make sure this [lesson] gets right," even though the captured lesson had a minimal impact. Therefore, organizations should carefully design their processes to handle all levels of lessons learned.

The data collected from the participants indicated that only BU C has a standardized approach to the LL process. While BU B has a "guidance document" specific to LL – according to Participant 3, the LL process seemed to differ between each team. Participant 9 described that BU C has a weekly fleet-wide meeting to review, share, and assign actions to lessons collected. A task planner software is used to track lessons and actions, and a separate content management software is used to update the Plan of Actions (POA) with LL, ensuring lessons are actually learned. Participant 3 mentioned that BU B would implement the same approach, as was proven in BU C. Moreover, Participant 3 commented that BU B would update its guideline to LL to correspond to the new process. Regardless of the LL process design, there should be clear, uniform standards to guide employees along each subprocess within the LL cycle. This finding is consistent with Rhodes and Dawson (2013) that organizations must introduce an official LL process to guide and engage employees with each LL subprocess.

Participants indicated the importance of incorporating means and processes to connect relevant stakeholders of the LL process. Most participants agreed that an organized weekly meeting to review and share LL is beneficial and that human interaction is still an effective means to transfer knowledge. For instance, Participant 3 said, "I think you could still get value without a meeting, but I think the meeting definitely adds more value to it [LL]." Participant 3 inferred that this increasing value comes from the increased context through conversations. A well-organized meeting might help ensure that lessons are followed through by providing additional opportunities to discuss and assign action items, facilitating the learning process. Additionally, Garfield (2017) suggests that scheduling regular meetings is a way of building trust. Therefore, organizations should incorporate scheduled meetings into the LL process design.

Most participants mentioned the importance of assigning roles to manage or facilitate the LL process as part of the LL process standardization. This clear accountability could ensure that lessons are evaluated and shared and that actions are monitored and implemented. This finding is consistent with Wiewiora and Murphy's (2015) research which showed that assigning a person to manage LL entries is a method for implementing quality assurance. When asked for things that could be done to promote LL capturing, Participant 7 suggested having a dedicated person manage the LL process. Participant 7 explained that, unlike in exploration and appraisal projects, there is no designated role for tracking and managing LL in teams working on major capital projects, impacting the LL cycle's activity level. The lack of a defined role to manage LL also emphasizes the varying perceptions of LL merits. The LL process may be viewed as more important for some operations or teams and less important for others. Jeon (2009) identified in a questionnaire that employees' contribution to the LL process is higher in organizations with a devoted KM team. Jeon (2009) and Liebowitz (2011) suggest assigning roles to support busy employees with each LL subprocess, such as supporting the LL submission.

The majority of respondents acknowledged the necessity to assign personnel to train employees and maintain the technologies supporting the LL process. For example, Participant 5 said:

> *You're going to have to make sure there is the OC [Organizational Capabilities] available behind to make that system work and usable, and fix problems of that said system, and make it so people can learn it, and then plan on not changing it in three years, once they finally are able to use the system. Or at least keep it in the same user interface to make it usable.*

Participants reflected that this is true regardless of whether the technology is an LLMS or other software packages. However, this support would be more critical when introducing new software.

This subtheme aligns with the governance framework according to Milton (2010), as discussed in chapter 2. Milton argues that leadership must establish clear expectations, roles, and responsibilities; otherwise, even a well-designed LL process may not be followed. Participant 9 believed that a poorly designed system that failed might even work if there was clear governance. Participant 9 said, "we could have made it [LL database] work if we put the right structure around it, but we just didn't." According to this statement, the organization may not have recognized the value of the LL process or that specific LL database.

Most participants recognized that governance must be implemented, and the LL program must be standardized. The criticality of governance to the LL program has been widely reported. Ribiere and Calabrese (2016) state that governance is an undervalued success factor in KM, although it is crucial to the sustainability of KM. Furthermore, APQC (2020) and Milton (2010) state that formal governance is essential in sustaining LL programs. Consequently, organizations should carefully design an official LL program that fits their context and incorporate appropriate governance elements to support the program.

4.2.2 Ensuring the Validity of LL

Most participants recognized that the quality and validity of LL are crucial for LL implementation and reuse. There should be processes to ensure that the LL are verified and analyzed, per the second step in the LL cycle discussed in chapter 2. Participant 10 described an analysis example that involved asking, "Is this an actual lesson learned, like in terms of operating parameters? Is this more of like a manufacturing fault? Was there something in the design that was wrong?" A formal group discussion could support this LL analysis, as Participant 6 described, "So

the engineer that is in charge of that [project] will collect all the lessons learned … and then review that as a group with the field and office to see what we want to take action on for the next program." Participants agreed that the review process should involve credible stakeholders such as supervisors or subject matter experts to ensure alignment and eliminate friction during the LL implementation phase. Participant 3 described the process as follows:

> *They [subject matter experts] would vet it again, and they'd either recycle it or take it back completely or approve it as a lesson learned. It needs to go through that to really gain credibility. So, I think that's important.*

Similarly, Participant 2 discussed the importance of consulting subject matter experts regarding the consequences of implementing LL actions and performing risk assessments of their impact. These comments about having a team to review and validate LL are in line with those of Liebowitz (2011), Milton (2010), and Wiewiora and Murphy (2015). Moreover, Participant 1 emphasized having supervisors' approval would increase the trustworthiness of LL.

Three participants mentioned using a system of peer reviews to improve LL quality and validity. Participant 2 pointed out that the peer review approach might be suitable to streamline the LL process for lessons involving lower impact and risks rather than going through an approval process flow. Participant 7 used Amazon's product review system to illustrate how peer review might be useful for LL programs. People read Amazon reviews to learn from the lived experiences of others, which might reveal successes and failures.

In addition to gaining credibility from key stakeholders, participants believed that LL should be logical and backed by data. It is likely that LL, recommendations, or actions from lessons, could be questionable. For example, a lesson might have been reviewed by leaders in the office but may be missing a critical piece of information from the frontline, or there might be a

lack of trust between site supervisors and office leaders. When asked how the LL review process impacts the perception of LL quality, Participant 1 said:

> *It depends on the input of which supervisor … not all supervisors have good inputs. … We can try for them and see whether our best practice or the new practice is better. We can compare … numbers to see which one is better. … [but] we're not going to go right ahead and do it. We have to think first whether we should or should not do it, depending on our location capabilities and whether the people are comfortable doing it or not.*

There was a sense that frontline supervisors would not blindly implement any LL unless it made sense to them or they were forced to comply. Participant 2 said that the lessons would be more valid and likely to be adopted if it could be demonstrated that they were derived from similar operations and areas. This comment adds to the fact that LL are context-dependent, as discussed in theme 1. Consequently, providing data to back up the claims within the lessons and making the LL creation process transparent could help generate buy-ins.

The findings within this subtheme align with many studies. For example, Weber (2007) reports that verification methods should be included within a KM approach to verify knowledge artifacts. Similarly, APQC (2021b) recommends that knowledge derived via LL be reviewed by experts, and Milton (2010) believes that quality assurance is an essential success factor of a LL process. Jeon (2009) points out that ensuring lessons' validity would prevent redundant verification by end-users, increasing the level of participation. Furthermore, part of the process of ensuring LL validity is to maintain and update the content of LL (Jeon, 2009; Liebowitz, 2011).

4.2.3 Following Through with LL (Institutionalize but Keep a Record)

Organizations should be critical about how actions from lessons will be followed through and institutionalized. Every participant recognized the importance of this component within the

LL process. This aspect was separated from the subtheme of standardizing the LL process and governance since an official LL process may lack effective measures for ensuring that lessons are learned. However, any LL process design should consist of methods to assign and implement action items.

Participant 8 described that there must be alignment on how to assign and carry out LL actions. This alignment could be achieved by dedicating personnel to manage and cascade actions for the team to work on. However, the actions from the lessons should have been verified or approved. The actions may consist of ready-to-implement best practices, corrective actions, or novel processes that must be proved and validated operationally for their worth. Ensuring actions are implemented is essential since every participant recognized that LL should be institutionalized, generally in standard operating procedures (SOPs) or well designs. Participant 9 said:

> *The whole point about lessons learned … it's about taking action on something that you've learned in the moment and institutionalizing that as part of your process, whether that be tools, operations, changes in the way you do things, procedures, documents, whatever it may be, it's taken action on that. … So, it becomes part of how we do business going forward.*

Participants gave examples of how they were institutionalizing the LL. Participant 4 described the process as:

> *[Rewriting SOPs] was a good way to take the knowledge I had and get it on paper to make a lot of the things that I've thought worked pretty standard. So, in essence, the best way to get the lesson learned is to not actually have to look at them, but [to] find a way to put them into procedures.*

Another example of institutionalization was given by Participant 10:

And so, when you start looking at potential lessons learned for the future, if it's a design lesson learned, you could embed that into the initial template that you've created. And then, that becomes the only document that you can use to create your documents going forward.

Participant 10 further commented that there are some correlations between design LL and execution LL since standardizing the O&G well design program compels the operations to be carried out per that program – to a certain extent. The interdependency suggests that the LL process should integrate lessons from both engineering and operations standpoint.

This finding on taking action and institutionalizing LL is consistent with the examples of LL definitions discussed in chapter 2. Weber and Aha (2003) describe that the lesson must be reused for it to positively impact results. According to Milton (2010), things must change to consider that a lesson has been learned. Similarly, NASA (2019) recognizes that LL must provide recommendations for future tasks.

Institutionalized actions might not need to be referred to; however, there could be actions that were unsuccessful or currently unactionable but still beneficial to keep as a record. As Participant 3 said:

We would want to document, what the impact was, and what changed. And then, when you close out, you would still be able to see like the ones that actually didn't go anywhere. So, if there was a new lesson learned, and you just never actioned it, you would still be able to see those to be like, oh, somebody's already tried that, or look at it and thought it wasn't valuable. So, you're not kind of churning and redoing things that have already been done.

This remark stressed the benefit of keeping lessons in a database and incorporating processes to handle different types of action items.

Due to the uniqueness of geology in each operating area, a LL may be logically valid and beneficial for one area. However, once adopted in another, the advantages may be lost, or the LL may lead to detrimental operational impacts. There may be instances where it is no longer required to refer back to a lesson once it has been institutionalized for one area of operations. Nevertheless, if the lesson was not documented, it may not be accessible to teams in other areas where it could be beneficial. A system of records is important, especially for a decentralized organization such as Company X. Additionally, Participant 4 said:

> *There're underlying things that happened in some of these lessons learned that, if you read it later down the line, will make more sense. And it will help you make new decisions. And so, finding ways for people to go back and search for stuff or having reminders session are just good ways to get information back into people.*

This comment suggested that new knowledge could be created when the operational context changes. Certain types of projects may be seen as a one-off. However, organizations may find the need to execute those projects again in the future. The Center for Army Lessons Learned (2011) emphasizes the need to archive LL for future usage, allowing valuable knowledge to be recycled. Consequently, organizations should consider utilizing a systematic LL recording system and develop processes to disseminate those LL to target audiences throughout the enterprise. This endeavor would help ensure that employees are aware of LL, actions to be followed through, and impactful LL are institutionalized across the organization.

4.3 Theme 3: Facilitate the People Element Supporting LL Programs

The dynamics of people within the organization greatly impact the success of the LL program and LLMS adoption, as per O'Dell and Hubert's (2011) statement that people are the key to an effective LL program. This theme focuses on the different facets of people's behavior and

interactions, as discussed by the participants. Three subthemes were developed: deliberate leadership, inspire and motivate, and nurture supporting cultures.

4.3.1 Deliberate Leadership

Leadership support is widely recognized as an important success factor for KM and LL programs (Carrillo, 2004; Davenport & Prusak, 1998; Weber, Breslow, et al., 2001). This subtheme explores leadership traits supporting the LL program from the perspectives of Wells employees within the upstream O&G sector. Participants highlighted several ways leadership might offer support to promote the LL program and LLMS adoption.

Most participants emphasized the significance of leaders being open to ideas and supportive during the learning process, especially during defining and implementing actions resulting from a lesson. Participant 1 said, “at least try to listen, and if it's [improvement idea from a lesson] not good, [supervisors] give us feedback. Don't say no right away. Try to listen first.” Similarly, Participant 2 said:

> *If the crew requested to do this [implement an action] with very solid and useful reasons, … [leaders] need to make sure it happens. Or if it is not possible, there should be some very good answers to explain. So, if there's some lesson learned that action items were brought up, and nothing happens, … it [the LL program] will not sustain.*

This openness promotes a culture of candor which could support a knowledge-sharing culture, not only hierarchical but also lateral transparency among peers. When asked to comment about ways to facilitate knowledge-sharing cultures, Participant 10 said: “I think it depends on your leadership and what type of atmosphere they promote.” This comment was not unexpected since it is widely known that leaders strongly influence organizational cultures.

Participant 9 suggested that the open and supportive behaviors can also extend to facilitate the deployment of a new LLMS. Participant 9 described how the current LL process was successfully implemented: “the leaderships are very willing to just try things. And if it fails, move on. If it works, then add it.” By adopting an agile mindset, leaders can adapt the LL process to the organizational culture and structure. Moreover, participants suggested that if leaders lead by example and engage in the LL process, utilizing specified tools to capture, share, and reuse lessons, this might promote both the LL process and the LLMS adoption. Garfield (2017) has supported this finding and suggested that leaders should lead by example and learn the tools and processes to instill desired behaviors. This practice will lay the foundation for KM, including its components, such as the LL program.

Another leadership aspect discussed by the participants was mandating an official LL program – defining the processes, roles, and technology to be used. This official LL program is part of the required LL process standardization effort discussed in theme 1. Leaders should set clear expectations for the employees and ensure they are accountable. Participant 7 suggested making the LL process an optional requirement may not be successful because “if you ask someone who's already busy like, hey, there's also this thing, it's optional. If you can go do it, go do it. People aren't going to do it.” Similarly, Participant 5 commented on leadership’s impact when introducing a new system and said, “it's got to be forced to start with. Nobody's going to go out and use the new … tool the first time until they have to.” This sense may have only been true when the value of the LL program has not been demonstrated to the employees and no other incentive or motivation exists; thus, leadership’s expectations become critical. A response given by Participant 9 emphasized the significance of leadership as:

The tool isn't really the big thing. The tools are just an enabler of that process. If you have superintendents and leaders … who don't support taking action on the lessons, we may talk about them, but then no one really follows through on it. It doesn't matter what tools you've got, right?

This aspect may be challenging if the LL initiative was implemented bottom-up. Hence, participants noted that getting buy-in from the leadership team is important to gain the right level of support. For leaders to be bought in, they should see value in the LL program and the reasons for pursuing its success. Garfield (2017) recommends that to get senior leaders on board and motivated, the implementation team should tell stories, make the business case, and sell the benefits.

4.3.2 Inspire and Motivate

This subtheme concerns how organizations could inspire and motivate employees to engage more actively with the LL program. Participants in this study indicated that factors impacting their inspirations and motivations include perceived benefits of the LL program, intrinsic incentives, and extrinsic rewards.

Participants indicated the perceived benefits as one of the most influential aspects of motivations and incentives to contribute to the LL program. Participants pointed out that people should be able to perceive that their engagement in the LL program is worthwhile and impactful. The benefits might be from successfully preventing relearning by institutionalizing LL into procedures or increased productivity when using a well-designed LLMS. Participant 4 gave an example of how LL can reduce the learning curve:

The good things will get recycled back into future documents. That's what drove a lot of the process and operational improvements. … With all of that iteration of improvements, it really reduced the learning curve for people working in different areas.

These improvement iterations indicated that some changes were made, leading to desirable results. Participant 3 said that employees need to be inspired by these changes:

If you're putting them [lessons] in, and you don't see any impact, you're not going to put it in because there is no value. So, to actually see that this [action item] is being actioned, I saw that it was closed out, or we did update it, people would be like, okay, cool. Like these are actually being translated to real valuable things. That's another reason you would get buy-in.

Participant 3 indicated that if people could see that actions from LL are being tracked and that their work was useful, it would encourage people to capture and share more lessons.

The perception of benefits also impacts employees' motivations to adopt technologies. If the LLMS meets users' requirements, provides beneficial outcomes, and demonstrates its benefits, employees would be motivated to adopt the LMS. Participant 7 said, "I think the key is, it has to pay off." This comment came up when the discussion was around a poorly-designed software for capturing LL. Participant 7 explained that there were only inputs but no outputs from the system. Therefore, there were no incentives to use the system, people could not see the benefits, and adoption declined. Participant 2 commented, "it doesn't matter whether we advertise that this [LLMS] is going to work. If they [employees] don't see the benefit by themselves, it will be very difficult [to gain adoption]." This remark explained one of the reasons behind the non-adoption of the LL repository in Company X.

The perceived benefits of the LL process and LLMS are crucial to gaining employees' commitment. This finding was also reported by Atwood (2002) and Weber (2007), who stressed that people within the organization must comprehend the benefits of the LL program. To support this perception, a process to monitor and measure the LL program's performance should be in place to maintain employees' enthusiasm. APQC (2021d) asserts that this monitoring is crucial to assess and fix any barriers. Similarly, Milton (2010) suggests this monitoring will assist leaders in determining and providing appropriate support. This support from the organization would help make the LL program more effective and demonstrate its benefit. Thus, employees will likely be motivated to use the LLMS and continue engaging with the LL program.

By comprehending the benefits of the LL program, employees are motivated to be better, to meet and exceed targets. Most participants provided several examples alluding to a desire to improve. For instance, Participant 6 said:

> *We capture lessons learned to make our operations more efficient, safer, and anything that might improve cycle time for the future. … As a business unit, we have to meet our metrics that we set out at the beginning of the year. So, if we don't do lessons learned, there's less of a chance to meet those metrics.*

Similarly, Participant 10 said, "I think we have to do it [LL] in order to be efficient. Otherwise, we're just going to continue to repeat the same mistakes." Another example of the desire to improve by capturing LL was cited by Participant 8 as:

> *[We capture LL] so we don't forget. Like, when we share it, and we capture it, and we have a system of record, we know that it's there. … then we can refer back to our system of record and search it again. … It helped make the job smoother, and also, when people*

outside the team ask questions, I can answer immediately and don't need to ask other people again.

Overall, participants recognized that LL could improve performance, prevent relearning, reduce the learning curve, provide means for effective communication, and support decision making. These benefits then become their incentives and motivations to contribute to the LL program. Interestingly, none of the participants mentioned the need to quantify the value of LL, a factor regarded as important by many, such as Caldas et al. (2009). All participants indicated that they recognized the value of LL regardless.

There was also a sense of personal accomplishment and pride as motivations. Participant 4 said the motivation comes from "personal pride of working, like if you feel you can make something better then why not?" Similarly, Participant 1 said, "to find out what is better for the operation or overall, for all the teams. … [making people] feel proud about the finding." In addition to personal gain, participants also stated that capturing and sharing LL is about helping others, whether supervisors or peers. Participant 2 said, "I don't want people to get messed up like myself. So, if we were facing a problem, we don't want our friends to face the same problem. That's why we have to share [LL] most of the time." Participant 10 described a motivation to help others to not feel lost when starting a new role or transferring to a new BU. Participant 10 explained that the LL program could be an effective way to transfer critical knowledge, saving people's time in "looking and searching for documents and processes." This motivation statement was instilled from personal experience and the desire to support others.

Some participants indicated that they are motivated to engage with the LL program when there is a clear top-down direction or goal. For example, Participant 1 said, "I think a good incentive is the support of our supervisor." With a clear direction from the organization, it is more

likely that employees would receive support. This comment shows the interconnectedness between leadership and employees' motivations which impacts the success of a LL program. In addition, having clear guidance from management and the organization impacts LLMS adoption. For instance, if several technologies were used to support the LL process, such as one team using Excel and another using an LLMS, it becomes difficult for employees to focus and understand the organizational intent and strategy. Participant 10 said, "I think it goes back to the strategy conversation as well. If you don't have a true guiding light that's driving your metrics. Everyone's initiatives are going to be the most important, and how do you prioritize those?" This remark was made in relation to organizations that continue to implement new initiatives without eliminating existing ones, resulting in a lack of focus and causing hesitation to work in a particular system. Participant 6 commented that an incentive to use an LLMS would be for engineering managers of each BU to agree on a system to be implemented. This alignment would provide employees with clear direction and expectations while minimizing distractions and rework. Studies have reported that organizations must have well-defined objectives and strategies for LL programs (Garfield, 2017; Trees & APQC, 2010).

The discussions with the participants leaned more towards intrinsic motivations and incentives. However, participants mentioned two aspects of extrinsic motivations: rewards and recognition. Participant 9's perspective around monetary rewards was:

> *There's a good point on like, money speaks, right? … If you say to someone every time you close out an action, I'll give you $25, you would be sure that people will close out actions quicker than they did before. So, if your question is, would monetary rewards work? Yes. Would we do it as a business? Not sure. But I think it would work.*

The majority of participants argued that financial incentives are somewhat effective. Participant 3 gave an example of a performance improvement initiative – not a LL program – within Company X that had monetary rewards for impactful submissions. Participant 3 said, "Once they started giving out rewards, and the rewards were tiered based on the impact on time and value, like cost value, people were just putting everything they could think of into that system." However, participants pointed out that monetary incentives are not sustainable. Participant 2 said, "it might need to start with the reward and incentive. And make people see the result of the system. Then once they buy in, they will commit to sharing." Likewise, Participant 6 said, "general incentives work. But I think those are very temporary." This finding is consistent with that of Carrillo (2004), Liebowitz (2011), and Milton (2020c), where extrinsic rewards were remarked as short-term and less powerful.

Another form of extrinsic reward mentioned by the participants was gaining recognition from peers or supervisors. Participant 1 said, "if the supervisors give us some recognition or something when the team comes up with good information for improvement lessons learned, … that would be good." Similarly, Participant 7 said, "Maybe if you put a lesson learned in and then someone uses it, and they click a button that said, they used it and it worked, you get something you get recognition from the company." The comments from the participants suggested that monetary rewards and recognitions work to a certain extent, especially when the organization is attempting to start new initiatives and instill new work behaviors.

Depending on their culture, organizations may need to determine whether or not to offer extrinsic rewards. Carrillo (2004) argues that there are controversies over whether to have incentives and rewards for contributing to the LL program and whether they should be monetary or non-monetary. Garfield (2017) acknowledges this divergent school of thought but suggests that

it is worthwhile to test various incentive and reward schemes to verify their suitability and whether or not they would encourage desirable behaviors. Milton and Lambe (2019) believe that KM must be linked to rewards and recognition for it to be part of employees' behaviors and culture. Organizations should identify the types of incentives, either intrinsic or extrinsic, to inspire and motivate people to engage with the LL program.

4.3.3 Nurture Supporting Cultures

Culture is crucial to every kind of initiative within an organization. However, prominent or unique organizational cultures could greatly facilitate LL programs. Data collected from the participants indicated that organizations should foster a culture where employees have accountability and ownership, agree with the LL process, are influenced by the right behavior, and are open and willing to share.

The LL process within Company X relied on employees' accountability to follow through with each subprocess. If employees do not take ownership over the LL process, there is a chance that lessons may not be captured or captured but not learned. Participant 9 said:

> *People need to feel ownership of the action and think, if I do this, this will make operations better next time. ...people come into this [LL] meeting not knowing ... that they may have extra action on top of their day jobs. ... they come out of this meeting and go, oh, man, I've got something extra to do. But they could easily not do it, and it may fall through the cracks, and it may be missed.*

This ownership is crucial for completing the learning cycle since they must see the actions through. However, ownership is required for every LL subprocess. Employees should feel accountable for capturing, sharing, and learning lessons. An instance of this accountability was given by Participant 1, saying: "It is a part of my job to capture lessons learned and work on improvement

opportunities." This ownership relates to having a structured process with defined process ownership and setting clear expectations.

Organizations should get agreement from their employees concerning the LL program. Employees should agree with the process they are working on; as Participant 4 said, "You don't want to have to work on things that you don't agree with." The LL process will be seen as part of the work routine when there is alignment. For example, Participant 8 described that capturing and sharing LL is not seen as additional work but as something that must be done regardless. Similarly, Participant 6 said, "we're supposed to be doing that [engaging with the LL program] anyway. So theoretically, it shouldn't increase our workload beyond what we should have been assigned." Another example from Participant 9: "and once it became part of the way we work, we [LL process implementation team] were able to step back, and now we are completely hands-free, and now it's just part of our business." These data extract examples show the importance of ensuring employees see LL activities as part of their day-to-day work. This finding is in line with previous studies (Abdelwhab Ali et al., 2019; APQC, 2021d; Liebowitz, 2011; Maier & Reimer, 2018; O'Dell & Hubert, 2011; Trees & APQC, 2010).

Alignment is not only required at the individual level. Teams and BUs should be aligned on the LL process if the LL program is to be rolled out or modified. Each team within a BU should have an agreement on the LL process design. If the program is to be designed for enterprise-wide use, each BU should come to an agreement prior to the rollout. Participant 7 gave an illustrative point on how misalignment could be an issue:

> *It feels like no one's talking to each other. And when they do talk to each other about, hey, we're making this platform, you guys should get in on this. People will say, well, we're also*

making a platform, and ours is very specific to what we need, and it just works better than what you're proposing. So, let's just do ours separately.

Similarly, Participant 10 described that if two entities within Company X have different plans and those plans do not match, it is unlikely that they will want to share the same product. As previously noted, this misalignment may also negatively influence employees' motivation to participate in the LL process.

Another important cultural characteristic to foster the LL program is the openness and willingness to receive and share knowledge and LL. When asked whether the LL capturing process impacts workload, Participant 2 said, "If you are willing to share, you will find time to put it in the system, right?" This willingness has to be supported by the right working environment. For example, Participant 10 said: "My best experiences that I've probably ever had in terms of culture would be [in BU A and C] because they really fostered that idea of let's learn from each other." Employees should feel they are supporting one another, not competing for performance. Additionally, they should feel that the LL program is a learning process without repercussions and blame for mistakes. Participant 1 said:

When we encounter a supervisor that's good, that sees [mistakes as] an opportunity for improvement, we tend to share more with him or with her than the ones that will be coming back at us with those mistakes. If the culture of the company is more towards like open-minded culture, we will share more, I think.

This no-blame culture is consistent with studies such as Newell et al. (2006) and Milton (2020a). Milton points out that a no-blame culture starts with a no-blame process. Therefore, organizations should evaluate their processes, environment, and values to ensure blame-free work activities.

The organizational structure should influence the right learning behaviors. Participant 10 gave an example of how the structure could influence an undesirable mindset:

> *I think it's just a factor of how do you create a leadership performance area where you're compensated in such a way that you're promoting that transparency between your teammates. And like some of that is the way that our [employees rating system] structure is set up, it is not very fostering to that type of attitude. Because it's like, why would I tell [my peers] anything if it's going to make him look better than me? I'm going to keep it to myself.*

Another example of how the organizational structure was influencing detrimental-learning behaviors is from Participant 9:

> *The culture when I first came here three years ago, we had like a, here's the rig of the month. We had then 20 rigs, and those 20 rigs were in five areas, so four rigs per area. So those four rigs in each area may have spoken to each other because they were all drilling the same designs in the same area … but they wouldn't speak to rigs outside that area, and they wouldn't overly speak to rigs in the area because everybody wanted to be the best. But what that stifled was us winning as a fleet right, us winning as a business. So, we got rid of that.*

Once the proper structure to influence learning behaviors are in place, it comes down to individual factors of trust and good relationship. Instilling desirable culture is difficult and time-consuming. However, O'Dell and Hubert (2011) state that "culture change is more often a consequence of knowledge sharing than an antecedent to it" (p.129). Consequently, organizations should endeavor to understand their employees' current natural behaviors and identify the necessary adjustments regarding structure, processes, and technology to foster cultures that facilitate the LL program.

4.4 Theme 4: Satisfy Users with Important LLMS Characteristics

This theme focuses on characteristics and features that the LLMS should have for it to satisfy Wells employees and increase the adoption rate. Three subthemes were generated from the data: the need for flexibility, usability is key, and the right information at the right time. Participants suggested important features under each characteristic that meets their requirements.

4.4.1 The Need for Flexibility

Data from the participants suggested that users' requirements may differ even within the same BU due to the uniqueness of the operations. An LLMS with a flexible software architecture would allow BUs to adapt the software's usability to address users' needs without changing its structure (Karlsen, 2019). Participants indicated the need for LLMS customizability to fit varying requirements. According to Participant 3, this customizability metric had a weight of 40% on the LL tool selection criteria.

In addition, flexibility enables scalability, which is a factor to address, as pointed out by Participant 4:

> *I think there are a lot of ways that we can go about creating something. ... It needs to be methodical to be able to adapt. I mean, a lot of stuff we build it's not scalable. It's just whether it works for what we wanted it to work for.*

This flexibility in scale would allow for the LLMS to be deployed for enterprise-wide use, which most participants believed would provide the greatest benefits. For example, Participant 8 said, "I think enterprise-wide would be great. Because sometimes we refer to other practice for other BUs as well." Additionally, Participant 3 said, "I think the end goal is … to be able to look at every POA and all business units and SOP holistically to capture those lessons learned. That's the future desired state." An enterprise-wide LLMS would open up the possibility of creating new knowledge

by connecting employees with various lessons and practices. However, Participant 9 shared concerns regarding enterprise-wide systems:

> *It just becomes too big to manage in an appropriate fashion. ... But would it be a good thing to be at a wider level? It would, but when I look at how many items come up that apply cross-functionally, less than 1%.*

Participant 9 pointed out that the LL program could instead be used between Wells function of different BUs with the same asset class level, meaning similar operations but not necessarily the same well designs. Participant 9 said, "We're not there yet, but that's where we'll win. When there's something that applies at an asset class level in Wells, I think that's where we can win, and that's the piece that's missing currently." Nonetheless, flexible software architecture is necessary for any degree of lesson sharing, be it enterprise-wide, business unit-wide, or asset class-specific.

In addition to impacting scalability, flexibility can accommodate changing LL processes within Company X, as indicated by the participants. Participant 10 said, "We have these initiatives around lessons learned that changed so much. We've changed processes within lessons learned three times in three years, and we're currently in the process of changing it again." The flexibility will allow customization and configuration changes to adapt to new processes. This finding aligns with Jeon (2009), who reports that the LLMS initial design should consider future expansion and modification. To be prepared for this adaptability, Karlsen (2019) remarks that organizations must invest in designing good software architecture, especially for large-scale, business-critical systems.

4.4.2 Usability is Key

Usability refers to the ease with which a user may efficiently and satisfactorily complete the intended task (Bass et al., 2021). Participants provided several comments related to the

usability of an LLMS, which are user-friendliness, fast response time, connectivity, AI assistance, and integrated software.

The most cited issue related to the LLMS was that it should be user-friendly. An LLMS should have a good user interface and require low effort for each LL subprocess. Participant 3 shared that BU B put user-friendliness and customizability as the highest priority on its LL tools selection criteria with a 40% weighted score. In comparison, other factors received 20% or less. Participants from other BUs also agreed that user-friendliness is key in increasing LLMS adoption and fostering the LL program. For instance, Participant 8 said, "I think if we have a system, maybe an existing system or a new system, that is easier to use, then maybe we can do [capture LL] more." Likewise, Participant 1 said, "If you can make it user-friendly and easy to use, easy to read, people will use it, definitely." Participant 4 described that "a good user interface, that's not burdening on the people using it, would be very helpful in capturing lessons learned. … a good user interface has minimal clicking. A good concentration of information per page." These comments suggested that the participants are open and eager to use an LLMS for LL activities. The user-friendliness would help the LLMS deployment team reduce resistance to changes, generate buy-ins, and present the value of using the LLMS. To ensure the LLMS's user-friendliness, Liebowitz (2011) addresses the importance of involving users during the design or development of an LLMS to prevent inadequate design and misalignment.

A component of user-friendliness is a fast response time; Participant 8 said, "I think it being slow is the most painful point for me." Furthermore, some participants noted that the LLMS should be able to accommodate users at remote operation sites with low-speed or unavailable internet connections. Participant 3 described the scenario as:

> *So, them [field supervisors] trying to connect, ensure they have connectivity, hotspot into their phone, just to enter in lessons learned, seemed a little bit ridiculous; where they can enter in an offline Excel sheet, send that to the operations engineer where they can organize those that are beneficial.*

Participant 3 remarked that this is one of the reasons why Excel is commonly used to store LL. This connectivity factor is essential since LL often originates from the frontline. The LLMS should support offline functionality to ensure the continuity of the LL process.

Participants mentioned that artificial intelligence (AI) should be incorporated into the LLMS to improve user experience and streamline the LL process. This AI component should facilitate seamless human-computer interaction. For example, Participant 4 defined the desired AI assistance as follows:

> *It's smart enough to know what you're supposed to be doing. That way, when it's time for you to do something, it's already ready, like it's working with you, and it's not an app to just input information.*

Participant 4 said further that this form of assistance is now prevalent in "good web apps." This response aligns with what Weber, Aha, and Becerra-Fernandez (2001) call interactive LL collection, where users are guided through the LL elicitation process. Additionally, AI could allow for effective change management, such as automatically updating procedures by linking the LLMS with other software. The automation would significantly reduce the user effort required, likely improving the user experience. This topic will be further discussed in theme 5.

Another factor that would increase usability was reported as the integration of an LLMS into software normally required for daily work or existing systems. Participant 8 said, "I think it will be good if that system can be embedded in the current system that we have." This comment

was raised from the concern that introducing a new standalone system would receive some pushback or negative perception, such as “oh, another system, a new system again,” as in Participant 8’s own words. Another perspective regarding software integration was given by Participant 4. Participant 4 illustrated the current situation and emphasized the desired state as:

> *I think … making it easier to do and more integrated into everyday work. Right now, everything's kind of separate and siloed. You got to do these reports, you got to create these POA, you make this PowerPoint, but if you worked in a kind of one system, and that one system … was your interface to put all your information in as you're going along, like, we had a really good lesson learned today, you find a way to put that in, you link it to a time and that time linkage creates a link to so many other different things.*

This integration aspect of the LLMS is more than just embedding the LLMS usage into daily activities. The organization might begin by considering incorporating the LLMS into the most commonly used software, as several applications are likely necessary for daily work. Additionally, organizations may look into using software integration solutions currently available in the market.

Weber, Aha, and Becerra-Fernandez (2001) recognized the issue with LL systems being a standalone architecture and recommended integrating LLMS into enterprise software to enhance the LL process by allowing for proactive lesson dissemination with the help of AI. In 2001, they reported barriers preventing the development of intelligent LLMS as hardware, programming languages, platforms, and AI technologies. With the current advance in technology and AI, such intelligent LLMS is likely possible and less costly to design and develop. Consequently, organizations should be able to develop or acquire an LLMS with the desired usability to satisfy users’ needs.

4.4.3 The Right Information at the Right Time

This subtheme concerns the users' need to receive desired knowledge. Participants indicated the need for an effective search engine and the ability to filter lessons. An AI-driven or intelligent search was a highly sort-after feature indicated by the participants. This search issue has been identified in theme 1 as an existing barrier related to the ineffectiveness of current systems. To address this issue, Participant 1 said, "it should be as easy as Google. Like when you search for something, it appears." Participant 7 illustrated how this "search like google" is important:

> *Let's say I needed a lesson learned about a gravel pack system [a type of well completion system], and you type in gravel pack. You'd get like 1,000 results for lessons learned about gravel packs, and they'd be from all over the world, and they would be all kinds of issues. Some related to gravel pack, some that just, maybe, had gravel in them, or pack in them … like our search functionality was not nearly as smart as you would think [of] something like Google, right? It wasn't smart enough to know that I was looking for something related to completions.*

Similarly, Participant 4 said:

> *I'm all about technology and having the information available when you need it. … like having something that's working with you to show the information that you may need. … I've completely sold my soul to Google because they give me the information that I need when I need it. So that same thing with lessons learned is how do you make delivery of information that you need better.*

This need for a great search engine aligns with many studies (El Khatib et al., 2021; Liebowitz, 2011; Milton, 2010; Oughton, 2021; Wiewiora & Murphy, 2015). Liebowitz (2011) points out that the LLMS would not be used if lessons are difficult to search for.

In addition to an effective search engine, participants indicated that a feature supporting lesson discovery is the ability to filter and query for specific LL. This feature within the system's user interface will allow users to explore specific LL originating from a BU, area, or topic related to the operations. Participant 6 explained why filtering is essential:

> *I find that as we move down the list of action items, we're very infrequently reviewing lessons learned that were completed previously or that were entered previously. So, something that would be more easily in terms of a user interface to filter based on the operation, I think, would be more valuable.*

Participant 9 described how BU C is using a tool to tag and filter LL:

> *[The tool] allows us to tag specific labels of what this lesson belongs to ... which then allows us in the system to be able to filter by specific lessons that allow us to make sure we're closing out actions.*

Likewise, Participant 3 explained the purpose of the filter function:

> *You can filter and search by those tags. So, if it was a certain area or a certain rig, you just search by that, and you can look at every hole section by whatever rig or field, and you can look it up and then find all those lessons learned that way. That would be the intent.*

The filter function allows employees to efficiently refer to specific LL, which could be helpful for LL activities such as the before-action reviews. This finding aligns with that of Oughton (2021), who reported effective search and filter function as an enabling factor of an LLMS.

Facilitating efficient lesson discovery would reinforce the desire to search for knowledge and LL, as indicated by the participants. For instance, Participant 1 said:

> *If I want to know how to improve the tripping speed [speed of pulling the drill string out of a wellbore], I should be able to go to the library and look at how many items are there that have been done to improve the tripping speed. Like a library [of LL] that I can look into like, oh, this one I can use, this one I've done before, this one I can make a trial.*

This statement stressed the need for organizations to give employees the resources they need to succeed. According to Levy (2018), employees generally want to perform well, and organizations should provide means to motivate users to search for knowledge. Therefore, an LLMS that can provide employees with the information that they want, when they want it, will likely receive adoption. This finding aligns with the handbook by the Center of Army Lessons Learned (2011), which notes that the LL sharing strategy is "to get the right information to the right person at the right time" (p.7). However, the context within this subtheme includes other aspects besides sharing LL.

4.5 Theme 5: Improve the LL Process with an LLMS

Data collected from the Wells employees indicated that a well-designed LLMS could be used to streamline the LL process and demonstrate its value. Organizations might enhance their LL program by adopting an appropriate LLMS. Two subthemes discuss how the LLMS can: (1) provide a structured system of records to facilitate both collection and dissemination of LL and (2) be used to effectively manage action and changes by facilitating the workflow.

4.5.1 Provide a Structured System of Records

Participants suggested that the LLMS should be designed to support a standardized lesson capture format to allow for a structured database accessible by everyone in the organization. This

subtheme theme addresses the lack of a systematic approach barrier discussed in theme 1. The LLMS should be used to address this barrier by carefully designing the lesson capturing format. For instance, Participant 5 said:

> *I personally think it's better not to write down a lesson learned if you can't articulate what's behind it. … I think if it can't yield who, what, when, where, and why, when you capture it, don't capture it. … You need to be putting in good lessons learned. If you're going to be using the database system, you really need to apply some information to it. And information needs to be contextualized to what was going on at the time.*

This statement aligns with an issue that Weber, Breslow, and Sandhu (2001) reported: "humans communicate their experiences in natural language" (p.2), which might lead to misinterpretation. They proposed using a standardized format that uses AI to guide the user throughout the submission process, to ensure quality lessons are submitted without unnecessary context. Furthermore, Participant 5's opinion is consistent with Levy (2018) and Milton (2010). They have emphasized the importance of documenting adequate context for each lesson entry to be understood without prior knowledge of the project.

Some participants suggested that the LLMS should allow for files attachment as part of the capturing process to guarantee that adequate information or data is collected. This comment is similar to that of Milton (2010), who suggests using multimedia to better convey knowledge. Additionally, participants remarked that everyone in the organization should have access to the LLMS to submit any lessons and search for knowledge and that the LLMS should enhance the visibility of LL. Abdelwhab Ali et al. (2019) have reported that providing employees access to the knowledge database facilitates the exploration and sharing of knowledge.

A structured system of records should allow people to trace back to any LL implemented into processes and procedures. People should be able to understand the origin of any LL. In addition to incorporating LL into procedures, Participant 4 pointed out that:

> *You could use lessons learned like citations. … When you add a database, the lessons learned, and you can cite a lesson learned that caused you to make this procedure that way. And that way, as people are learning, they can say, where did this come from? You can always go back and look at it. … You almost put markers within the document that say this is where it came from. … Having markers and tags to create more of a data structure around the lesson would probably make them more useful.*

This reference to lessons' origin could be especially useful for employees outside of that BU to learn and understand best practices. The tags and metadata provide a structured database, allowing the submitted lessons to be categorized and prioritized, processes indicated as necessary by the participants.

Participants hinted at the need for prioritization by saying, "it depends on how critical the action item is" – according to Participant 1; "you look at the consequent" – according to Participant 2; and "a big [LL] is something that impact design that has to involve other people, global team, or the things that change our current practice" – according to Participant 8. This prioritization suggested that lessons and their corresponding actions may need to be treated differently based on their importance.

This finding is consistent with many studies which recognize standardized format and indexing as an essential component for any form of LL repository (Dülgerler & Negri, 2016; Rowe & Sikes, 2006; Weber, Aha, et al., 2001; White & Cohan, 2016). A well-designed LLMS would be a structured system of records that allows for LL to be discovered by search and filters, desirable

functions indicated by participants discussed in theme 4. This structure could facilitate lesson discovery and support effective action and change management. According to Jeon (2009), only a well-structured system could serve the various knowledge requirements of employees.

4.5.2 Allow for Effective Action and Change Management

A well-designed LLMS could allow for effective lesson management such as action assignment, approval process flow, LL review, and LL dissemination. These facets are crucial for preventing the LLMS from devolving into a database where no lessons are learned.

Part of lesson discovery is ensuring actions are closed out, and lessons are learned. Participants suggested that the LLMS should provide means of communication to action owners to take action, follow up, or close out corrective actions. For instance, Participant 9 explained that: "I want to be able to action someone, send them an automated email … to say, hey, you've got a lesson." Likewise, Participant 6 said, "I think it would be beneficial if there was some sort of automated system that would follow up with the owner and the action item." This automation would aid in streamlining the lesson workflow and ensure that the actions assigned to the lesson are validated and completed before further dissemination. This finding is consistent with Milton's (2010) assertation that the LLMS should contain features to push lessons to users. Moreover, Liebowitz (2011) remarks that many LLMS failed from the lack of active LL analysis and dissemination. This finding is closely related to the subtheme of *the right information at the right time* in theme 4.

Additionally, participants indicated that the LLMS should support the review and validation of LL, as discussed in theme 2. The LLMS should be able to indicate whether a lesson is a draft, actions have been approved and are being worked on, or a LL is ready to be shared and implemented. For instance, Participant 5 commented that the LLMS should be a "tool where we

could put them [LL] in. And then only so many people have team approval, … that goes through and approves them after some review by the team." Participants highlighted the significance of the approval process as a form of validation and agreement, which could facilitate the implementation of LL. For example, Participant 1 said, "if we are going to do it [implement a LL], we need the consent of the supervisor. So, to say that it's okay for you guys to do it." Participant 1 further suggested "a library of lessons learned that have been tested and verified that we can just grab and use for all operations." This verification and validation could increase trust and employees' perceived value of the LLMS.

Another aspect of effective action and change management is for AI to streamline the process that leads to changes. Participant 3 said:

> *They [BU B] wanted to use some sort of AI logic to like, if once the lesson learned is approved, that language from there will go and search any sort of POA or SOP, find an instance of it, and either update it or at least bring it to knowledge that needs to be updated. We still want to do that.*

This suggestion is in line with the AI-enabled KM trend reported in a survey by APQC (2021a, 2021c). In the survey, KM experts and practitioners identified AI-driven search and AI content recommendations as important KM technologies to embrace now, intending to promote knowledge discovery.

If the LLMS can be integrated with an enterprise content management system that could provide the means to manage the updates of POAs and standards, it would significantly streamline the LL process resulting in effective change management. Participant 9 described how it could reduce workload:

With this system, we only have to update in one place. But it's tagged to [different types of operations]. So, because it's tagged in that way and that sought of metadata, database level, you only have to make one update, and it applies to everybody. ... So then, as you make that update, it applies to multiple business units and asset class levels.

Participant 3 further explained that the intended state for an automatic workflow is to locate and update appropriate POAs or SOPs once the LL has been closed out, ensuring that LL are institutionalized. This process is a way of ensuring organizations reach a level 2 LL maturity level suggested by Milton (2012) in chapter 2.

Part of effective change management is to connect people with LL and connect people with one another. Participants suggested that the LLMS should be designed to facilitate these knowledge networks. For instance, Participant 3 stated how a centralized LLMS would eliminate knowledge silos and link individuals with another team and their LL, or at least make them aware of it. This benefit of having a centralized LLMS is in line with that of Oughton (2021). An LLMS could be integrated with an expert locator system, which Abdelwhab Ali et al. (2019) have reported as one factor facilitating knowledge sharing within the organization.

Moreover, Liebowitz (2011) suggests forming online communities of practice to support knowledge-sharing culture and the LLMS. This network feature would facilitate tacit knowledge sharing through socialization, per Nonaka and Takeuchi (1995). Furthermore, Participant 2 suggested the LLMS should link the planning and engineering team, execution team, and supervisors to allow lessons to flow through each stakeholder and ensure alignment and understanding of the lesson. This integration would facilitate knowledge transfer between the field and the office and provide awareness of changes to processes and procedures. According to Lis (2012), the LL program's success requires all stakeholders' involvement.

Adopting a well-designed LLMS compatible with the standardized LL process might ease the management of an organization's LL program. However, according to the literature and participant data, technology alone is insufficient. The team in charge of any LL program initiative must take a holistic approach and consider all people, processes, and technology-related factors.

5 Recommendations and Conclusion

This research aimed to explore factors impacting the adoption of an LLMS within large O&G organizations. Literature addressing the barriers and enablers of KM, LL programs, and LLMSs were reviewed to determine how organizations might increase the likelihood of successful LLMS implementation. After which, semi-structured interviews were conducted to understand employees' perceptions of barriers and enablers to LLMSs within the context of the Wells department. Thematic analysis was then used to analyze the data in which the findings and interpretations were presented in Chapter 4. This chapter concludes the study by summarizing the main research findings concerning the research aim and questions. In addition, this chapter provides practical implications, reviews the limitations of the study, and provides recommendations for future research.

5.1 Research Summary

By collecting data from employees within the Wells department, the researcher was able to examine how a highly operationally dynamic organization would gain employees' adoption in using an LLMS. The findings from the data analysis provided answers to the main research question – what factors impact the adoption of an LLMS within large O&G organizations – in the form of five themes: understand existing barriers, incorporate enabling processes and governance, facilitate the people element supporting the LL programs, satisfy users with important LLMS characteristics, and improve the LL process with an LLMS. In addition, these five themes provided answers to the research sub-questions.

5.1.1 Research Sub-question 1

The findings revealed that existing barriers should be addressed before an LLMS deployment. The research sub-question 1 – what barriers do employees face concerning LL

programs – was addressed by discussing the existing hurdles participants face or believe to be detrimental to a LL program. The data analysis indicates that the barriers include the LL program being difficult to manage, the lack of a systematic approach to LL, the LL process requiring too much effort, and the current software being ineffective at supporting the LL process.

5.1.2 Research Sub-question 2

The research sub-question 2 – what factors would lead employees to adopt an LLMS – shows that adoption-enabling factors are associated with processes, people, and technology. Although this distinction was made in the literature review (e.g., Gorelick et al., 2004), it was evident from the data analysis that integrating these three aspects is essential. While processes and people factors are not directly related to the LLMS, they facilitate the effectiveness of the overall LL program, increasing the perceived value and attracting employees to engage with the LLMS. Participants indicated that the LLMS adoption could be increased by incorporating enabling processes and governance. The processes identified in this study include standardizing the LL process and related governance, ensuring the validity of LL, and ensuring lessons are followed through. The data analysis uncovered key aspects of the people-related factors: deliberate leadership, inspiring and motivating employees, and nurturing supportive cultures. Factors directly related to an LLMS are identified as the flexibility of an LLMS to expand and change, the need to focus on usability by understanding users' needs and requirements, and the ability to provide employees with desired information when required. If these factors are addressed, it is expected that LLMS adoption should increase.

5.1.3 Research Sub-question 3

The last research sub-question was: how could an LLMS facilitate and streamline the LL process. Two main aspects of using an LLMS to improve the LL process were identified: providing

a structured system of records and allowing for effective action and change management. An LLMS facilitates the LL process by streamlining each sub-process, allowing the users to be more productive in their work activities. The structured system of records enhances lesson discovery leading to lesson learning and implementation, acting as a knowledge conduit. A well-designed LLMS, integrated into the organizational culture and work processes, should improve users' ability to manage action items from lessons seamlessly. Automation would further enhance this improvement by initiating automatic proves that lead to institutionalization and changes.

5.2 Implications for Practice

The findings of this study suggest several practical implications for organizations pursuing lesson-learning capabilities. Overall, this study strengthens the idea that an effective LL program has immense potential and benefits, and an LLMS may facilitate this efficacy. Organizations may realize this value only if their LL endeavors are intentional. Therefore, strategies involving the entire life cycle assessment of the LL program are required if the organization aims to gain value by learning from experience.

Organizations should evaluate their strategic objectives and the reasons for their interest in the LL program. Practitioners should seek to understand the nature of work and employees' natural tendencies within the organization. There exist barriers that demotivate employees from engaging in the LL process. Organizations should allocate time to learn about these barriers, implement monitoring processes, and provide the necessary support to assure the effectiveness of the LL program.

The next step should be establishing an official LL program, including processes, personnel to support the learning cycle, and required technologies. Each component of the LL program should be clear and standardized to the work characteristics within the organization. Governance

should be in place to ensure expectations are set and the LL program is of high quality with the learning process fully completing its cycle. Leaders should drive the LL program regardless of employees' level of contributions or enthusiasm. Organizations should identify appropriate ways to inspire and motivate employees, showing the implications of their work and effort. This support would create critical knowledge-sharing cultures that allow continuous knowledge flow.

This study re-emphasizes the need to understand varying users' needs and requirements, preventing forced adaptation of technology to processes and cultures. Organizations could use available in-house tools to better understand the LL process-technology fit before purchasing or developing an LLMS. By understanding users' needs, distinct LLMS characteristics could be identified to satisfy the users, generate buy-ins, and increase LLMS adoption.

Highly dynamic enterprises should focus on the flexibility of their software architecture. This flexibility is intended to facilitate future expansion, modifications, and adaptation to varied demands within the organization. An LLMS should be designed as an enterprise-wide system to maximize the potential benefits of lesson learning. However, it would require features such as effective search, filter, and categorization to support structured documentation and lesson discovery. An enterprise-wide LLMS could act as a LL repository to document institutionalized LL for future reference or for other entities within a decentralized organization to learn. KM practitioners could increase employees' trust in LL by fostering transparency and providing backup data to the lessons in the database. This information would help lessons to be reused across BUs, adapting to differing contexts.

Adoption of an LLMS is contingent upon its usability. Organizations should consider factors such as user-friendly interface, fast response time, good connectivity, AI-assisted workflow, and integrating the LLMS with existing software. Additionally, organizations should

design features or processes to provide employees with the right knowledge at the right time, assisting with the commitment to follow through with action items and gain new knowledge. The results of this study suggest that employees would adopt an LLMS if it provides more value than existing systems and processes. To increase this perceived benefit, organizations should identify ways to use the LLMS to streamline existing processes and workflow.

An effective LLMS could positively impact the organizational learning capability, but only if employees adopt and utilize it. This study has emphasized that focusing on the technology alone is insufficient for adoption. Organizations should take a holistic approach to LL programs and carefully observe the dynamics between factors that might drive or negate employee adoption of an LLMS.

5.3 Limitations

Several limitations to this study need to be acknowledged. This study focused on factors impacting an LLMS adoption from the perspective of Wells employees within a global O&G company. Although data were collected from Wells employees in various BUs to account for the diverse opinions and cultural effects, they are still part of the same function within the company. As a result, participants might share certain organizational cultures or work characteristics. These limitations resulted from the scope of this study and could impact the findings' transferability to other departments, companies, or industries.

The purposive sample strategy may have resulted in employees who are more enthusiastic about improvement opportunities, thus, may be more interested in LL programs. Moreover, participants with experience using LL databases were able to provide more input concerning the barriers to LLMS adoption. However, this study intended to uncover various opinions from different BUs.

Lastly, the researcher had no prior experience conducting qualitative studies. This lack of experience may have impacted the data collected during the semi-structured interviews and the data analysis with the reflexive TA method. Participants' responses may have been affected by the researcher's perception of an LLMS's benefits. Furthermore, the researcher's professional working experience could have biased the data interpretation. However, subjectivity is part of reflexive TA (Braun & Clarke, 2021a).

5.4 Recommendations for Future Research

Based on the scope limitations of this study, there are opportunities for further research. The LL program is one component of KM. Thus, the overall KM strategy would impact the success of the LL program. Further research could explore the interaction between the LL program, and other KM approaches, such as communities of practice, enterprise social networks, and internal training programs, to understand how they might facilitate each other. There were indications in this study that the integration of an LLMS with other KM components could increase LLMS adoption and facilitate organizational learning. Moreover, the technology component for each KM approach could be further evaluated. Future research could examine how technological advancements have affected KM and LL programs.

Further study could be done to understand factors impacting the LLMS adoption and users' requirements from the perspective of employees from other departments within an upstream O&G organization. This exploration could result in distinct stakeholder needs from the employees within Wells. In addition, the scope could expand to include the perspectives of senior leadership. A broader understanding would be beneficial in developing an enterprise-wide LLMS and ensuring its adoption.

The last recommendation is for further study to perform a multi-case study to determine the influence of organizational culture on factors impacting LLMS adoption. There were indications in this study that the cultural differences between each BU of Company X impacted the LLMS adoption factor. Exploring and comparing the Wells department of other O&G companies could yield valuable insights into how the organizational culture has shaped the adoption factors and how those might affect the success of a LL program.

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Appendix A – Interview Guide

1. Can you briefly talk about your current role?
2. How do lessons learned relate to your current role?
3. How do you use lessons learned in your job?
    - 3.1. What do you think about the impact of lessons learned on operations?
    - 3.2. How would lessons impact your decision-making?
4. Why do you capture and share lessons learned?
    - 4.1. What are your drivers for contributing to lessons learned capturing?
5. On what occasions do you capture and share lessons learned?
    - 5.1. What do you feel about sharing knowledge with others?
    - 5.2. What about your mistakes?
6. How are you capturing and sharing lessons learned?
    - 6.1. Can you explain the capturing process?
    - 6.2. How much does this impact your usual workflow?
    - 6.3. Self-Service vs. Facilitated capturing, what is your preference?
    - 6.4. Do you have personal notes? What do you think about sharing them?
7. How are action items from the lessons managed?
    - 7.1. Who assigns and tracks them?
8. What issues do you personally face when capturing and sharing lessons learned?
    - 8.1. How did you overcome those issues?
    - 8.2. What are some of the barriers you faced?
    - 8.3. Are you satisfied with the current level of participation in your organization?
9. What do you think could be done to make you capture and share more lessons?
    - 9.1. Any technology or processes that would make it easier?
    - 9.2. What kind of incentives would increase your contribution?
    - 9.3. How do leadership expectations impact your contribution?
10. How do you or your organization reuse the captured lessons learned?
    - 10.1. How are lessons learned infused into procedures, policies, or turned into best practices?
11. On what occasions do you find yourself looking for captured lessons learned?
    - 11.1. Can you explain the process you used to access the information?

11.2. How difficult was it?

11.3. What would make you trust those lessons?

11.4. How would you gauge the accuracy of the documented lesson?

11.5. How would you feel about adopting a lesson learned from your colleague that has not been reviewed?

12. What issues do you face while implementing or reusing lessons learned?

12.1. How did you overcome those issues?

12.2. What are some of the barriers you faced?

13. What could be done to make you reuse more captured lessons learned?

13.1. Any technology or processes that would help?

13.2. What kind of incentives would increase your contribution?

13.3. How do leadership expectations impact your contribution?

14. Can you tell me about your experience with Lessons Learned Management Systems, such as an online database or repository?

14.1. Can you explain your understanding of such systems?

14.2. Why do you think LLMSs are usually not very successful?

15. How would lessons learned management systems impact your workload?

16. Who do you think should be responsible for an LLMS?

17. What do you think about enterprise-wide vs. business unit sharing?

18. What would make you adopt or use an LLMS?

19. In your opinion, what would make LLMS software user-friendly?

20. Is there any additional information that you would like to share?