Improving Knowledge Management by means of Lean Thinking

A case study of project Lessons Learned exchange at the Engineering department of Janssen Biologics

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Executive Summary

Many of the activities carried out by organizations are performed by project teams. Product launches, new systems and processes, as well as their maintenance, are often implemented through project-based activities. Making these activities successful requires a long list of criteria, which heavily depend on effective use of a company's knowledge assets. An example of such assets is the lessons learned from previous projects, which entail knowledge and experiences gained during the project lifetime. Sharing lessons learned can contribute to project success by safeguarding best practices, preventing repeating past mistakes, and anticipating risks.

Managing the lessons learned process can be rather challenging. Determining the future value of knowledge and providing the right knowledge at the right time to the right knowledge-customer, are some of the aspects contributing to this difficulty.

Lean thinking is a methodology that can offer process improvement through determination of value to end-customer and identification and elimination of waste and its root-causes. Even though this method originated in the manufacturing industry, its principles are believed to be applicable to other sectors. The nature of knowledge management is different from that of the manufacturing sector. In this work we analyse to which extent lean thinking principles can be of benefit to a non-manufacturing process such as the lessons learned.

When applying lean thinking principles to knowledge management (also known as lean knowledge management) and lessons learned processes, one needs to take the characteristics of knowledge into consideration. Knowledge processes differ from manufacturing activities in that they include the need for context for sharing tacit knowledge and knowledge value being time, individual, and purpose dependent.

This study examines such applicability from a theoretical and a practical point of view. Through literature research an overview of the state-of-the-art on lean knowledge management is provided. In order to examine the applicability of these theoretical findings in practice, the case study of the Engineering department of Janssen Biologics is selected. The focus of this study is mainly on the lean thinking principles define value, create flow, and establish pull as they are seen as most challenging with regard to knowledge management. Through interviews and workshops, the current lessons learned process and the needs and wishes of the knowledge-customers at Engineering are identified. Improvement proposals are formulated based on these findings and tested in a pilot to determine their workability in practice. This study is constrained by time, budget, and resource limitation which influence the formulated improvement proposals.
Project lessons learned are often collected and documented with the aim of application in future projects. Predicting the future value of lessons learned is challenging as knowledge is not discrete and can be subjective. To overcome this difficulty, setting up facilitated intervision sessions where peers share knowledge and give feedback is advised. Such feedback can also be offered by IT tools that offer selection, filtering, and ranking possibilities.

Unsuccessful knowledge management initiatives in the past can hinder successful implementation of present ones. Overcoming this burden of the past can be realized through dedicated Management involvement. Management needs to highlight the importance of lessons learned and their impact on present projects. Leading by example can facilitate creation of positive memories.

One size fits all is not applicable to knowledge management efforts. Managing knowledge assets needs to be customized to the needs and wishes of knowledge-customers. This requires long term investment of time and resources.

The lessons learned process needs a process owner who keeps its importance on the agenda. This individual should also monitor its functionality and identify factors that hamper its success. Such evaluation should take place on a regular basis upon which improvements can be made.

For most project-based organizations knowledge management is not a core business activity. In cases where other more urgent issues occur during a project lifetime (which is often the case), attention of the project team can shift away from collecting and retrieving lessons learned. Management can provide incentives and rewarding to encourage desired behaviour.

The lessons learned process should be included in the project management trainings. The importance of lessons learned to project success needs to be emphasized, the process should be explained, and roles and responsibilities need to be defined. The goals is making lessons learned collection and retrieval a standard project step.

Through this work, initial steps in improving the lessons learned process at Engineering have been realised. We recommend examining their long term successful enforcement next. Such examination should consider the potential role Management and the project sponsor play in achieving success. Also the human aspect regarding knowledge exchange norms, habits, and culture at Engineering should be considered.
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## List of Abbreviations

1. BI: Business Improvement  
2. FPX: Flawless Project eXecution  
3. JBV: Janssen Biologics B.V.  
4. KM: Knowledge Management  
5. LKM: Lean Knowledge Management  
6. LL: Lessons Learned  
7. LT: Lean thinking  
8. PE: Project Engineer  
9. PM: Project Manager  
10. SHE: Safety, Health, and Environment
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Chapter 1: Introduction

Enterprises today find themselves in a competitive and international market where product customization is growing (Bendell, 2006). In order to stay competitive and function optimally under such circumstances, firms need to be critical towards their production methods and the quality of their products and services. Cost reduction and customer satisfaction or lack thereof can in some cases be the maker or breaker of businesses (Wu & Liker, 2000). There are various process optimization methods that can be used to reach these goals, one of which is Lean Thinking (LT) (Hicks, 2007).

LT offers an increase of value to end-customers by identifying and eliminating waste and its root-causes (Bhamu & Sangwan, 2014). Value is what the end-customers define it to be and thus product specific. It is therefore essential to know who end-customers are and what they view as added-value (Baines et al., 2006). Flows of creating and attributing to this value creation process need to be defined, generated, and sustained over time (Womack et al., 1990). LT was initially applied in the automotive manufacturing sector (Green, 1999). However, since then many other sectors have implemented its principles as they also wished to profit from its benefits (Bhasin, 2012). As LT was based on specific characteristics of manufacturing activities, shortcomings and problems can arise from implementing this method to other non-manufacturing activities such as Knowledge Management (KM) (Hicks, 2007).

Value to end-customers can, among others, be created and derived from knowledge assets within organizations. These assets and their effective application can be critical for organizational success and act as a differentiating competitive factor (Wiig, 1997). Management of these knowledge assets is known as KM which is described by Dombrowski et al. (2012) as a process that creates, disseminates, and embodies knowledge and can be either centrally or de-centrally organized within an enterprise. KM aims at making an organization aware of its knowledge both, collective and individual, and finding ways to make the most effective and efficient use of it. Alavi et al. (2005) believe firms that are able to effectively manage their knowledge resources can expect to obtain benefits such as: improved customer service, cost reduction, improved decision making, innovation, quick and effective problem resolution, and efficient transfer of best practices.

1.1 Research motivation and objectives

Even though knowledge assets and their effective management is important for organizational success (Wiig, 1997), such effective management has proven to be difficult resulting in failure of several KM efforts (Storey & Barnett, 2000 and Guptara, 1999 and Lucier & Torsilieri, 1997). As
LT can contribute to process improvement leading to an increase in customer satisfaction, the question arises whether a combination of principles of LT and KM is possible and what effects such combination may have. One way such a combination can take place is by incorporating KM principles in LT (for example the work of Andersen and Ronne (2013)). A second way is to optimize KM by applying LT principles, hence Lean Knowledge Management (LKM) which is the focus of this study.

Looking at the scientific literature, we notice that LKM has not received the extensive attention that principles of LT and KM have been given. There are researchers such as Hicks (2007) who have stated that KM can benefit from potential opportunities LT has to offer and have emphasised the need for further research on LKM.

The authors who initially introduced LT to the wide public; Womack, Jones and Roos (1999) claim in their book ‘The machine that changed the world’ that LT as a philosophy has the potential to be applied in various sectors and offer them significant improvements (Hicks, 2007). Green (1999), however, does not agree with ‘one size fits all’ notion of LT with regard to applying its principles to all sectors. He believes that each sector has its own specific characteristics and that more research should be done before one can speak of wide applicability of LT. Hicks (2007) concludes that lack of scientific research has resulted in uncertainty about LT’s applicability to and possible effects on non-manufacturing activities. What these researchers agree on, is that LT can possibly offer benefits to non-manufacturing sectors. However, it is not clear to what extent LT principles can be translated in these sectors and what effects such application may have (Green, 1999 and Hicks, 2007 and Womack et al., 1990).

This study aims at narrowing the above given knowledge gap with regard to LKM not only from a scientific point of view but also by looking at LKM’s applicability in practice. For this purpose the case study of the Engineering department of an international pharmaceutical company, Janssen Biologics B.V. (JBV), a subsidiary of Johnson & Johnson, located in Leiden, The Netherlands, was chosen. JBV’s workload in recent years has increased which has led to an increase in the number of projects the Engineering department conducts. This department is the main focus of this study. The majority of Engineering department’s activities are project-based which makes this department a project-based organization (JBV A, 2015). The main activities of such organizations are structured around projects. They have established distinct working processes for successful execution of projects they perform (Thiry, 2008).
LT and continuous process improvement play an important role in the operational strategies of JBV and hence the Engineering department. An increase in the number of projects has brought about the need for this department to examine possibilities of process improvement with regard to KM. Such improvements can help prevent rework and improve overall efficiency (JBV A, 2015). Cross project learning and knowledge exchange is a great way of improving efficiency and preventing rework. Sharing Lessons Learned (LL) of projects as a manner of knowledge transfer is one way of achieving this goal (Baaz et al., 2010). This study focuses on improving project LL process and examines how LT can contribute to such improvement. JBV’s extensive experience with LT and the Engineering department’s project-based activities make this department a suitable candidate for this study.

The need for this study is therefore twofold:

1. **Scientific relevance**: there is a knowledge gap with regard to the extent of applicability of LT principles to KM. This gap is also present in case of KM of project LL which is the main focus of this study. We aim at narrowing this gap.

2. **Societal relevance**: effective management of knowledge sources has proven to be challenging and there is a need for improvement of KM activities. This need is also present at the Engineering department of JBV, an enterprise with extensive experience with LT. Engineering is undertaking more projects and wishes to improve efficiency and prevent rework through better management of its knowledge sources. This study aims at improving knowledge exchange with regard to project LL processes by means of LKM and thereby contributing to improvement of KM activities.

### 1.2 Research question and sub-questions

The main research question of this study is:

*To what extent can Lean Thinking principles be applied to Knowledge Management processes of a company with the aim of improving exchange of project Lessons Learned?* 

Following this main research question the following sub-questions can be formulated. The first two sub-questions (1 and 2) aim at defining the working processes of our study. Sub-question 1 is addressed via desk research (chapters 2 and 3) and sub-question 2 through data collection (chapter 5 and 6). Sub-questions 3 and 4 are research questions and are addressed through investigation. All these sub-questions aim at examining different aspects of the above given main research question by breaking it down into sub-sections. This makes our research more manageable.
1. What is Lean Knowledge Management?
   1. What is LT and what do its principles entail?
   2. What is Knowledge and what are its characteristics? Why is there a need for KM?
   3. What are project LL and which challenges are faced in learning from projects?
   4. What is known about applicability of LT principles to KM?

2. What are the characteristics of the Engineering department case study?
   1. Who are the main stakeholders and what are their needs?
   2. How are project LL currently exchanged between these stakeholders?
   3. What are the barriers to exchanging project LL?

3. What are the effects of applying LKM to the Engineering department case study?
   1. Which aspects of LT are (not) applicable to project LL and why (not)?
   2. What are the drivers, opportunities, and barriers of applying LT to KM and in particular to project LL?

4. To what extent can results of the Engineering department be generalized to all cases of LKM?
   1. Under which circumstances can this approach be used in other cases?
   2. What are possibilities and limitations of such application?

1.3 Research approach and thesis outline

In order to answer the above given questions we need to take a closer look at principles of LT and KM. As the main focus of this study is project LL, attention is also given to this manner of knowledge exchange. To be able to fully understand and examine the applicability of LT to KM not only the scientific aspects need to be reviewed but also the specific characteristics of the case study. Together the above aspects enable us to get a better understanding of the extent to which LT principles can help improve KM. The below given research framework (figure 1) was chosen for this study to ensure all aspects are covered and to provide structure in research steps as well as in this thesis report.

Sub-question 1.1 through 1.4 are addressed by means of literature study, results of which can be found in chapter 2. Chapter 3 gives an overview of application of LT principles to KM resulting in a literature based model of LKM. Methods and instruments used in collecting data from the case study can be found in chapter 4.
In order to answer sub-questions 2.1 through 2.3, data is collected from the case study with regard to all aspects of project LL process which is given in chapters 5 and 6. The literature based LKM model of chapter 3 is applied to the case study to formulate process improvement proposals. This leads to version 1.0 model of LKM that can be found in chapter 7. To examine whether these improvements work in practice, they are tested in a pilot. This pilot together with data collected from literature is used to answer sub-questions 3.1 and 3.2 in chapter 8. We also examine if results from Engineering department are applicable to other departments of JBV, testing the generalization of the model. The results of this step are given in chapter 8 and sub-question 4.1 is thus addressed. Discussion on possibilities and limitations of LKM model can be found in chapter 9 answering sub-question 4.2.
Chapter 2: Related Work (Literature Study)

Lean Thinking (LT), Knowledge Management (KM), and Lessons Learned (LL) of projects have been the subject of many scientific research studies. These studies can offer insight and better understanding of these concepts and factors that contribute to their success. In this chapter we examine this important source of information by taking a closer look at a number of scientific research studies. We focus on answering the first sub-question of this study (as given in chapter 1). By the end of this chapter, the reader has a better understanding of LT, KM, LL, and Lean Knowledge Management (LKM).

In section 2.1 a short introduction is given on different process improvement methodologies. Section 2.2 concentrates on the LT concept, answering sub-question 1.1. Section 2.3 gives an overview of KM, providing the needed insight to answer sub-question 1.2. In section 2.4 LL of projects are addressed with the aim of answering sub-question 1.3. Section 2.5 examines sub-question 1.4 and looks at LKM in the scientific literature. The summary of this chapter can be found in section 2.6.

2.1 Process Optimization Methodologies

As mentioned in chapter 1, there is a need for companies to be critical towards their production methods and the quality of their products and services. This helps them to stay competitive in an international market (Wu & Liker, 2000). There are various process optimization methodologies that can be used to reach cost reduction and customer satisfaction, such as Total Quality Management, Deming Cycle, Six Sigma, and LT. In this section we take a closer look at these methodologies.

2.1.1 Learning Organizations

In the competitive and international market of today, learning and innovation are key success factors. Organizations that are looking for a lasting competitive advantage over their counterparts need to invest in learning and change (Aggestam, 2006). In the context of learning, organizations can be categorized into four types, according to McGill and Slocum (1993):

1. **Knowing Organizations**: are those that consider their well-established processes as optimal and find efficiency to be essential to success. Such organization can only be successful in a mature and static market.

2. **Understanding Organizations**: are mainly focused on their core values and communicating and reinforcing them within the company culture. Hence they are not open to change and improving their learning experiences.
3. **Thinking Organizations**: have a problem-solving mind-set, where problems are often tackled in a fragmented and static manner. Solutions are therefore mainly related to a single business process. Such organizations are highly dependent on specific management practices and tools.

4. **Learning Organizations**: seek learning and progress in all their activities, for all their stakeholders, and even competitors. Every activity is considered to be a learning experience and results are used for future improvements of business processes. This organization is open to change and encourages progress and innovation.

In this study, we concentrate on learning organizations as they accommodate for innovation and learning within an organization, which is essential to long-term company success. These organizations emphasize the need for establishing processes for acquiring, developing, using, and sustaining knowledge. The concepts of learning organizations and KM are interdependent (Aggestam, 2006) and in section 2.3.2 we take a closer look at this interdependency.

### 2.1.2 Total Quality Management

Total Quality Management is a holistic methodology used for organizational improvements. This methodology offers organizations a set of guiding principles based on continuous improvements of business or production processes. When applied correctly this method offers organizations a long-term competitive advantage in the market (Ooi, 2009). There are various definitions found in the literature for total quality management. However, according to Hung et al. (2011, pp. 214) most researchers see this method as a management approach. They “agree that the most influential dimensions of total quality management include: a) top management support, b) employee involvement, c) continuous improvement, and d) customer focus”. Even though learning and emphasis on knowledge is needed for success of this method, the main focus of total quality management is not on these aspects (Hung et al., 2011). Therefore, we leave this method out of scope of our study.

### 2.1.3 Deming Cycle

Deming Cycle, also known as PDCA Cycle (Plan, Do, Check, and Act) is a method that aims at quality improvement and efficiency. This method examines strategies and constructs methods to develop, test, and apply changes within organization that can result in improvements. This approach sees steps taken towards improvement as a cycle, hence a continuous process that would bring the organization closer to its goals. According to Singh this method is mainly focused on change management to achieve pre-set goals of an enterprise in a systematic manner (Singh, 2013). Although Deming Cycle is one of the methods applied within Janssen
Biologics (JBV), it is not their main focal process improvement methodology and is therefore left out of this study’s scope.

2.1.4 Six Sigma

Six Sigma is a strategic improvement methodology which is best applied in a company-wide manner. This method focuses on reduction of variation in processes, offering simultaneous cost reduction, and an increase in customer satisfaction (Bendell, 2006). Variation in processes is tackled using a set of statistical and quality tools (Hines et al., 2004) imbedded in the DMAIC (Design, Measure, Analyse, Improve, and Control) cycle (Bendell, 2006). Improvements are achieved by concentrating on a single project at a time by either a full-time (Black Belt) or a part-time (Green belt) improvement manager or engineer. Learning is mainly on the job under supervision of a senior individual and projects are usually not signed-off if the financial saving goals are not achieved (Bendell, 2006).

Six Sigma is especially of value in manufacturing processes where variation is an issue (for example in demand, loading, resource availability, or performance). In such cases it can offer great improvements. This method is however, less effective in situations where there is systematic waste or chronic and reoccurring lack of value definition (Bendell, 2006). JBV applies Six Sigma for improvement of its production processes. However, as knowledge processes are the subject at hand in our study and Six Sigma is less suitable for improvement of qualitative processes, we do not consider this methodology.

2.2 Lean Thinking

In this study, LT is the main process improvement methodology examined. The reason for this selection is twofold: 1) JBV widely uses LT principles for process improvements and 2) LT principles have the potential of being applied to non-manufacturing activities (such as KM) as well as manufacturing activities where they originated (Hicks, 2007). In this section, we aim at answering sub-question 1.1 given in chapter 1: **what is LT and what do its principles entail?**

Initially, it should be noted that there are various terms in the scientific literature for Lean methodology, such as: Lean, LT, Lean Philosophy, Lean Manufacturing, and Lean Production. LT and Lean Philosophy are mainly used to describe the philosophy and way of thinking behind the method. Lean Manufacturing and Lean Production are often used for explaining the method, tools, and steps to be taken. Lean is used for all the above (Bhasin, 2012). Lean methodology is also known as the Toyota Production System and can be referred to as Just-In-Time Production. In this study we mainly use the term LT and concentrate on the philosophy behind the method.
After the Second World War, Toyota, a Japanese automotive manufacturer, managed to produce a greater variety of cars at lower costs and higher quality compared to its counterparts in the West. To the surprise of Western automotive manufacturers, Toyota was able to do so by lowering her inventory, resources, investment, and defects (Bhamu & Sangwan, 2014). The International Motor Vehicle Programme researchers of the Massachusetts Institute of Technology set out to find the secret of Toyota and documented their findings in the book called ‘The machine that changed the world’ (Bendell, 2006). In this book they for the first time introduced the term **Lean** for the Toyota production method (Womack et al., 1990).

Nowadays the manufacturing sector is customer-driven and characterized by product customization and international competition. In order to survive in such environment organizations need to be in touch with the needs of their customer, be highly responsive to changes, and reduce costs. In the manufacturing sector, LT has been widely perceived as a possible solution to such challenges (Hines et al., 2004). LT aims at being greatly responsive to customer demand by eliminating waste. The goal is to produce products and services at lowest costs and only when required by the customer (hence the term Just-in-Time) (Bhamu & Sangwan, 2014).

### 2.2.1 Lean Thinking steps

LT consists of the following five steps (visualized in figure 2):

1. **Define Value**: this step concentrates on the needs of the customer. Goal is to identify this customer and what he/she regards as value (Thangarajoo & Smith, 2015). Value needs to be defined as specific as possible (in terms of capabilities, quality, variety, price, etc.) and this can only be achieved through frequent and regular dialogue with the customer.
customer (Bhamu & Sangwan, 2014) which is referred to as Voice Of the Customer (Womack et al., 1990).

2. **Identify Value Stream:** when value from customer’s perspective has been defined, the next step is to identify activities that add-value. Such activities are those that transform input into an output that the customer values (Thangarajoo & Smith, 2015). Non-value-added activities are those that do not add value to the final product from the customer’s point of view (Baines et al., 2006). Such activities are those that can be avoided and those that cannot be avoided. Attention should be given to those activities that do not add value and can be avoided (referred to as waste in LT) and to eliminate them from the process (Thangarajoo & Smith, 2015 and Oehman & Rebentisch, 2010).

3. **Create Flow:** after waste (and its root-causes) has been eliminated, the remaining value-added activities need to be linked in such a way to allow flow of value (Thangarajoo & Smith, 2015). Flow through value creation process needs to be defined, created, and sustained over time (Green, 1999). Special attention needs to be given to those people who create value (Poppendieck, 2011).

4. **Establish Pull:** this step concentrates on providing the customer with what he/she needs and when this need occurs (Petersen, 2009). Womack, Jones and Roos define the Pull concept as no one upstream activity should produce a good or service until the customer downstream asks for it (Womack et al., 1990). For the Pull concept to be successful, good communication and collaboration with downstream customer is needed in order to fully understand his/her needs and expectations (Thangarajoo & Smith, 2015).

5. **Strive for Perfection:** the final step is continuous strive for perfection as LT believes processes always have room for improvement (Thangarajoo & Smith, 2015). The first four steps have made processes more transparent which helps Management to explore new possibilities for improvement (Thangarajoo & Smith, 2015 and Dennis, 2002).

Value Stream Mapping is a tool used to identify activities that add value within and between product transformation steps. This tool helps to identify the optimal value stream by constructing the current situation (before the improvement) and the future state (after the needed improvements), highlighting changes that need to be made. Value stream mapping helps visualize the current processes and activities. Hereby assumptions behind them become more clear and these can then be challenged in light of value from customer’s perspective (Thangarajoo & Smith, 2015).
As mentioned earlier, activities that do not add value and are avoidable are called waste. LT identifies seven types of waste which are: 1) over-production, 2) inventory, 3) over-processing, 4) motion, 5) transport, 6) defects, and 7) waiting (Thangarajoo & Smith, 2015). LT aims at identifying the root-cause of these wastes which hinder optimal performance and eliminating them (Thangarajoo & Smith, 2015). This requires thorough understanding of detailed activities of business processes through which products or services are produced (Bendell, 2006). LT emphasizes not only on waste reduction at all levels, but also on changing corporate culture to prevent wasteful activities both now and in the future (Bhasin & Burcher, 2006 and Oehman & Rebentisch, 2010).

2.2.2 Lean Thinking in non-manufacturing sectors

The narrative given above is from, a philosophical perspective, describing the principles and goals of LT. We have given less attention to the practical side of LT describing various tools, techniques, and practices. The reason for this approach is twofold. First, in order to fully make use of the benefits of LT, implementation of the methodology needs to take place at strategic level as well as at operational level (Hines et al., 2004). Second, many of the tools and techniques used by LT are mainly useful for manufacturing processes (Petersen, 2009). LT requires company strategy to orient towards customer needs and expectations (Lyonnet et al., 2012) and not just to concentrate on tactics and mechanisms to implement Lean way of thinking (Bhasin & Burcher, 2006). It is therefore important to understand the possible contribution of LT at strategic level and then focus on practical tools and techniques. The latter is not addressed in this study and is left out of scope.

As mentioned earlier, LT was initially applied in the automotive manufacturing sector (Green, 1999). However, since then many other sectors have implemented LT principles as they also wished to profit from its benefits (Martinez & Lu, 2013). Principles of LT are thought to be universal and have the potential of being applied successfully in various sectors (Poppendieck, 2011). The customer oriented strategic LT can be applied to different industries, however, the shop-floor tools cannot. Concepts that aim at providing customer value can be in line with LT principles even if LT tools such as Kanban, level scheduling, etc. are not implemented (Hines et al., 2004). The use of LT can be seen in many non-manufacturing industries such as banking, mining, public service, hotel, and health care (Thangarajoo & Smith, 2015). As LT was based on specific characteristics of manufacturing activities, shortcomings and problems can arise from implementing this method to non-manufacturing activities such as KM (Hicks, 2007).
LT can be seen in the light of learning organizations. Recall 2.1.1, where learning organizations are defined to seek learning and improvement in all their activities. Learning and progress are essential to LT. LT as a methodology has seen great evolution and improvement over the years and continues to do so. Moreover organizations that implement LT principles have undergone learning both in improving their processes and in the manner they apply LT principles in practice (Hines et al., 2004).

2.3 Knowledge Management

KM is the second methodology central to this study. In this section we take a closer look at KM, what it entails, why it is important, and what its specific characteristics are. By doing so we aim at answering sub-question 1.2 given in chapter 1: *what is Knowledge and what are its characteristics? Why is there a need for KM?*

An issue that needs attention before we can proceed, is the use of terms data, information, and knowledge in the scientific literature. Alavi and Leidner (2001) noticed in their literature review that data were usually seen as raw numbers and facts, information as processed data, and knowledge as authenticated information. However, this definition was not followed consistently. They conclude that often knowledge and information are viewed as interchangeable and that Information Management and KM are both used to describe the same methodology (Alavi & Leidner, 2001). Wang and Noe reached a similar conclusion in their review (Wang & Noe, 2010). In this study we use knowledge to refer to both knowledge and information and use KM to refer to both KM and information management.

As we saw in section 2.2.1, identification and delivery of value to the end-customer is important for organizational success. This value can, among others, be created and derived from knowledge assets within organizations. These assets and their effective application can be critical for organizational success and act as a differentiating competitive factor. Management of these knowledge assets is known as KM (Wiig, 1997).

2.3.1 Knowledge Management and its benefits

Dombrowski *et al.* (2012) describe KM as a process that creates, disseminates, and embodies knowledge and can be either centrally or de-centrally organized within an enterprise. KM contributes to creation, storage, transfer, and application of knowledge within organizations (Ooi, 2009). The aim of KM is making an organization aware of its knowledge both, collective and individual, and finding ways to make the most effective and efficient use of it. In cases
where knowledge is not present within the organization, formulating strategies of obtaining it is also part of KM (Alavi et al., 2005). This aspect is however, out of scope in this study.

As Alavi and Leidner (2001, pp. 108) put it, the advantage of KM is in providing the organization with the “ability to effectively apply the existing knowledge to create new knowledge and to take action that forms the basis for achieving competitive advantage from knowledge-based assets”. They point out that IT tools should be seen as facilitators of contact between knowledge demand and knowledge source and not as the final goal of KM. It is also essential to recognize that KM needs to be a continuous process and set of practices within an organization both embedded in individuals and groups (Alavi & Leidner, 2001).

As mentioned in chapter 1, KM can lead to benefits such as: improved customer service, cost reduction, better decision making, innovation, quick and efficient problem resolution, and efficient transfer of best practices (Alavi et al., 2005). However, these benefits are not the main reason behind KM endeavours. Mahe and Rieu (1998) found that most KM initiatives are a reactive response to previous loss of knowledge. This is often experienced upon the departure of a knowledgeable employee from the organization. This loss of knowledge was found to be the tip of the iceberg of knowledge loss within the organization that initially paid little attention to KM (Mahe & Rieu, 1998).

2.3.2 Knowledge and sharing

In this section we take a closer look at knowledge and knowledge sharing. Initially we need to understand what knowledge is and how knowledge sharing takes place. Next, we concentrate on how sharing can be achieved and encouraged.

Knowledge can be imbedded in individuals, organizations, and documents (Dove, 1999). There are two types of knowledge:

1. **Explicit knowledge**: can be verbally formulated, documented, and stored. The person who possesses explicit knowledge is aware of having it and can communicate it to others. This type of knowledge is rather easy to transfer (Dombrowski et al., 2012). Explicit knowledge can be formulated in rules, guidelines, and principles (Ooi, 2009).

2. **Tacit knowledge**: is more difficult to formulate and therefore challenging to document and store. This type of knowledge is acquired through personal experiences and is also influenced by personal attitudes, beliefs, and behaviour (Dombrowski et al., 2012). Tacit knowledge is integrated in an individual and can be transferred through imitation and practice (Ooi, 2009).
Alavi and Leidner (2001) noticed assumptions about tacit knowledge being more valuable than explicit knowledge in the scientific literature. However, they believe such a claim cannot be made in all cases of KM (Alavi & Leidner, 2001).

Knowledge sharing (transfer) can take place in four ways that are greatly interdependent and intertwined (Alavi & Leidner, 2001). Nonaka et al. (2000) define these to be:

1. **Socialization**: conversion of tacit knowledge to new tacit knowledge through social interactions and shared experience among organizational members.
2. **Externalization**: converting tacit knowledge to explicit knowledge through repeated use of metaphors, analogies, and models.
3. **Internalization**: conversion of explicit knowledge to tacit knowledge through action and practice, thus learning by doing.
4. **Combination**: converting explicit knowledge into complex and systematic explicit knowledge through merging, categorizing, reclassifying, and synthesizing existing explicit knowledge.

Knowledge sharing can occur face to face, when individuals exchange knowledge in person (e.g. a physical chat with a colleague), or via communication tools (e.g. teleconference), or via written correspondence (e.g. emails, books, documents in repositories, etc.). This knowledge sharing can be active, meaning there is room for interaction (e.g. interactive workshop) or passive, where knowledge transfer is one way (e.g. reading a book). It has been noted that the most effective manner of sharing is active face to face contact as there is room for feedback and knowledge can be placed within the right context (Wang & Noe, 2010). Each knowledge flow has a content, direction, and role of sender and receiver (Dombrowski et al., 2012).

Knowledge sharing flourishes in an environment that encourages sharing in a systematic manner (Ooi, 2009). Benefits of state of the art technologies (and tools) were found to be limited if everyday practices did not provide support. Management involvement has a positive influence on knowledge sharing. Top management support influences both the level and quality of sharing as it creates commitment within the organization. Also perception of usefulness of sharing has a great influence on level and quality of knowledge sharing. Other aspects that influence sharing are user friendliness and effectiveness of KM tools and rewarding desired behaviour. Lack of incentives (either recognition or reward) was found to be a great barrier to knowledge sharing. It has also been noted that cooperative cultures encourage sharing whereas competitive cultures discourage it (Wang & Noe, 2010). Another aspect that should be considered is personal preferences of individuals with regard to sharing (Ooi, 2009). Some people may prefer face to face contact whereas others favour written correspondence.
In learning organizations, knowledge and intellectual assets play an essential role. For learning to take place optimally, knowledge and knowledge sources need to be identified, management, and maintained. Moreover, knowledge processes need to be defined and optimized. Only then can effective learning by both individuals within the organization and the organization as a whole take place. KM concentrates on these activities. Effective KM requires an open culture with emphasis on improvement and innovation, where leadership encourages change. Also working processes need to be directed towards continuous improvement. In other words KM success necessitates a learning organization. These two concepts are interdependent and should be considered as such (Aggestam, 2006).

### 2.3.3 Characteristics of knowledge and KM

Knowledge has the following characteristics which make its management troublesome:

1. For sharing to take place a common knowledge base is needed (a knowledge overlap between individual A who needs to understand the knowledge of individual B) (Alavi & Leidner, 2001).

2. Knowledge fades. Research has shown that organizations are not only capable of learning and creating knowledge but that they can also forget. This means that individuals do not remember or lose track of gained knowledge. Therefore a correct manner of storing, organizing, and retrieving of organizational knowledge (a.k.a. organizational memory) is an important part of KM (Alavi & Leidner, 2001).

3. Organizational memory can be both positive and negative and has the potential to influence future behaviour. Organizational memory is more than a collection of the memory of its individuals as it also entails culture, processes, structures, norms, and habits of the organization as a whole. Positive memory can help facilitate change as past experiences have been positive. However, it can also have negative impact by creating bias based on negative past behaviours. This could lead to status quo being maintained and organizational learning to be prevented (Alavi & Leidner, 2001). This phenomenon is also known as ‘burden of the past’.

4. Knowledge has a shelf life and it can become irrelevant and outdated. There is a need to eliminate knowledge that has become obsolete and outdated as its maintenance can not only clog the system but also cause wrong decision making. Therefore continuous monitoring of databases, standards, and guidelines are necessary. However, determining the shelf life of knowledge can be very difficult (Mahe & Rieu, 1998).

5. KM can be complex due to limited availability of standards and approaches. One size fits all is not applicable when it comes to KM and techniques need to be customized to the needs and wishes of the organization (Wiig, 1997).
6. KM processes are not objective, discrete, or independent. They are influenced by company culture and the norms and habits of social interaction between individuals. This has influence on both how knowledge is shared and interpreted (Alavi et al., 2005). Alavi and Leidner (2001, pp. 131) note that “no single or optimum approach to organizational KM can be developed” as KM is “not monolithic but a dynamic and continuous organizational phenomenon”.

7. Knowledge and especially its value to different individuals can be very difficult to grasp. Value of knowledge can depend on individuals, context, type of knowledge, objectives of using it, etc. For this reason measuring knowledge and its value can be troublesome (Dove, 1999).

<table>
<thead>
<tr>
<th>Table 1: Characteristics of Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Knowledge can be explicit or tacit.</td>
</tr>
<tr>
<td>2. Common knowledge is needed for knowledge sharing and exchange.</td>
</tr>
<tr>
<td>3. Knowledge can fade. Organizations learn and create knowledge but they also forget.</td>
</tr>
<tr>
<td>4. Organizational memory can have positive or negative effects on future KM activities.</td>
</tr>
<tr>
<td>5. Knowledge has a shelf life and can become irrelevant and outdated.</td>
</tr>
<tr>
<td>6. There is a lack of standards and approaches for KM processes.</td>
</tr>
<tr>
<td>7. Knowledge can be subjective and dependent on culture, norms, and habits.</td>
</tr>
<tr>
<td>8. Value of knowledge is dependent on various factors and difficult to grasp.</td>
</tr>
</tbody>
</table>

Literature findings of sections 2.3.2 and 2.3.3 have been summarized in table 1 and they are used as input in the following chapters. These summarized characteristics of knowledge can make its effective management difficult which may result in failure of KM efforts (Storey & Barnett, 2000 and Guptara, 1999 and Lucier & Torsilieri, 1997).

2.3.4 Enabling KM

KM needs to be incorporated in a systematic manner in an organization’s daily operations. Without systematic and comprehensive KM, databases for example can become knowledge junkyards where relevant and necessary knowledge is hard to find. Long-term and proper implementation of KM can reduce overall workload and can make activities more efficient by streamlining them (Wiig, 1997).

Management of an enterprise has a decisive role in the success of KM projects. According to Wiig (1997) the role of Management in KM is:

1. Top-down monitoring and facilitation of knowledge-related activities.
2. Creation and maintenance of knowledge infrastructure.
3. Renewing, organizing, and transferring of knowledge assets.
4. Leveraging (using) knowledge assets to realize their value.

Often attention is given to selection process of employees with specific knowledge, skills, capabilities, and competences. In addition to this, enterprises need to consider how to transfer this knowledge and expertise to others. There is also a need for exploitation of knowledge (sources) that already exist within the organization (Wang & Noe, 2010). The main challenges KM faces are maintaining, locating, and applying existing knowledge. Based on this, IT tools can be optimally used for assistance (Alavi & Leidner, 2001). Knowledge sharing between individuals, and within and between teams and departments allows enterprises to exploit and capitalize their knowledge sources. It should be noted that organizational cultures as well as individual characteristics influence the success of KM undertakings (Wang & Noe, 2010).

2.4 Lessons Learned

One way of capturing knowledge and know-how gained in projects is the use of LL (Buttler et al., 2012). When this process of reviewing projects for learning takes place at the end of the project, it is also called post-mortem evaluation (Baaz et al., 2010). In our study we concentrate on the process of collecting, safeguarding, and sharing LL in project-based organizations. This approach is chosen as the Engineering department of JBV is a project-based organization and improvement opportunities with regard to its LL process exist (see chapter 5). In this section we aim at answering sub-question 1.3 given in chapter 1: what are project LL and which challenges are faced in learning from projects?

LL are lessons from a project (Buttler et al., 2012) which can entail both positive and negative aspects (Baaz et al., 2010). LL can help prevent repeating past mistakes (reinventing the wheel) and safe-guarding best practices (Buttler et al., 2012) and thereby help improve future decision making in projects (Pitagorsky, 2000). Learning from projects and transfer of both explicit and tacit knowledge has been shown to be a critical success factor for projects (Buttler et al., 2012). Other reasons for LL, according to Baaz et al. (2010, pp. 72) can be: “making knowledge explicit, developing knowledge, increasing knowledge sharing within and across projects, increasing job satisfaction, improving participants working relationships, and contributing to learning”.

Lack of learning from projects has been identified in the literature (Williams, 2004) and many organizations struggle with LL processes (Buttler & Lukosch, 2012). The process of collecting LL from projects can be fairly challenging as capturing knowledge about mistakes especially on project management aspects within a project team is complex. This complexity is sometimes
overcome by transferring of knowledgeable individuals in projects. However, the amount of knowledge that can be transferred in this way is limited. Moreover, this knowledge remains in the minds of the individuals and upon their departure will leave the organization. A second way of safeguarding knowledge is capturing, safeguarding, and sharing LL (Buttler et al., 2012). The latter is our main focus during this study.

2.4.1 Learning from projects
Learning from projects faces various difficulties and in this section we take a closer look at some of these aspects:

1. **Identifying LL**: The difficulty of identifying LL, especially those resulting from feedback and dynamic effects, is one of the important challenges. It was found that often project review processes are not in place and little effort is put into discovering lessons that can be useful for future projects. Lack of time for review, lack of standard project-review methods, and lack of ability of finding useful LL are some of the factors contributing to this challenge (Williams, 2004). Also blindness towards current work practices and lack of commitment and incentives can be a potential cause (Baaz et al., 2010). This problem can be made less complex by constructing a process for collecting, documenting, storing, distributing, and reusing LL (Williams, 2004).

2. **Project complexity**: Collecting LL is found to be difficult, among others due to the complexity of projects. Understanding individual aspects will not lead to understanding the system as a whole when problems are complicated and interdependent, making identification of LL challenging. According to Williams (2004, pp. 274), techniques based on “decomposing a project into its constituent parts, has proven insufficient” in extracting LL from projects. Difficulty is not in gathering data about problems but understanding the underlying reasons of a problem taking place. Constructing models and using simulation can be a solution to this challenge (Williams, 2004). Models and simulation can help in finding the root-causes of complex problems (Cooper et al., 2002).

3. **Capturing non-technical LL**: LL can concern issues that are technical as well as organizational (project management related). Research has shown that capturing organizational LL (such as communication, teamwork, vendor selection, stakeholder management, etc.) can be more challenging. One reason for this difficulty is the fact that knowledge on these ‘softer aspects’ is mainly tacit (Buttler et al., 2012). Storytelling together with 5 Whys method (see chapter 4) can be used to identify reasons behind past mistakes. and facilitate transfer of tacit knowledge. Using these methods both the
content and the context of knowledge can be transferred which is needed for tacit knowledge exchange (Buttler & Lukosch, 2012).

4. **Learning**: The next challenge is learning itself. As we saw in section 2.3 sharing knowledge is important in the learning process. Sharing necessitates the ability to identify which individual has what type of knowledge and to which level of specificity. For example, Project Managers (PMs) usually have an overview of the project, while Project Engineers (PEs) possess detailed knowledge. Both types of knowledge are important and complement each other (Buttler et al., 2012). This difficulty can be tackled by providing organizational knowledge maps that can enable individuals to rapidly locate sources of knowledge (Alavi & Leidner, 2001). For these individuals to be willing to share knowledge, the organizational culture plays a pivotal role. An open and honest culture can be a facilitator to learning, whereas a competitive and less transparent culture forms a barrier (Buttler & Lukosch, 2012). Source anonymity in less open cultures can contribute to individuals speaking freely and being critical towards both the process and content of LL (Buttler & Lukosch, 2012).

5. **Manner of gathering**: Gathering LL in groups can lead to better results as not only individual knowledge is collected but also group knowledge through interaction. However, knowledge collection in groups can be hindered by well-known group phenomena such as groupthink (Buttler et al., 2012). Buttler and Lukosch (2012, pp. 4) indicate groupthink to be “a mode of thinking in highly cohesive groups in which the desire to reach unanimous agreements overrides the motivation to adopt proper decision-making procedures”. They point out that this phenomenon leads to “the unquestioning belief that the group must be right and a tendency to ignore or discredit information contrary to the group’s position” (Buttler & Lukosch, 2012, pp. 4). This can result in the group not being critical towards past decisions and the outcome of their activities (Buttler & Lukosch, 2012). This challenge can be combated, according to Pitagorsky (2000), by using a Facilitator and a Scribe for the LL session. Facilitator is an objective individual who is not part of the project team. This person needs to be “compassionately ruthless as well as having project management, content area, and facilitation skills” according to Pitagorsky (2000, pp. 35). Scribe identifies the participants and makes sure all aspects of the project (scope, scheduling, communication, etc.) are reviewed during the session. Scribe can also review project documents to detect possible issues and interview key players to find problems and best practices. He/she can document knowledge during the session and publish and distribute LL (Pitagorsky, 2000).
6. **Lack of LL process:** A systematic process for extracting and disseminating management lessons from projects is required for optimal collection of LL. One of the reasons behind lack of a systematic process, according to Cooper *et al.* (2002, pp. 213), is “the misguided prevalent belief that every project is different, that there is little commonality between projects, or that the differences are so great that separating the differences from the similarities would be difficult if not impossible”). They find this notion not to be true and stresses the need for coming up with a systematic LL process. They also indicate that “the difficulty in determining the true causes of project performance” can also contribute to this issue (Cooper *et al.*, 2002, pp. 213).

7. **Lack of time and conviction:** Often LL and evaluation of projects do not take place due to lack of time as daily tasks take over or because the added-value of LL is not clear (Baaz *et al.*, 2010). Advice is to make time. For example LL sessions can be organized at important milestones/decision points, and also upon completion of projects. Effective capturing of LL requires knowledge collection *during* different phases of a project, such as planning and execution, to capture relevant knowledge (Pitagorsky, 2000).

### Table 2: Challenges in exchanging project LL

<table>
<thead>
<tr>
<th>Potential challenge</th>
<th>Possible remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ability to find useful LL.</td>
<td>1. Construction of LL process for documenting, storing, distributing, and reusing LL.</td>
</tr>
<tr>
<td>2. Project complexity caused by interdependencies.</td>
<td>2. Use of models and simulation.</td>
</tr>
<tr>
<td>3. Collection of organizational LL related to project management aspects (mainly tacit knowledge).</td>
<td>3. Use of Storytelling and 5 Whys method in finding root-causes and providing context.</td>
</tr>
<tr>
<td>4. Identification of knowledge source and level of expertise.</td>
<td>4. Organizational knowledge maps.</td>
</tr>
<tr>
<td>5. Groupthink</td>
<td>5. Use of Facilitator and Scribe in LL sessions.</td>
</tr>
<tr>
<td>7. Lack of time and conviction.</td>
<td>7. Making time and coupling milestones to LL sessions.</td>
</tr>
</tbody>
</table>

Table 2 provides an overview of potential challenges sharing LL can face and how we can remedy them. We saw above that creating and implementing LL processes are important to collection, safeguarding, and sharing of LL. A LL process provides structure and brings about time efficiency (Baaz *et al.*, 2010). Cooper *et al.* (2002) emphasise that for LL processes to be successful, organizations need to: 1) understand that the investment in learning can pay off and
therefore they should expect projects to have two outputs; the product itself and learning, 2) be aware that the right kind of data from past projects is needed to support this learning, 3) make a distinction between truly unique projects and regular ones, and 5) Identify patterns and commonalities between regular projects to help harmonize project management processes and as a result also LL processes.

In constructing and implementing a LL process the advice would be to build on principles people are familiar with (e.g. for JBV this would be the principles of LT given in chapter 5) which would make implementation and acceptance of a LL process easier. In order to facilitate the improvement process, Baaz et al. (2010, pp. 73) recommend the following: “1) reuse the existing LL method’s good qualities, 2) handle known barriers as presented in literature, 3) encourage a balance between excellences (positive) and challenges (negative), and 4) suggest improvements and create commitment”.

2.5 Lean Knowledge Management

We saw above that identifying LL can be difficult and complex, as determining the value of future knowledge can be challenging. LT principles offer guidelines in determining value and the question is to what extent these guidelines are applicable to LL. In order to be able to examine this notion, we need to get a better understanding of applicability of LT principles to KM. Recall 2.3.2 where it is stated that, learning organizations benefit from KM. LT can be applied to activities of such organizations (section 2.2.2) and offer effective implementation of KM efforts. This section addresses sub-question 1.4 given in chapter 1: what is known about applicability of LT principles to KM?

As mentioned earlier, LT originated in the manufacturing sector and its evolvement has been based on specific characteristics of this sector (Dennis, 2002). Research has stated that KM can benefit from potential opportunities LT has to offer (Hicks, 2007). However, it is not clear to what extent LT principles can be applied to non-manufacturing activities and what effects such application can have (Green, 1999 and Hicks, 2007 and Hines et al., 2004).

In this study we focus on LT steps of 1) Define value, 3) Create flow and 4) Establish pull. These three steps where chosen based on insights of section 2.4. Here we saw that, determining the value of LL for future projects is one of the main challenges of LL. Another important challenge is construction of a LL process that would enable collection, safeguarding, and sharing (thus pulling) LL. Based on these insights, we assume that these are the most challenging steps and therefore in need of attention. They can offer better understanding with regard to identification of value of knowledge, determination of future value of knowledge, and creation
of knowledge flow. Such understanding can help improve KM efforts. The other two LT steps, namely: 2) Identify value stream and 5) Strive for perfection are left out of scope in our study. Defining value is needed before identification of waste can take place. Therefore definition of various waste types for KM is not the main focus.

The number of scientific publications with regard to determining value of knowledge and knowledge flow in the context of LT, are rather slim. Hicks has examined the applicability of LT to KM identifying the possibilities and limitations of such application (Hicks, 2007). In a research by Quint Wellington Redwood, IT consultancy and University of Amsterdam highlights the need for adaptability of KM in the future and the role LKM can play in providing this adaptability (Quint Wellington Redwood, 2012). Hendriks et al. (2012) take a closer look at the five principles of LT in their publication in the IT Management magazine. In addition to the above given sources, knowledge pull has been the subject of research in other studies which can be found below.

2.5.1 Value of Knowledge

Identification of value of knowledge is seen as an essential step (Hicks, 2007 and Quint Wellington Redwood, 2012 and Hendriks et al., 2012). By making the customer the main focus of KM activities, valuable knowledge can be identified (Quint Wellington Redwood, 2012). Hendriks et al. (2012) believe valuable knowledge is simple which ensures its understanding. They also emphasize the need to pay attention to knowledge becoming outdated.

Hicks (2007) states that knowledge has value in itself and additional value can be created by how knowledge is organized, represented, exchanged, and visualized. He notes that defining value in the context of KM is challenging as value is subjective. Waste in KM is less visible and more difficult to identify than in manufacturing activities. Defining value can depend on the purpose of using knowledge as well as whether this use takes place in the present or in the future. He believes waste in knowledge can “include the effort necessary to overcome difficulties in retrieving or accessing information, or the activities required to confirm and correct inaccurate information” (Hicks, 2007, pp. 238). He defines valuable knowledge to be appropriate, accurate, and up-to-date. Hicks concludes that this lack of ability to define value and understand waste can be a barrier in applying LKM (Hicks, 2007).

2.5.2 Knowledge Flow

Once value of knowledge has been determined, attention can be given to creating knowledge flow. Hendriks et al. (2012) indicate the need to reach consensus on why KM takes place and how it should take place. Using these two aspects the route and hence flow of knowledge can
be identified and created. When this route is determined, factors that may form a barrier to knowledge flow need to be removed or lowered (Quint Wellington Redwood, 2012).

Hicks identifies four types of waste that may form a barrier to knowledge flow (Hicks, 2007):

1. Knowledge flow is hindered by lack of generation.
2. Knowledge is unable to flow due to lack of identification.
3. Excessive or unnecessary knowledge is generated and maintained, which clogs the system and leads to appropriate and accurate knowledge not easily being identified.
4. Inaccurate knowledge flows resulting in undesirable downstream activities.

In order to prevent these types of waste, duplication of activities should be minimized and outdated or unnecessary knowledge should be removed (Hicks, 2007).

2.5.3 Knowledge Pull

As mentioned earlier, compared to other aspects of LKM, knowledge pull has received more attention in the scientific literature. Knowledge pull is also known as real-time knowledge or Just-in-Time knowledge.

The concept of knowledge pull concentrates on providing knowledge if and when it is demanded by the customer (Hicks, 2007), hence Just-in-Time knowledge. According to Kerschberg and Jeong (2005, pp. 1) “the concept of Just-in-Time KM is appealing in that, the goal is to provide the right information, to the right people, at the right time so they can take action based on that information”. To Malhorta (2005, pp. 17) Just-in-Time KM is delivering knowledge “without latency or delay”. In order to be able to facilitate knowledge pull, future value of knowledge needs to be determined. Hendriks et al. (2012) state that companies are much more aware of their current knowledge needs than their future knowledge needs. Agile software technologies are seen as a promising tool to facilitate knowledge pull (Quint Wellington Redwood, 2012 and Hendriks et al., 2012). The latter, however, is out of the scope of this study.

The task of a pull system for KM according to Mahe and Rieu (1998, pp. 18-4) “consists in bringing people together for them to directly exchange knowledge or to orient them to archives of past projects”. In traditional push approaches the chosen knowledge for future reuse is selected based on a forecast. Making this forecast is found to be difficult. The pull approach has the benefit of providing swift results in contrast to the traditional push approach which requires long investment periods after which results can be experienced (Mahe & Rieu, 1998).
Improving Knowledge Management by means of Lean Thinking

Overproduction of knowledge takes place when extra or unnecessary knowledge is provided or when the delivered knowledge is not in tune with the wishes of the customer. In both cases knowledge is not useful, hence waste. Unnecessary knowledge entails information that is not needed and can be the result of duplicate work or creating irrelevant deliverables. Duplicate work may be the result of redundant functions in working processes, unclear task divisions, or lack of sufficient communication and coordination. Also organizational and process changes that require adjustments can lead to unnecessary knowledge (Oehman & Rebentisch, 2010). Knowledge can also be defective which means there is a valid need for it, however, this need is not properly met (Oehman & Rebentisch, 2010) either because knowledge is not available or wrong knowledge was produced or delivered.

Delivery of knowledge should happen just as it needs to be applied without the customer needing training or being faced with information overload (Cole et al., 1997). Using information technology as a means of KM is not enough and does not remedy this problem. Attention needs to be given to relevant knowledge at a particular time and context for the customer. Easiness of search and simplification of process (without need for training) is seen as an important criterion for knowledge pull processes (Hanka & Fuka, 2000).

2.6 Chapter summary

In order to stay competitive in an international market, companies need to be critical towards their production processes and the quality of their products and services. Learning organizations seek improvement in all their activities and for all their stakeholders, specially their customers. In project-based organizations one way of capturing and exchanging project knowledge and know-how is through project LL. Both KM and LT can improve customer satisfaction with regard to project LL process. The question is whether a combination of these principles is possible and what effects such combination may have. In particular, the extent KM can benefit from LT principles.

Much attention has been given in the scientific literature to principles of LT, KM, and LL. LT consists of five steps: 1) define value, 2) identify value stream, 3) create flow, 4) establish pull, and 5) strive for perfection. Through these steps waste and its root-causes can be identified and eliminated. KM is found to be challenging due to special characteristics of knowledge, such as: 1) knowledge being explicit or tacit, 2) knowledge fading with time, 3) knowledge having a shelf life and becoming irrelevant and outdated, and 4) knowledge at times being subjective and its value difficult to grasp. In addition to these special characteristics, knowledge exchange with
regard to project LL is faced with additional challenges such as: 1) identification of LL, 2) project complexity, and 3) capturing non-technical LL.

In the context of LKM, valuable knowledge needs to be simple to ensure understanding. Attention should be given to irrelevant and outdated knowledge. Overproduction of knowledge through for example duplicate work needs to be prevented. Identifying value of knowledge is found to be challenging due to its possible subjective nature. Knowledge flow can be hindered by: 1) lack of generation, 2) lack of identification, 3) generation and maintenance of excessive or unnecessary knowledge, and 4) flow of inaccurate knowledge. Delivery of knowledge should take place just as the customer needs it without latency or delay. There should also be no need of training for pulling knowledge from the source.
Chapter 3: New Lean Knowledge Management insights

Both Lean Thinking (LT) and Knowledge Management (KM) can contribute to an increase in customer satisfaction. We wish to examine to what extent principles of LT can help improve KM. We specifically look at three principles of LT and their application to KM, namely: Value of Knowledge, Knowledge Flow, and Knowledge Pull.

In chapter 2.5 an overview of related work in the scientific literature with regard to these three aspects was given. We saw that literature on Lean Knowledge Management (LKM) was rather slim and research mainly concentrated on possible difficulties faced in applying LT to KM. Less attention was given to how to overcome such difficulty. In this chapter we address this knowledge gap by building on findings of section 2.5 and providing new insights. We consider potential challenges faced when applying LT to KM and also identify possible manners of overcoming them.

The structure of this chapter is as follows: initially a short recap of specific characteristics of KM is given in section 3.1 and these characteristics form the building blocks of the next sections. Section 3.2 takes a closer look at value of knowledge followed by section 3.3 where knowledge flow is the main focus. Section 3.4 examines possibilities of knowledge pull and in section 3.5 a summary of this chapter can be found.

3.1 Characteristics of Knowledge

When attempting to apply LT principles to improve KM processes, one must take the specific characteristic of knowledge into consideration. Recall, table 1 given in chapter 2. Here, it is useful to return to this table as it provides an overview of important characteristics of knowledge (table 3). We adjusted table 1 by combining characteristics 7 and 8 as they both concentrate on dependency of value of knowledge on other factors.

<table>
<thead>
<tr>
<th>Table 3: Characteristics of Knowledge (table 1 adjusted)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Knowledge can be explicit or tacit.  → Value</td>
</tr>
<tr>
<td>2. Common knowledge is needed for knowledge sharing and exchange.  → Value</td>
</tr>
<tr>
<td>3. Knowledge can fade. Organizations learn and create knowledge but they also forget.  → Value</td>
</tr>
<tr>
<td>4. Organizational memory can have positive or negative effects on future KM activities.  → Flow</td>
</tr>
<tr>
<td>5. Knowledge has a shelf life and can become irrelevant and outdated.  → Value</td>
</tr>
<tr>
<td>6. There is a lack of standards and approaches for KM processes.  → Flow</td>
</tr>
<tr>
<td>7. Knowledge can be subjective and its value can be difficult to grasp.  → Value</td>
</tr>
</tbody>
</table>
In this section, we examine these specific characteristics of knowledge in light of LT principles. However, before we can define value of knowledge, flow of knowledge, and ability to pull knowledge by the customer, we should make sure it is clear who this customer is. When we talk about the customer and his/her needs and wishes in light of KM, we are not talking about the final customer of the product/service which uses knowledge for its production processes. We are talking about the customer of knowledge. In order to prevent confusion between the two, from this section onwards we refer to this customer as knowledge-customer and consider his/her needs and wishes (Hicks, 2007).

### 3.2 Value of Knowledge

In section 2.5.1 we saw that determining the value of knowledge is an essential step in LKM (Hicks, 2007 and Quint Wellington Redwood, 2012 and Hendriks et al., 2012). Knowledge has value in itself and additional value can be created by how knowledge is organized, represented, exchanged, and visualized. Defining value can depend on when its application takes place and for which purpose (Hicks, 2007). Valuable knowledge is simple, up-to-date, appropriate, and accurate (Hicks, 2007 and Hendriks et al., 2012). Determining the value of knowledge can be challenging as knowledge can be subjective (Hicks, 2007). However, by making the knowledge-customer the main focus of KM activities this challenge can be somewhat simplified (Quint Wellington Redwood, 2012).

Even though knowledge is broadly seen as an essential competitive advantage, not enough is known about identification of its value in practice (Malik & Malik, 2008). Effective decision making needs correct, trusted, and specified knowledge. Outdated knowledge can be irrelevant or even lead to wrong decisions. Therefore correctness and trustworthiness of knowledge and its source is essential (Kerschberg & Jeong, 2005). LT emphasizes the need for examining value through the eyes of the customer and determining this value through frequent and regular dialogue (which is known as voice of the customer) (Bhamu & Sangwan, 2014).

#### 3.2.1 New insights regarding value of knowledge

Here we take a closer look at the specific characteristics of knowledge regarding value determination (given in table 3) through a LT lens. Potential challenges to determining value of knowledge are identified and for each challenge, a possible remedy is formulated:

1. **Knowledge can be explicit or tacit.** Explicit knowledge does not have/require context whereas tacit knowledge does (Maqsood et al., 2007). This makes determination of the value of tacit knowledge challenging. A process of determining value needs to enable this context sharing. A manner of transforming tacit knowledge into explicit knowledge
is through discussion groups (Kerschberg & Jeong, 2005). It should be noted that individuals can place knowledge in a different context and reshape knowledge from its original form. Hence tacit knowledge is open to interpretation (Maqsood et al., 2007).

2. **Common knowledge is needed for knowledge sharing and exchange.** This common ground can be created through formal processes with intention of sharing knowledge (trainings, peer-reviews, workshops, etc.) but also via informal processes that may not have knowledge sharing as their main focus (such as chatting with a colleague). Both of these processes can create common knowledge and should be given attention.

3. **Knowledge can fade. Organizations learn and create knowledge but they also forget.** Individuals that were once specialist in a specific topic can forget their knowledge with time, especially if they don’t apply their knowledge on a regular basis. The same analogy applies to organizations. Therefore value determination process needs to take storing, organizing, and retrieving of acquired and created knowledge into account (Alavi & Leidner, 2001).

5. **Knowledge has a shelf life and can become irrelevant and outdated.** Value of knowledge fades with time (Edvardsson & Oskarsson, 2011) and therefore there is a need for selection and elimination of invaluable knowledge (waste). An example of irrelevant knowledge can be information overload caused by poor filtering options (Kerschberg & Jeong, 2005). Before we can eliminate waste, value (of for example standards and guidelines) needs to be determined by experts. The process of determining value should take this aspect into consideration.

7. **Knowledge can be subjective and its value can be difficult to grasp.** Value of knowledge is dependent on many factors such as individuals, objectives of using knowledge, context, culture, norms, etc. (Alavi et al., 2005). Offering feedback opportunities (Mahe & Rieu, 1998) can be a manner of easing this difficulty as it offers the knowledge-customer the opportunity of determining the value of knowledge.

Once valuable knowledge has been identified, its readability and understanding should be improved. This can be reached through structuring of knowledge items and simplifying the content as much as possible. To what extent simplification is desirable, needs to be determined within the enterprise with the aim of maximum simplification (Levy, 2012).

### 3.3 Knowledge Flow

Creating a knowledge flow is the next step that needs attention. As given in section 2.5.2 before we can create a knowledge flow, concession needs to be reached on why and how this flow should take place (Hendriks et al., 2012). Knowledge flow can be hindered by: 1) lack of
knowledge generation, 2) lack of ability to identify valuable knowledge, 3) generation and maintenance of excessive or unnecessary knowledge, and 4) flow of inaccurate knowledge which can clog the system and cause incorrect decision-making (Hicks, 2007).

Valuable knowledge needs to be easy to access by knowledge-customer and easy to update or change by him/her and the administrator (Cole et al., 1997). A framework for exchanging knowledge should be created with emphasis on needs of the knowledge-customer and simplicity (Maqsood et al., 2007). The aim of flow creation tools should be making searching and finding valuable knowledge easy and enabling exchange (Levy, 2012). It was found that formalizing KM processes makes their frequency regular and these processes eventually become a part of the organizational working process (Maqsood et al., 2007).

### 3.3.1 New insights regarding knowledge flow

When looking at the specific characteristics of knowledge (table 3) through a LT lens, the following additional aspects may form a barrier to knowledge flow. Here, a possible remedy is formulated in dealing with each potential challenge:

4. **Organizational memory can have positive or negative effects on future KM activities.**
   
   In case of negative effects or ‘burden of the past’ bias can take place and knowledge flow can be hampered (Alavi & Leidner, 2001). This bias can result in resistance towards change which can be needed for success of KM activities. Creating new positive memories can help overcome this challenge. For example, if LL processes and efforts in the past have not been successful, individuals may be hesitant to take part in a new endeavour. The role of Management in creating positive memories can be key. Management needs to be involved, dedicated, and lead by example which can increase chances of success in new KM efforts (Lyonnet et al., 2012).

6. **There is a lack of standards and approaches for KM processes.** The silver bullet for successful creation of knowledge flow has not been found (Alavi & Leidner, 2001) and it remains to be seen whether such a silver bullet even exists. However, we can learn a great deal by investigating what went wrong in past KM efforts and try not to repeat such mistakes. These lessons can originate from within an organization as well as from outside. It is therefore essential to monitor and evaluate KM processes within an organization. Also keeping in touch with developments in the field of KM through for example collaborations with research institutes and universities, can be important.

When knowledge flow has been created, barriers that can hinder flow need to be removed. Valuable knowledge should be generated and (IT) tools used for knowledge flow should enable
identification of this valuable knowledge. In this way over-generation and over-flow of knowledge can be prevented. KM processes need to include activities for identification of unnecessary and inaccurate knowledge and (IT) tools should offer ways of eliminating them. Special attention needs to be given to prevention of duplications of activities that can result in knowledge overload.

### 3.4 Knowledge Pull

A traditional push system attempts to identify knowledge for future use based on a forecast. Making such a forecast is difficult (Mahe & Rieu, 1998) as value of knowledge can depend on individuals, context, type of knowledge, objectives of using it, time of its use, etc. (Dove, 1999). The result of such traditional push system can therefore be: information overload, irrelevant or outdated knowledge, incorrect knowledge, etc. In contrast to a push system, a knowledge pull system concentrates on providing knowledge if and when it is demanded by the knowledge-customer (Hicks, 2007). In order to facilitate knowledge pull, future value of knowledge needs to be determined. As organizations are more aware of their current knowledge needs than their future needs (Hendriks et al., 2012) this aspect can be challenging.

As we saw in section 2.5.3, a pull system should link individuals with each other to directly exchange knowledge or connect them to databases containing valuable knowledge (Mahe & Rieu, 1998). Also here duplication in activities can result in waste as delivered knowledge may not be in tune with wishes of knowledge-customer. Pulling knowledge may also be hindered by knowledge being unavailable or incorrect (Oehman & Rebentisch, 2010). To provide knowledge just in time to meet knowledge-customer’s demand, attention needs to be given to time and context of knowledge use. Pulling knowledge should be easy and not require training (Hanka & Fuka, 2000).

#### 3.4.1 New insights regarding knowledge pull

We found during this study that a good sign of the need for knowledge is the need for learning indicated by the knowledge-customer. This wish for learning can trigger pulling knowledge from the knowledge source (database or individual). Individuals are usually gravitated towards those who are perceived to be an expert (Malik & Malik, 2008) as they can offer valuable knowledge. Knowledge sharing allows learning to take place through improvement of existing knowledge and combination of present with new knowledge (Maqsood et al., 2007). Hence, creation of a knowledge pull process can use the need for learning as a trigger for pulling knowledge by the knowledge-customer.
Learning mainly takes place via social interaction through which accessibility and sustainability of knowledge is increased. Thus, increase of communication between employees helps to transfer valuable knowledge, experience, and expertise (Malik & Malik, 2008). Through such interaction both the content and the context of knowledge can be transferred which is needed for exchanging tacit knowledge (Buttler & Lukosch, 2012). Formal and informal manners of learning are equally important. Informal interactions help knowledge exchange through hierarchies and both within and outside the organization. Creating opportunities of sharing is a manner of encouraging informal knowledge exchange (Malik & Malik, 2008). A LKM process needs to take these aspects into consideration.

### Table 4: New lean knowledge management insights

<table>
<thead>
<tr>
<th>Value of knowledge</th>
<th>Potential challenge</th>
<th>Possible remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Knowledge can be explicit or tacit.</td>
<td>A. Provide context for tacit knowledge via discussion groups.</td>
<td></td>
</tr>
<tr>
<td>B. Common knowledge is needed for knowledge sharing and exchange.</td>
<td>B. Enable opportunities for creation of common knowledge via formal and informal processes.</td>
<td></td>
</tr>
<tr>
<td>C. Knowledge can fade. Organizations learn and create knowledge but they also forget.</td>
<td>C. Offer storing, organizing, and retrieving opportunities for acquired and created knowledge.</td>
<td></td>
</tr>
<tr>
<td>D. Knowledge has a shelf life and can become irrelevant and outdated.</td>
<td>D. Recognize that knowledge has a shelf life and enable elimination of outdated and irrelevant knowledge.</td>
<td></td>
</tr>
<tr>
<td>E. Knowledge can be subjective and its value difficult to grasp.</td>
<td>E. Offer feedback opportunities to knowledge-customer.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Knowledge flow</th>
<th>Potential challenge</th>
<th>Possible remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Organizational memory can have positive or negative effects on future KM activities.</td>
<td>A. Create positive memories through dedicated involvement of Management.</td>
<td></td>
</tr>
<tr>
<td>B. There is a lack of standards and approaches for KM processes.</td>
<td>B. Learn from KM activities both within and outside the organization.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Knowledge pull</th>
<th>Potential challenge</th>
<th>Possible remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Providing knowledge if and when demanded by the knowledge-customer is challenging.</td>
<td>A. Use wish for learning by knowledge-customer as a trigger for pulling knowledge.</td>
<td></td>
</tr>
<tr>
<td>B. Learning necessitates social interaction.</td>
<td>B. Create formal and informal interaction opportunities within and outside the organization.</td>
<td></td>
</tr>
</tbody>
</table>
LKM insights given in this chapter together with LL findings of section 2.4 form one of the building blocks of LL process improvements given in chapter 7.

### 3.5 Discussion

When attempting to apply LT principles to improve KM processes, the specific characteristic of knowledge should be taken into consideration. Table 4 gives an overview of potential challenges such application can face and possible remedies in dealing with them. These new insights into LKM can help improve success of KM initiatives.

Work of Hicks (2007) on Lean Information Management (given in chapter 2.5) is an important scientific source on LKM. In this section we compare our findings with his work regarding value of knowledge, knowledge flow, and knowledge pull to further improve our understanding of LKM.

**Value of knowledge** – Hicks (2007) states that defining value in the context of KM is difficult as value can be subjective. Value of knowledge, according to him, can depend on the purpose of using knowledge as well as whether this use takes place in the present or in the future. To Hicks (2007) valuable knowledge is appropriate, accurate, and up-to-date. In his work, Hicks mainly focuses on identifying waste in the context of LKM. He notes that this waste is less visible and more difficult to identify than in manufacturing activities.

Recall chapter 2.2.1 where, waste in the context of LT is described. Activities that do not add value and are avoidable are considered to be waste. Before we can identify such waste however, we need to define value from customer’s point of view (Thangarajoo & Smith, 2015 and Oehman & Rebentisch, 2010). In his work Hicks does not address determining value according to knowledge-customer. Even though he identifies potential difficulties in such process, he provides no guidelines in overcoming them. Our findings given in table 4 can be a starting point in dealing with such difficulties and can complement Hicks’s work.

**Knowledge flow** - as given in chapter 2.5.2, Hicks (2007) identifies four types of waste in the context of LKM that can hamper knowledge flow:

1. Knowledge flow is hindered by lack of generation.
2. Knowledge is unable to flow due to lack of identification.
3. Excessive or unnecessary knowledge is generated and maintained which clogs the system and leads to appropriate and accurate knowledge not easily being identified.
4. Inaccurate knowledge flows resulting in undesirable downstream activities.
He advises minimizing duplication of activities and removal of outdated and unnecessary knowledge to prevent such wastes (Hicks, 2007). In table 4, we identified two other possible challenges that can form a barrier to knowledge flow. Negative organizational memory (burden of the past) and lack of standards and approaches for KM can influence creating knowledge flow. Taking all these aspects into consideration can help improve applying LT to KM.

**Knowledge pull** – according to Hicks (2007) knowledge pull is providing knowledge if and when it is demanded by the customer. However, he does not address how this can be achieved. We identified learning as a trigger for pulling knowledge and recommend creating formal and informal social interaction opportunities to facilitate learning (table 4).

We should note here that in our study we left identification of waste in the context of LKM out of scope (chapter 2.5). Hicks’s work on the other hand mainly focuses on identifying this waste. Therefore both findings can provide insight into LKM from different perspectives.

### 3.6 Chapter summary

Determining value of knowledge is an important and challenging step in applying LKM. These challenges arise due to special characteristics of knowledge. It is only after we have defined value from knowledge-customer’s point of view that we can create knowledge flow and identify factors that can hamper this flow (waste). Pulling knowledge can be triggered by the need for learning and through formal and informal social interaction opportunities such knowledge pull can be facilitated.
Chapter 4: Research methodology

The last two chapters have focused on insights based on scientific literature. We wish to apply these findings in practice to test their applicability. For this purpose, we look at the project Lesson Learned (LL) process at the Engineering department of Janssen Biologics (JVB) and examine how this LL process can benefit from our findings on Lean Knowledge Management (LKM), given in chapters 2 and 3. In order to be able to conduct such application, we need to collect information about this case study and get a better understanding of how its LL process works.

This chapter gives an overview of the methodologies and instruments used to collect and analyse data. Section 4.1 concentrates on different methods used in our study for data collection and analysis and gives attention to data verification and validation. In section 4.2, data collection and analysis instruments are described.

4.1 Methods

In order to get a better understanding of the LL process at Engineering, data needs to be collected. Our objective is to construct a picture of the current situation of the LL process. Hereby aspects that are functioning well and those in need of improvement according to the knowledge-customer can be identified. In Lean Thinking (LT) terminology, this identification of needs and wishes of the customer is known as voice of the customer (Womack et al., 1990).

As mentioned in sections 2.4.1, capturing LL and in particular non-technical lessons can be challenging. The reason for this difficulty is the fact that this type of knowledge tends to be tacit (Buttler et al., 2012). Hence, we expect that in addition to explicit knowledge which is often safeguarded in guidelines, standards, directories, etc. of the Engineering department, tacit knowledge in the form of expertise and know-how, needs to be collected. As tacit knowledge requires a context, the selected data collection methodologies need to offer opportunities of providing such context to the collected knowledge. Data to be collected is expected to be mainly of qualitative type and therefore we select accommodating manners of data collection.

Initially data is collected from documents, manuals, guidelines, databases, directories, and JBV’s intranet site. These sources provide basic insight into organization and processes of Engineering. We also collect data from individuals with different roles within the department. This additional data provides better understanding of the current LL process as well as the needs of our knowledge-customer. Following sections concentrate on the latter.
The first method used for data collection in this study is interviews. Interviews offer room for sharing context and allow for extra questions to be asked and feedback to be given (Griffee, 2005). The second method used is workshops, which also provide context to knowledge and offer room for interaction, knowledge exchange, and feedback. The final method is a pilot study. Conducting a pilot study can help in assessing the feasibility and applicability of the improvement model to the LL process. Through this pilot, effectiveness of different improvements can be tested and we can examine the likelihood of their success. Moreover, potential challenges and problems can be identified and possible remedies can be formulated (van Teijlingen & Hundley, 2001).

In the following sections we take a closer look at these three methods and explain in which step of our study they are used. Here, it is useful to return to our research framework given in chapter 1, as this framework (figure 3) provides more clarity. We have slightly adjusted this figure to highlight which methods are applied at which stage and where their results are given.

![Research Framework](image)

**4.1.1 Interviews**

Interviews are seen as a suitable way of collecting qualitative data (Griffee, 2005). They are a common method used for identifying needs and requirements according to key stakeholders (University of Portsmouth, 2010). In this study, the main manner of interviews is face to face individual interviews. We select this manner of interviewing because our knowledge-customers are physically present and we wish to create a safe environment. We anticipate the need for such a safe environment where individuals feel free to express their opinions and perceptions. As the current project LL process is in need of improvement, it might be difficult for
Improving Knowledge Management by means of Lean Thinking

interviewees to express their opinion in a group. Face to face individual interviews have other benefits next to the one given above. Barriball and While (1994) believe this type of interviews have a number of advantages, including: 1) exploring attitudes, values, beliefs, and motives, 2) observing non-verbal indicators which provide opportunities for evaluating validity of answers, 3) facilitating comparability of answers, and 4) ensuring personal response of interviewees without influence from third parties.

There are three types of interview techniques, namely: 1) informal conversational interviews, 2) semi-structured interviews, and 3) standardized open-ended interviews (Department of Health and Human Services, 2009). Semi-structured interviews are most often used in collecting qualitative data (Griffee, 2005) and they are also used in our study. In these interviews, the outline of topics to be covered and the main questions are predetermined. However, the interviewer is free to change the wording and order of questions and ask additional questions in case clarification is needed (Griffee, 2005, Department of Health and Human Services, 2009). Barriball and While (1994) state that semi-structured interviews are well suited for exploring perceptions and opinions with regard to complex issues as they enable probing for more information and providing clarification.

In order to be able to identify the needs and wishes of the knowledge-customers via interviews, we initially need to determine who these knowledge-customers are. We also need to define the outline of the interviews as well as the topics to be covered. This initial data collection takes place via informal conversational interviews. These interviews give insight into activities and working processes of the Engineering department as well as its organizational structure. The finding of these interviews can be found in chapter 5.

Once knowledge-customers are identified and the outline and topics of interviews are determined, the main interview questions are defined. To make sure these questions are suitable and cover all predefined topics, a pilot interview is conducted (Griffee, 2005). This pilot or practice interview not only helps in getting feedback about the content of the interview, but also the approximate amount of time needed, the sequence of questions, and the manner of conducting interviews is evaluated.

As mentioned above, we anticipate the need for a safe environment during interviews so that the interviewees feel comfortable to express their perceptions and opinions. For this reason interviews are anonymous and confidential and their findings are processed as such. We divide our knowledge-customers into three main categories and process data within each category. This, to ensure anonymity and confidentiality of responses. To make sure no information is lost
during the interviews (with permissions of the interviewees); all interviews are recorded and fully transcribed. More on interview questions and knowledge-customer categories can be found in chapter 6.

Knowledge can be subjective and time and context of usage dependent (Alavi et al., 2005 and Dove, 1999). As the knowledge-customers in our case study are expected to have different perceptions and opinions, it is necessary to prevent bias in the collected data. As mentioned earlier, in identification of knowledge-customers different categories are defined. From each category various individuals with different background (such as level of expertise, years of experience, level of education, type of employment, years of employment at JBV, etc.) are selected. In total 21 in-depth interviews are performed. This way different aspects of LL process can be covered and bias in data can be prevented which leads to data verification.

The results of these interviews can be seen as raw data. This raw data can only deliver added value when meaning is derived from it through interpretation. One way of analysing interview data is by becoming familiar with it and its context. When the evaluator is familiar with the data, different categories can emerge during analysis and cause and effect links can become apparent. This allows the evaluator to understand and hence interpret data without imposing his/her personal ideas or convictions (Grifee, 2005).

In this study, initial familiarization takes place via informal conversational interviews in addition to observations and examination of databases, manuals, directories, and intranet site of JBV. The next step is recording and fully transcribing in-depth interviews. These transcriptions are then read several times over a period of time. Through this familiarization, coding (identifying different categories and themes) within collected data can take place (Grifee, 2005). Coding of data is applied consistently across all interviews through which a summary of each theme/category is made. The summary of our interpretations can be found in chapter 6.

We need to make sure interpretations made above represent the views and opinions of the interviewees. Therefore, interview findings need to be validated. One manner of data validation is through re-interviewing. This can take place individually or in a group (Grifee, 2005). Due to time limitations, a group re-interviewing technique is chosen for our study in the form of a “LL-process workshop”.

4.1.2 Workshops

Workshops can be used to collect data as well as to validate data. In this study we use them for both of these purposes. Workshops are suitable as they provide interaction and there is room for feedback and active sharing of knowledge (Wang & Noe, 2010).

The first workshop we organise is a “LL-process workshop” where data, collected by means of in-depth interviews, is validated. This workshop is also used to receive guidance from experts on possible direction for model improvements (see below). The validated data in the first part of this workshop is then used as input for this expert guidance. A selection of our knowledge-customers is invited to take part in this two hour workshop. This selection consists of representatives from different categories of interviewees with various areas of expertise. More about organization and results of this workshop can be found in chapter 6.

Based on our findings from literature (chapters 2 and 3) and our findings from the case study (chapters 5 and 6), we construct an initial improvement model for the LL process (chapter 7). This model needs to be verified and validated. Verification takes place by means of expert advice on formulating improvement proposals (chapter 7). In order to test the applicability and workability of our model in practice, and hence validation of our model, we conduct a pilot study (chapter 8). All the above given steps aim at improvements specific to the Engineering department. However, we also wish to examine the applicability of our model to other departments of JBV, for which we organise a second workshop.

A “generalization workshop” is organized to examine the degree of applicability of our findings to other departments of JBV. Representatives from various JBV departments with different backgrounds and areas of expertise, are invited to this workshop. We aim at having a diverse group, to ensure all aspects of selected topics are considered and discussed. Information about organization and results of the “generalization workshop” can be found in chapter 8.

4.1.3 Pilot study

As mentioned in the previous section, we wish to test the applicability of our initial model in practice and thereby validate it. For this purpose, we organise a pilot study. Our knowledge-customers, who took part in the in-depth interviews, are our target group. This pilot has a duration of 6 weeks. Our target group works on different projects and all of them are part of the pilot study (regardless of their stage). Data collection takes place via email, personal conversations, and participation in different meetings. Through this pilot we wish to create acceptance for change, detect potential problems, and find effective and workable solutions.
(van Teijlingen & Hundley, 2001). The results are used to improve our initial model and its applicability in practice. More information about this pilot and its findings given in chapter 8.

4.2 Instruments

In our study, we use different techniques for collecting and analysing data. The 5 Whys is used during interviews and conversations for effective data collection. SADT technique is used to visually represent processes and important activities. The fishbone diagram helps to visualise cause and effect relations between interview findings. Below a short description can be found.

4.2.1 The 5 Whys

The 5 Whys technique was developed by Toyota for finding root-causes to problems and is widely used within LT initiatives. The idea behind this technique is that, every effect has a cause and it is only by determining the underlying cause of effects that we can solve problems effectively. The first step is to define the problem completely and accurately. Next, the initial cause of this problem is defined by asking why and repeating this process five times. Often after five times, the root-causes of problems can be identified. This technique is both simple and effective and can be applied to problems of different nature (Serrat, 2009). After root-causes of problems (waste) are identified, we can determine ways of dealing with them effectively (Zidel, 2006). We apply this technique during our informal and in-depth interviews as well as in workshops and conversations. Our aim is to identify problems and their root-causes (chapter 6).

4.2.2 SADT

Structured Analysis and Design Technique (SADT) is a visual instrument used to illustrate systems in an orderly and well-structured manner. This technique can be applied to any kind of system and offers insight through decomposition. SADT is used for data analysis and its findings can contribute to better understanding of complex issues (Marca, 2013).

SADT technique concentrates on activities (anything that can be described by an active verb) and their interrelation. Inputs and outputs of each activity are defined as well as control and mechanisms affecting them (Kappes, 1997). Figure 4 illustrates a basic SADT diagram. Input is all that is used to produce the output. Control represents constraints to an activity and mechanism is all resources needed to perform it. Output is all input that is transformed by the activity (Kappes, 1997). We use this technique to illustrate project...
steps, LL process before, and after improvements (chapters 6 and 7).

### 4.2.3 The Fishbone diagram

The Fishbone diagram (figure 5) is another technique widely used in LT initiates. This instrument illustrates the relationship between attributes and factors related to them.

Problem statement is given on the main section and possible causes on each side. There are 6 main categories that can contribute to a problem: human, methods, measurements, machines, materials, and Mother Nature. Fishbone diagram is also known as the cause-and-effect technique (Yazdani & Tavakkoli-Moghaddam, 2012). We use this technique in chapter 6 to categorize our findings of the in-depth interviews.

![Figure 5: General Fishbone diagram](image)

### 4.3 Chapter summary

Data collection is performed to get a better understanding of the LL process at the Engineering department of JBV. This data can provide insight into the current situation of the LL process. Hereby aspects that are well functioning and those in need of improvement according to the knowledge-customer can be identified. Three main methods are applied for data collection.

The first method selected is interviews. They provide room for sharing context and offer opportunities of feedback. Workshops are the second method used. They too provide context to knowledge and give room for interaction, knowledge exchange, and feedback. Finally, a pilot study is conducted to help assess feasibility and applicability of the improvements in practice.

We also apply instruments to collect and analyse data. The 5 Whys is used during interviews and conversations for effective root-cause identification. SADT technique facilitates visual representation of processes and activities. Lastly, the fishbone diagram contributes to identification of cause and effect relations through visualization.
Chapter 5: An introduction to the Engineering department

In order to examine the applicability of our theoretical findings of chapters 2 and 3, we wish to implement them in a case study. Our case study is conducted at the Engineering department of Janssen Biologics (JVB) located in Leiden, The Netherlands. We aim at improving project Lessons Learned (LL) process of this department by means of Lean Knowledge Management (LKM). In order to be able to do so, we initially need to get a better understanding of the organization of the Engineering department, how they conduct projects, and their process of LL. The following two chapters provide these insights, starting with an introduction to the case study in this chapter.

In section 5.1 a short introduction to JVB is provided, followed by section 5.2 where a general description of the Engineering department and its activities are given. In this section sub-question 2.1 formulated in chapter 1 is partially addressed. Flawless Project eXecution (FPX) project management methodology is the main focus of section 5.3. Section 5.4 concentrates on the project LL process and looks at documented and undocumented LL. A summary of this chapter can be found in section 5.5.

5.1 Janssen Biologics BV

JVB, a subsidiary of Johnson & Johnson (2014), is a biopharmaceutical company that produces, acquires, and markets unique medicines in an international market. This company has a leading position in research, development, and production of monoclonal antibodies that focus on three disease categories, namely: cardiovascular, immunological disorders, and cancer. The driving force behind JVB’s activities is the needs of patients. In order to be able to meet these needs, JVB invests in research, forges partnerships, and above all invests in its employees. Through these efforts JVB is able to offer high quality products to patients (Janssen Biologics, 2015).

Recall chapter 2.1.1, where learning organizations are identified to be those that seek learning and improvement in all their activities and for all their stakeholders (McGill & Slocum, 1993). JVB (and hence the Engineering department) can be categorized as a learning organization for the following reasons.

The employees of JVB are the ones making the difference in all of the company’s activities (Janssen Biologics, 2015) and JVB offers them opportunities for learning and development. JVB employees follow trainings on a regular basis, covering industry and areas of expertise. Each
employee has a yearly educational budget that he/she (in consultation with his/her manager) can spend on education and development purposes (J BV A, 2015).

Learning is not just limited to development of individual employees as attention is also given to overall improvement of business and production processes throughout the company. Here, Lean Thinking (LT) plays an essential role. Improvements mainly take place through two types of initiatives: Continuous Improvements and Business Improvements (BIs). Continuous improvements focus on activities within departments and can be initiated by all employees. Interdepartmental initiatives aiming at process improvement throughout the company are called BIs (J BV A, 2015).

In chapter 2.3.2 we underline the role company culture plays in knowledge sharing. This culture also influences learning with regard to LL from projects (chapter 2.4.1). Cooperative cultures encourage knowledge sharing and offer opportunities of learning, whereas competitive cultures hamper these activities (Wang & Noe, 2010 and Buttler & Lukosch, 2012). This aspect of Knowledge Management (KM) is left out of the scope of our study due to time restrictions and needs to be studied in the future.

5.2 Engineering department

JBV has different departments among which the Facility, Maintenance, and Engineering department. This department manages buildings, technical installations, and other equipment of the company (Janssen Biologics, 2015). Knowledge exchange at this department takes place through formal and informal channels. Formal channels include: employee initiated updates or departmental and group meetings.

The Engineering department supports JBV’s manufacturing activities through improvements and modifications to production equipment and installations and facilities. This department works closely with other departments of JBV to achieve the best possible results in a cost-effective manner (Janssen Biologics, 2015). The majority of the activities at Engineering are project-based, which makes this department a project-based organization. The work-load of this department has increased in recent years, which has brought about the need for better management of its knowledge assets. These aspects together with JBV being a learning organization and applying LT broadly throughout its business and production processes, makes the Engineering department a suitable candidate for our study.

Within the Engineering department, knowledge is exchanged in a formal and informal manner. All employees of this department are required to take part in monthly Departmental Meetings.
and weekly Check-in sessions, which are two formal manners of exchanging knowledge. In the following sections, attention is given to knowledge exchange with regard to activities at the Engineering department. However, we initially introduce different categories of employees, through which we partially address sub-questions 2.1 of chapter 1: who are the main stakeholders?

5.2.1 Employees of the Engineering department

The employees of the Engineering department can be divided into four main categories (JBV A, 2015):

1. **Modification Engineers**: mainly work on BIs, however, some of them can also take on the role of Project Engineer (PE) in projects if and when needed.
2. **Project Engineers**: take part in projects and provide the content related expertise needed (e.g. electrical, mechanical, civil, etc.). A number of senior PEs can also take on the role of the Project Manager (PM) in smaller projects.
3. **Project Managers**: are mainly dedicated to project management activities such as keeping track of planning, resources, costs, etc. They are responsible for project progress during its lifetime.
4. **Management**: is responsible for the overall optimal functionality of all activities of the Engineering department.

5.2.2 Activities of the Engineering department

Activities at Engineering can be divided into two main categories, namely: BIs and projects. BIs are low complexity improvements and modifications with a technical or civil character. Mid to high complexity improvements or modifications take place through projects. Distinction between these two categories is made based on the number of disciplines and time needed for their execution. BIs, in general, involve fewer departments than projects and require less time to implement (JBV A, 2015).

**Business Improvements** - As mentioned earlier, low complexity improvement initiatives from JBV departments, are known as BIs. When these initiatives have mainly a technical or civil character, they are led by the Engineering department. One engineer (also known as modification engineer) is assigned to each BI. This engineer is appointed based on his/her area of expertise and availability. Tasks of a modification engineer are diverse and include: cost calculations, planning, design, etc. (JBV A, 2015).
BIs are managed through the *Visual Scheduling Board* of Engineering, which provides the modification engineer an overview of the status for each BI. Knowledge exchange between these engineers mainly takes place in an informal manner. They usually sit close to each other and often feel free to consult their colleagues when faced with a challenge. Once every two weeks a *Modification Meeting* is held to discuss the status of on-going BIs and issues faced (JVBA, 2015).

**Projects** - Projects carried out at JBV are both global and local. Generally speaking, everyone can come up with an idea which leads to a project. However, the business owner needs to approve this idea and act as its sponsor. The business owner is therefore the official requester of a project. After the approval of a project, this sponsor becomes the customer of the Engineering department (in cases where input from Engineering is needed for performing a project) (JVBA, 2015). In this study we only consider approved projects.

A PM is appointed to each approved project and in cases of projects with mainly a technical or civil character; this PM is from the Engineering department. The PM is responsible for putting together a project team and keeping track of project progress. For such projects, also a PE from the Engineering department is assigned as a core team member (JVBA, 2015).

Knowledge exchange with regard to projects is both formal and informal. PMs generally sit close to each other and so do the PEs. Informal exchange of knowledge often takes place within each group; however, they also exchange knowledge with each other. Formal manners of knowledge exchange are weekly project meetings (*Core Team Meetings*) and biweekly *Status Update* meetings for on-going projects at Engineering (JVBA, 2015).

### 5.3 FPX project management methodology

Most projects at JBV follow specific project management guidelines which are called FPX. The main focus here is on stakeholder management and team alignment. In FPX terminology the project team (including the PM) is called core team and its members (which can be PEs) are called core team members. Each project holds a weekly meeting called the core team meeting where all core team members are present. These members are from different departments in JBV and can have extended team members within their own department. These extended team members support the activities of the core team member and provide assistance when needed. Each project has a sponsor who is the requestor of the project (JVBA, 2015).

All those who are part of the core team are required to follow the FPX training. PMs follow a two day project lead FPX training and core team members follow a one day core team member
training. During these trainings participants learn how to use the FPX methodology. It is recommended for modification engineers to follow the core team member FPX training even when they do not take part in projects. Most projects follow the FPX guidelines; however, it is possible that in unique projects some aspects of FPX are not fully implemented. BIs require less structure and therefore do not strictly follow FPX project management guidelines (JBV A, 2015).

5.4 Project LL process

Cross project learning and knowledge exchange are great ways of improving efficiency and preventing rework in project-based organizations. As mentioned in chapter 2.4, sharing project LL, which is the main focus of this study, can contribute to cross project learning and knowledge exchange (Baaz et al., 2010). Knowledge and experiences gained during project lifetime are called LL (Buttler et al., 2012).

At Engineering, there is a formal LL process for projects but not for BIs. Project LL consist of both explicit and tacit knowledge. Explicit knowledge gained through projects and found important to future activities is often safeguarded in standards and guidelines. Tacit knowledge is gained in the form of know-how and experience. Recall chapter 2.3.2 where it is given that some assume tacit knowledge to be more valuable than explicit (Alavi & Leidner, 2001). At Engineering, both types of knowledge are seen as important.

Knowledge exchange with regard to LL of projects takes place in both a formal and an informal manner. The formal process involves documentation of LL in projects (JBV A, 2015). In order to distinguish between these two manners of knowledge exchange, we label the formal manner “documented LL” exchange and the informal manner “undocumented LL” exchange.

Undocumented LL are the personal knowledge and know-how a PM or PE gains by participating in a project. Exchange of these LL mainly takes place in an ad hoc and informal manner through personal contact with others. This manner of sharing LL is part of daily activities of most PMs and PEs at Engineering and functions well. The same could be said about LL of BIs with regard to informal knowledge exchange (JBV A, 2015).

This ad hoc and informal manner of exchanging LL is dependent on personal preferences of individuals as well as their availability of time and physical presence. These aspects determine the manner and frequency of exchanging LL, which are found to vary. Next to this informal manner of exchanging LL, there is a formal LL process for projects (JBV A, 2015).

Documented LL are a formal part of project steps. According to FPX guidelines, collecting project LL is an activity which is typically performed at the end of a project. The aim is...
identifying aspects of the project that were performed well or poorly. FPX advises to share these LL to improve future projects. Collecting LL, according to FPX guidelines, should take place during an Evaluation/LL Meeting organized by the PM shortly after project close-out. Core team members, sponsors, stakeholders, and key extended team members are to be invited to this session. Beforehand a survey should be prepared and sent, so that attendees can comment on key areas of the project. The PM should summarize replies of this survey and discuss them during this meeting. FPX also advises to have an external facilitator. Key LL are to be identified and stored in the LL database. It should be noted that LL are an explicit part of the PM FPX training and are given less attention during the core team member training (FPX training that the PEs attend) (JBV A, 2015).

5.5 Chapter summary

JBV is a biopharmaceutical company and a subsidiary of Johnson & Johnson. This company can be categorized as a learning organization for two reasons. 1) JBV provides opportunities of learning and development for its employees and 2) achieves overall business and production process improvement through LT initiatives.

Engineering is a sub-department of Facility, Maintenance, and Engineering department. Knowledge exchange at this department takes place via formal and informal channels. Employees of Engineering can be divided into four categories, namely: 1) modification engineers, 2) PEs, 3) PMs, and 4) Management. Activities at this department (BIs and projects) concentrate on improvements and modifications with a technical or civil character. BIs are low complexity modifications whereas projects are mid to high complexity. Distinction between these two categories is made based on the number of disciplines and time needed for their execution.

Most projects at JBV follow specific project management guidelines which are called FPX. Following a FPX training is a requirement for those who are core team members. PMs follow a two day project lead training and core team members follow a one day core team member training. Knowledge exchange with regard to LL of projects takes place both formally (documented LL) and informally (undocumented LL). Sharing of undocumented LL is part of daily activities at Engineering and functions well. However, this manner of exchange is dependent on personal preferences of individuals as well as their availability of time and physical presence.

Documented LL are a formal part of project steps and according to FPX guidelines, collecting project LL is performed at the end of a project. Collecting LL takes place during an Evaluation/LL meeting.
Meeting organized by the PM shortly after project close-out. Core team members, sponsors, stakeholders, and key extended team members are invited to participate in this meeting. LL are an explicit part of the PM project lead FPX training and are given less attention during core team member training that the PEs attend.

This chapter introduced us to the Engineering department of JBV. In chapter 6 we take a closer look at this department and specifically its LL process. Through in-depth interviews we aim at getting a better understanding of the current situation and the wishes of our knowledge-customer.
Chapter 6: Results and analysis

Chapter 5 gave an introduction to the Engineering department case study and its need for better management of knowledge resources. This chapter builds on this and aims at providing more insight into the Lessons Learned (LL) process of projects. We describe how in-depth interviews are performed and a “LL-process workshop” is organized. Data collected through these interviews and workshop is then analysed and a discussion of our findings is provided.

In section 6.1 organization of interviews is given, followed by their results in 6.2. Here, sub-questions 2.1 and 2.2 formulated in chapter 1 are addressed. In section 6.3 a discussion of our findings from the interviews can be found. Organization of the LL-process workshop and its results is the focus of section 6.4 where sub-question 2.3 is answered. A discussion of these outcomes is given in section 6.5 and the chapter summary can be found in section 6.6.

6.1 Performing in-depth interviews

The workload of the Engineering department has increased in recent years. Through better management of its knowledge assets and in particular improvement of its LL process, a more efficient use of time and resources can be gained (JBV A, 2015). We performed in-depth interviews to get a better understanding of the current LL process as well as needs and wishes at Engineering with regard to its improvement (chapter 4.1.1). Our findings from literature (chapters 2 and 3) and the case study (chapters 5) are used as preparation for these interviews.

Recall chapter 5.4, where a distinction between documented LL and undocumented LL is made. Our initial findings indicate that knowledge exchange with regard to undocumented LL functions well. This ad hoc and informal manner of exchange, however, is dependent on personal preferences. Also time availability and physical presence of individuals can be of influence. There is a need for a structured and resilient process to complement this informal manner of LL exchange. Such a process can be monitored, evaluated, and improved if and when needed. This is the documented LL process and the main focus of our study.

Employees of the Engineering department (our knowledge-customers) can be divided into four main categories: modification engineers, Project Engineers (PEs), Project Managers (PMs), and Management. This categorization is made based on their role and activities they perform (see chapter 5.2.1). Those selected for interviews have different background (such as level of expertise, years of experience, level of education, etc.) to ensure diversity. Hereby, the current situation can be examined from different angles.
In total 21 individuals were interviewed:

- 7 Modification engineers
- 9 Project Engineers
- 4 Project Managers
- 1 Manager

For each knowledge-customer category, a different set of questions is formulated based on our findings from chapters 2, 3, and 5. Questions intended for the modification engineers and the PEs give more attention to Business Improvement (BI) and project steps as well as the LL process (respectively appendix 1 and 2). PMs and Management questions concentrate on long-term objectives and strategies regarding Knowledge Management (KM) and general needs and wishes concerning the LL process (respectively appendix 3 and 4).

The modification engineers and the PEs were notified approximately a week in advance about the purpose of interviews and the type of information needed from them. It was also communicated that their responses are anonymous and confidential, thereby creating a safe environment (see also chapter 4.1.1).

Modification engineers were asked to select two BIs they had worked on and concentrate on knowledge exchange during their course. The aim of this selection is to see which steps are taken by each engineer during the BIs he/she works on. As a modification engineer works alone on BIs, we wish to examine whether a standard process is followed. Those engineers also taking part in projects as core team member were asked to consider the LL process (appendix 5).

For the PEs, we selected 4 projects they had worked on which were either completed or in their final stages (appendix 6). This selection is made in such a way that at least two interviewees had taken part in each project. Our goal here is to examine project steps taken by various individuals and whether there are similarities. We asked all PEs to also consider the LL process prior to their interview. Selection of specific BIs and projects helps prevent interviewees talking about abstract activities. By concentrating on personal experiences more insight can be derived from given answers.

All interviews were recorded with permission of interviewees so that we could concentrate on the given responses. We applied the 5 Whys method (chapter 4.2.1) to determine root-causes of problems during interviews. In cases where answers were not clear or we expected underlying effects were not mentioned, we asked additional questions. However, we chose not to influence the interviews. For example, an interviewee is asked whether he uses documented
Improving Knowledge Management by means of Lean Thinking

LL as a source of knowledge in his projects and why. Imagine that his response is no and that he only mentions lack of clarity on roles and responsibilities to be the reason. We know from prior interviews that some engineers also find the LL system not user-friendly. In such a case, we will not ask follow up questions which can guide the response towards this topic. Our follow up questions would solely concern root-causes with regard to roles and responsibilities.

At the end of each interview, participants were asked to give feedback on how the interview was performed and if any aspects were missing. We also reviewed interview questions and manner of performing them ourselves. This was used to improve the interviewing process.

6.2 Results of in-depth interviews

We analyse the results of the in-depth interviews for each category of knowledge-customers. This way, anonymity and confidentiality of results can be achieved. This section provides the main results for modification engineers, PEs, and PMs and Management. We hereby address sub-questions 2.1 given in chapter 1: **who are the main stakeholders and what are their needs?** and sub-question 2.2: **How are project LL currently exchanged between these stakeholders?**

6.2.1 Modification Engineers

Interview questions for this category concentrated on knowledge exchange and steps taken during BIs. Those modification engineers that participate in projects as core team members were also asked to comment on the documented LL process of projects. Detailed interview results can be found in appendix 7.

**Knowledge exchange** - all those interviewed are found to be open to sharing knowledge. Formal sharing takes place during the **Modification Meeting**; however, the main manner is verbal and face to face communication. Some are proactive in searching and exchanging knowledge whereas others prefer to ask or answer questions when necessary. Those with more years of experience know which colleagues have certain type of knowledge and expertise.

**BI steps** - BIs do not follow the Flawless Project eXecution (FPX) project management methodology (see chapter 5.3). **Visual Scheduling Board** provides an overview of BIs, their status, and their dedicated engineer (chapter 5.2.2). This board defines 4 stages for BIs: Feasibility/Design, Preparation, Execution, and Finalization. Most BIs are found to go through these stages. However, the way of working, the order of stages, and which third parties are involved at which stage are found to vary depending on the modification engineer. We find BIs to be less structured than projects. No formal process is followed in carrying out a BI. This is mainly due to the fact that BIs are very diverse and can entail a vast variety of modifications.
and improvements. It is difficult to standardize process steps for these activities. There is no formal LL process for BIs and LL exchange is mainly ad hoc and informal.

As BIs are less structured than projects and do not have a formal LL process, we leave them out of the scope of our study. Hence, their results are not analysed in detail. It should be noted here that some interviewees indicate the need for more structure with regard to knowledge documentation and exchange. LL of BIs are seen as a great source of knowledge for all at Engineering by several interviewees. They indicate the need for a formal LL process for BIs. These aspects need to be examined in the future.

**Documented LL process of projects** - as mentioned in chapter 5.2.1, some modification engineers can take on the role of the PE in projects as a core team member. This group (4 out of 7 participants) is asked questions about the LL process of projects. These results remain part of our study scope and are analysed here (appendix 7).

It is found that all 4 participants do not use documented LL as a source of knowledge in their projects. The main reason is, difficulties faced during searching. Some indicate that document names do not correspond with the LL content. The manner of saving documents (scanning) can become a barrier. Working with SharePoint (intranet storage location) is also seen as a challenge by some. Lack of overview and categories of LL is another root-cause. Next to searching difficulties, ambiguity about FPX guidelines on roles and responsibilities and the LL procedure are mentioned as reasons for not using documented LL. An overview of the above given findings can be found in table 5.

As lack of categories and overview is given as one of the root-causes, we asked the 4 participant to name 5 categories of LL they would find valuable to their projects. These are (see table 6):

1. Communication and collaboration.
2. Project coordination and roles and responsibilities.
3. Vendor evaluation.
4. Planning.
5. Technical aspects.

**6.2.2 Project Engineers**

The PEs were asked questions with regard to knowledge exchange, steps they take during their projects, and documented LL process. Detailed interview results are given in appendix 8.
Knowledge exchange - the PEs interviewed are found to be open to sharing knowledge. Knowledge is exchanged mainly within the core team but also with extended team members and other stakeholders. Manner of exchange is often face to face and verbal communication and has an informal character. Some are proactive while others only share when approached. Most respondents find informal knowledge exchange to function well.

Project steps - projects reviewed during interviews follow FPX guidelines (chapter 5.3), which correspond to the Four-Phase Model of project management (figure 6). In this model 4 phases are defined for a project lifecycle (for more information about these phases refer to the cited book) (Nicholas & Steyn, 2012):

1. **Conception**: initiation, feasibility, and proposal preparation steps. Conception is out of scope in our study as we only consider projects that are approved and seen as feasible.
2. **Definition**: project/system definition and user and system requirements formulation.
3. **Execution**: design, production/build, fabrication, testing, implementation, training, acceptance tests, installation, and termination steps.
4. **Operation**: system maintenance and evaluation. Note that only short-term maintenance (aftercare) of the system is part of this project step.

Projects are found to have a clear structure and the above given phases are followed in the intended order. Depending on project complexity, different sub-phases can be defined. However, as we wish to get a high level overview of projects we only concentrate on the above given 4 phases. The main role of the PEs in projects is providing content related expertise. Knowledge sources are individuals (within and outside the department) and systems (databases, project directory, standards, guidelines, technical documentation, etc.).

Involvement in the LL process (chapter 5.4) is through participation in the **LL/evaluation** meeting at the end of a project.

Documented LL process of projects - all participants indicate that they do not use documented LL as a source of knowledge in new projects. Three main causes identified in order of importance to the PEs are: 1) searching, 2) roles and responsibilities, and 3) procedure. Table 5 gives an overview of root-causes behind each category.
### Table 5: Why are documented LL not used as knowledge input in new projects?

<table>
<thead>
<tr>
<th>Searching</th>
<th>Root-cause</th>
<th>PE (9)*</th>
<th>Mod. Eng. (4)*</th>
<th>PM (4)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>There is a lack of overview and categories.</td>
<td>6</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>2.</td>
<td>Working with SharePoint is difficult.</td>
<td>5</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>2.1</td>
<td>There are too many SharePoints.</td>
<td>3</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>2.2</td>
<td>Not everyone has access.</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2.3</td>
<td>A link is needed to get to the right SharePoint.</td>
<td>3</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>3.</td>
<td>LL are scanned and saved as PDF; searching via keywords is not possible.</td>
<td>4</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>4.</td>
<td>Name of document does not correspond with content of LL.</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>5.</td>
<td>Directory contains both project close-out and project review documents.</td>
<td>2</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>5.1</td>
<td>These documents are not only used for LL purposes.</td>
<td>2</td>
<td>-</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Roles and responsibilities</th>
<th>Root-cause</th>
<th>PE (9)*</th>
<th>Mod. Eng. (4)*</th>
<th>PM (4)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>FPX guidelines with regard to roles and responsibilities are not known to all.</td>
<td>4</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>2.</td>
<td>I don’t know what is expected of me.</td>
<td>2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3.</td>
<td>I don’t know what I can expect of others.</td>
<td>2</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Root-cause</th>
<th>PE (9)*</th>
<th>Mod. Eng. (4)*</th>
<th>PM (4)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Organization and/or form of LL/evaluation session is PM dependent.</td>
<td>5</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>1.1</td>
<td>Participants of this session are not predefined.</td>
<td>4</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>1.2</td>
<td>When LL documentation or retrieval should take place, is not predefined.</td>
<td>3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2.</td>
<td>There is a lack of trigger in project documents for LL retrieval.</td>
<td>5</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>3.</td>
<td>There is a lack of consistency in implementation of FPX guidelines.</td>
<td>4</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

* No conclusion should be drawn from these numbers at this stage. We will come back to them in chapter 7.
PESs are asked to name 5 categories of LL they find valuable for their projects (table 6):

1. Communication and collaboration with other departments.
2. Project coordination and roles and responsibilities.
3. Planning.
4. Vendor selection and contracts with third parties.
5. Safety.

Table 6: Categories of LL valuable to new projects

<table>
<thead>
<tr>
<th>Category</th>
<th>PE (9)*</th>
<th>Mod. Eng. (4)*</th>
<th>PM (4)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Communication &amp; collaboration</td>
<td>9</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>2. Project coordination &amp; roles and responsibilities</td>
<td>8</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>3. Planning</td>
<td>7</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>4. Vendor selection &amp; evaluation</td>
<td>5</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>5. Safety</td>
<td>4</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>5. Resources</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>5. Technical aspects</td>
<td>-</td>
<td>2</td>
<td>-</td>
</tr>
</tbody>
</table>

* No conclusion should be drawn from these numbers at this stage. We will come back to them in chapter 7.

6.2.3 Project Managers & Management

In this section interview results of both PMs and Management are given, as issues covered during these interviews were similar. This also ensures confidentiality and anonymity of responses as only 1 manager was interviewed. The emphasis of the findings given below is, however, on PMs. The main topics of interviews were knowledge exchange, project steps, and documented LL process. Detailed results can be found in appendix 9.

Knowledge exchange - informal verbal communication is found to be the main manner of knowledge exchange. Most PMs indicate they operate autonomously and are open to sharing information. Assertiveness and effective communication and organization skills are seen as important.

Project steps - one of the first activities of PMs is putting together a project team. This core team comes together during the Kick-off meeting to discuss the project. Extended core team members and project sponsor also attend this meeting. The PM uses the Project Brief document (appendix 10) to collect necessary data about the project, including: scope, team, planning, milestones, resources, etc. This document is used as input for the Kick-off meeting.
The PM uses this information during the Portfolio Review meeting (chapter 5.2.2) to get approval from resource managers on required resources. However, first a peer-review takes place. The Project Brief is used by the PM throughout the project lifetime to keep track of progress. In the Core Team meetings relevant information is saved in this document. At the end of a project a LL/evaluation meeting is organized (chapter 5.2.2). Also here, the PM uses this document to collect important lessons.

After project termination, the PM uses the Project Review document (appendix 11) to close-out the project. Issues such as project costs, goals, quality, and customer satisfaction are part of this document. Key LL are one of the aspects given specific attention. PMs are asked to evaluate their project specifically on aspects relating to contractor performance and safety, health and environment (SHE). This document is reviewed by a peer. The Project Review is used in closing out a project during the Portfolio Review meeting.

Figure 6: LL process in project steps before improvements

The above given project steps are visualized using SADT technique (chapter 4.2.2) in figure 6. The purple arrow represents input and the red arrow output of a project. Blue arrows indicate
control actions required for a project step and without which this step cannot take place. For example a peer-review of the Project Brief document is needed before it can be presented to resource managers at the Portfolio Review meeting. Control actions are also those that trigger activity in a project step. Such actions are often output of a former step. For example, a project plan containing information about activities, schedules, budget, and resources needs to be formulated before design, build, and implementation of a system.

The green arrows represent the means necessary to perform a project step (e.g. people, documents, systems, etc.). A1 to A4 represent the sequence of activities. Note that in figure 6 operate step has been highlighted purple. This to indicate that the main focus of the current LL process is on this project step. It should be mentioned that a project has many inputs, outputs, controls, and mechanisms. Here, we only mention those that are essential to the documented LL process.

**Documented LL process of projects** - generally speaking, the documented LL process is as follows. After project termination, a LL/evaluation meeting is organized by the PM. The Project Brief document is used to guide the collection of lessons in this meeting. Important lessons are then transferred to the Project Review document. After peer-review, the latter document is presented to resource managers at the Portfolio Review meeting. Here, LL are discussed in detail. It should be noted that officially no project can be closed-out without documented LL. At this meeting, it is decided if LL should be shared at the Cross Functional meeting, where PMs of all departments are invited. After closing out a project, the Project Review document is scanned and saved at the project close-out location by the SharePoint administrator.

The current storage location of LL has the following structure. The Project Review documents are saved based on the year of their closure. In this folder documents are saved according to project name and/or project number. Stored Project Review documents go back to 2009 and about 78% of all closed-out projects have LL. It should be noted that feasibility studies are also saved here and these studies do not contain LL.

Project LL selected for sharing during the Cross Functional meeting are presented by the project PM to his/her peers. During this meeting there is room for questions, feedback, and knowledge exchange. The composition of attendees at this meeting changes regularly and attendance is about 60%. The documented LL process is visualized using SADT technique in figure 7.
All interviewed PMs indicate that they do not use documented LL as knowledge input in their projects. The main reasons for this are challenges faced during searching. Lack of overview and categories is the main cause. Some also indicate that documents and storage location used for LL are also used for other purposes. Lack of a retrieval trigger in the LL process, can also play a role (table 5). Five LL categories that could offer valuable knowledge to PMs in their projects are (table 6):

1. Communication and collaboration and team work.
2. Vendor selection and contractor management.
3. Planning.
4. Safety.
5. Resources.
6.3 Discussion regarding results of in-depth interviews

All interviewees indicate that LL of past projects are an important source of knowledge in new projects. They state that LL can prevent rework and improve efficiency in future projects (JBV B, 2015). LL are mainly seen as challenges and problems a project is faced with and less as best practices. This emphasis on negative LL has also been identified in literature (chapter 2.4.1). At present, solely undocumented LL (chapter 5.4) are retrieved in new projects. This exchange is mainly through informal personal contact. The trigger for exchange is often the need for learning of an individual.

Even though all interviewees are open to sharing knowledge, their approach can be different. Some are proactive both in searching for and sharing knowledge. Others prefer to be approached by others before sharing and are not too keen on asking questions. PMs indicate the need for assertiveness and effective communication and organization skills for functioning well at Engineering. Personal habits in knowledge sharing are also identified in literature (chapter 2.3.3).

The need for such skills can also be seen in the categories of LL considered as valuable to new projects. Communication and collaboration is the most important category. Organization skills, such as project coordination and effective definition of roles and responsibilities, are also important. This need seems to go hand in hand with the roles given to individuals by FPX. Some stress the need for additional training next to FPX for individuals to develop such skills (see extra aspects in appendix 8, 9).

Four categories of LL are identified as valuable to all knowledge-customer categories (table 6). Their value of importance however, varies (except for communication and collaboration). The fifth LL category is different. For the PEs this category is safety, modification engineers view technical aspects as valuable, and PMs consider LL about resources as important.

The modification engineers working on projects and the PEs not taking on a PM role seem to be less aware of the LL process. Those who have a PM role in projects often know the steps of this process and have taken part in collecting LL. The difference in the nature of activities as well as the type of FPX training they receive can influence this awareness.

Some indicate the need for steering and enforcement by Management for successful KM activities and hence the LL process (appendix 7, 8). PMs and Management strongly believe LL retrieval should not be made obligatory. In their eyes, individuals experiencing the benefits themselves, is the best motivator (appendix 9). Need of support from Management for
successful KM activities is also seen as important in the literature (chapter 2.3.2, 2.3.4). Other factors that can contribute to KM success are also given during interviews. Giving follow-up to LL is seen by some as important. Some indicate the need for an individual as a central point of coordination for KM activities. Better utilization of the need for learning at the beginning of a project, can also contribute to more LL retrieval.

There are also factors that can hamper success of the LL process. Not feeling appreciated for investing time and effort in KM activities is mentioned in the interviews. In the literature, lack of incentives such as recognition and reward (chapters 2.3.2, 2.4.1) are also seen as a potential barrier to success. Being judged for making/sharing mistakes, is another factor mentioned. High workload can influence effective communication and sharing. Some with more experience indicate not seeing the need for retrieval of LL from a system, as they have LL relevant to their area expertise as tacit knowledge. Lack of time can also hinder success of LL process (appendix 7, 8, 9). The latter is also mentioned in the literature as a barrier to success (chapter 2.4.1).

Even though informal manner of exchanging knowledge works well at Engineering, some indicate the need for formalizing some activities or better implementation of formal processes. They believe this can help monitor, evaluate, and improve KM activities (appendix 8). Monitoring the LL process can for example lead to identification of reoccurring problems. This new information can then be used to target the root-cause of such problems more effectively.

The main root-causes we found during in-depth interviews are process related. Different factors that prevent well-functioning of the current LL process, as given in table 5. This finding is in line with literature findings in chapter 2.4.1. Aspects related to determining value of knowledge and its challenges, however, receive less attention. In literature this challenge is seen as one of the main difficulties of effective management of knowledge (chapter 2.3.3, 2.4.1).

Difficulties in determining value of knowledge are not mentioned by modification engineers (appendix 7). One PE indicates that collecting LL with regard to know-how and experience is difficult. Another PE sees difficulty in selecting valuable LL for his/her project (appendix 8). Challenges in determining future value of knowledge are mentioned by one PM. He/she also indicates difficulty of formulating valuable LL (appendix 9).

The PEs have less involvement in the LL process than PMs. They do not take part in the Portfolio Review and the Cross Functional meeting where LL are discussed in detail. Often only PMs that are closing their projects attend the Portfolio Review and as such, sharing of LL does not reach
other PMs through this channel. As attendance at the Cross Functional meeting is not 100%, LL do not reach all PMs. Also at this latter meeting just a selection of LL is shared and discussed.

6.4 LL-process workshop

In the above sections we interpreted data from the in-depth interviews (coding given in chapter 4.1.1). We need to make sure these interpretations represent the views and opinions of those interviewed. Therefore, interview findings need to be validated. We choose a group re-interviewing technique in the form of a “LL-process workshop” for our study. As mentioned in chapter 4.1.2, workshops can be used to collect data as well as to validate data. This workshop is used for both of these purposes.

6.4.1 LL-process workshop organization

The LL-process workshop has a duration of two hours. As time of workshop participants is valuable and limited, we choose not only to use this workshop as a manner of validating interview findings but also as a way of providing direction for future steps of our study. The first hour is used for data validation. The second hour aims at obtaining input from experts on possible direction for improvements.

In order to fully benefit from the input of participants, a facilitator takes part in the workshop. This facilitator makes sure: 1) predetermined agenda is followed within the defined time, 2) all participants are equally able to take part in discussions and, 3) generated information is documented.

The group invited to take part in this workshop consisted of the following roles:

- Modification engineer also working on projects: 2
- Project Engineer: 2
- Project Engineer also taking on PM role: 1
- Project Manager: 1
- Management: 1

The above selection represents different knowledge-customer categories we interviewed. Input from this group is used to validate interview findings. In addition, we also invited: the SharePoint administrator, a documentation specialist, and a FPX trainer, who could provide us with expert guidance in the second part of the workshop.

In preparation for the workshop, these participants were requested to consider the LL process and look at the storage location of LL. We asked them to think about factors that can hamper
retrieval of LL in new projects. They were also asked to consider the quality of LL. Finally we requested them to think about how LL process can be improved and which changes are needed for success.

Interview findings are structured as causes and effects, using a fishbone diagram (chapter 4.2.3). Problem statement “documented LL are not used in new projects” is given on the main section. Three cause categories identified during data coding (table 5) are given on each side. For each category root-causes are given. As can be seen in figure 8, we include all root-causes mentioned during interviews in our fishbone regardless of the number of times they were mentioned. This diagram is printed on A0 paper and used as input for the workshop.

Figure 8: Fishbone diagram of interview findings
Data validation and identification of main root-causes led to a lively discussion between participants. There was disagreement about the identified root-causes illustrated in the fishbone. This was expected as during the interviews different individuals had different opinions and the fishbone is made based on all identified root-causes. This lack of unanimity also confirms what is found in the scientific literature given in chapter 2 about value of knowledge being subjective and content and time of use dependent (Alavi et al., 2005).

The second hour of the workshop had a brainstorm character where together with the participants, manners of dealing with these root-causes are identified. Subsequently, the perceived effectiveness of these manners and the amount of effort needed in bringing them about was determined. In the next section our findings are given.

### 6.4.2 LL-process workshop findings

In this section we address sub-question 2.3 given in chapter 1: **what are the barriers to exchanging project LL?** Initially, it is important to note that during validation only feedback from those who had participated in interviews (7 participants) was considered. Input from other experts was mainly used in the second part of the workshop.

To validate interview findings, initially participants were asked to indicate if any root-cause is missing on the fishbone diagram. Changes and additions were made to the two categories given below.

- **Searching is difficult and requires a lot of time:**
  1. *There are too many SharePoint* is changed to *LL (in) SharePoint cannot be found.*
  2. *There is a lack of searching options* is added.

- **Lack of consistent procedure for retrieval of LL:**
  1. *Important LL are not always followed-up* (for example translation into standards or guidelines) is added.
  2. *Aim of documenting LL not clear* is added.

Next, participants were asked to indicate which root-causes they found most important. Each participant could choose two factors. Those factors with highest scores were then used in the second part of the workshop to formulate countermeasures. The results per category are given in table 7. Note that root-causes seen as not important have been removed and those with the highest scores are highlighted red. Results given under the PM category also include input of Management.
The second hour of the workshop was a brainstorm session. Countermeasures are defined for the identified root-causes given in table 7. Next, the impact and the needed effort for each countermeasure is determined (table 8). Impact is measured from a total of 5 points, with 1 being very low and 5 being very high. Effort is also measured from a total of 5 points. However, here 1 is very high and 5 is very low effort. Final score is determined through multiplication of impact and effort. The advice of the experts during the workshop is to only consider countermeasures with high scores in formulating improvements. They also suggest considering all root-cause categories.

Table 7: Documented LL are not used in new projects: Root-causes

<table>
<thead>
<tr>
<th>Root-cause</th>
<th>PE (3)*</th>
<th>Mod. Eng. (2)*</th>
<th>PM (2)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. There is a lack of overview and categories.</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3. LL are scanned and saved as PDF; searching via keywords is not possible.</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>6. LL (in) SharePoint cannot be found (new).</td>
<td>2</td>
<td>1</td>
<td>-</td>
</tr>
</tbody>
</table>

Roles and responsibilities are not clear

<table>
<thead>
<tr>
<th>Root-cause</th>
<th>PE (3)*</th>
<th>Mod. Eng. (2)*</th>
<th>PM (2)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. I don’t know what I can expect of others.</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Lack of consistent procedure for retrieval of LL

<table>
<thead>
<tr>
<th>Root-cause</th>
<th>PE (3)*</th>
<th>Mod. Eng. (2)*</th>
<th>PM (2)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. There is a lack of trigger in project documents for LL retrieval.</td>
<td>-</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>4. Important LL are not always followed-up (new).</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

* No conclusion should be drawn from these numbers at this stage. We will come back to them in chapter 7.

Table 8: Documented LL are not used in new projects: Countermeasures

<table>
<thead>
<tr>
<th>Countermeasure</th>
<th>Impact*</th>
<th>Effort*</th>
<th>Score*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Make LL visual.</td>
<td>4</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>2. Make a template that can be used for collecting LL and searching for LL.</td>
<td>5</td>
<td>3</td>
<td>15</td>
</tr>
</tbody>
</table>

LL (in) SharePoint cannot be found
6.5 Discussion regarding results of LL-process workshop

The most important root-causes identified during the workshop are process related. This is in line with our findings from the in-depth interviews. Causes related to the value of knowledge are only mentioned when quality of formulated LL of past project was discussed. Those who had reviewed a number of these LL (2 individuals) indicated that they are at times formulated as evaluation and not as LL. Emphasis of these LL is on what had gone wrong and less on prevention in the future. In the workshop as during in-depth interviews, LL are mainly seen as challenges a project faces.

Lack of overview and categories is the most important root-cause identified during the interviews and this was also the case during the workshop. Designing a LL Template for collecting and searching, is the countermeasure with the highest score in dealing with this factor.

The other two root-causes identified in the workshop are new and are not part of table 5. Let us consider the first new factor: LL (in) SharePoint cannot be found. Going back to interview results (appendix 7, 8) we see that some modification engineers (4) and PEs (5) mention they did not know the storage location of LL. As we wanted to know the reason behind this fact, we applied the 5 Whys method. The results we found are root-causes given under searching, root-cause 2 in table 5. During the workshop, experts saw this factor as a root-cause in itself and believed it should be given attention as such. During interviews no PMs or PEs taking on the role of the PM saw this factor as an issue. This finding is consistent with the findings of the workshop. Three countermeasures dealing with this root-cause are identified during the workshop. All three have high scores and need to be considered in the design step (chapter 7).
The second new factor is: **Important LL are not always followed-up.** The need for following-up on LL and attention to guidelines and standards comes back in the interviews but not as strongly as during the workshop (appendix 7, 8, 9). One countermeasure that has a high score was defined for dealing with this factor. It should be mentioned here that lack of following-up LL is not seen as a barrier to success in the scientific literature we reviewed. In order to see whether this factor is also of influence in other case studies, future research is needed.

Note that not all participants of in-depth interviews, took part in the workshop. This can result in views of those present to be highlighted. Changing the composition of workshop participants may influence the outcomes. This is one of the main limitations of the group re-interviewing technique (Grifee, 2005).

### 6.6 Chapter summary

In-depth interviews and the LL-process workshop are used to collect data about project steps and the LL process from the Engineering department. All those interviewed indicate that LL of past projects are an important source of knowledge in new projects. Currently, undocumented LL are the main knowledge source with regard to lessons from past projects. Documented LL are not used as the LL process is found to be in need of improvement. Searching in the present LL system is seen as challenging and requires a lot of time. Some indicate that the LL process is not performed consistently by all PMs. Ambiguity about roles and responsibilities can also form a barrier to success. The main root-causes identified are process related and challenges in determining the (future) value of knowledge are given less attention.

The main categories of LL found valuable to future projects are:

1. Communication and collaboration.
2. Project coordination and roles and responsibilities.
3. Planning.
4. Vendor selection and evaluation.
5. Safety/Resources/Technical aspects.

During the LL-process workshop, findings of the interviews are examined and new causes for not using documented LL are identified. Lack of overview and categories is seen as an important cause during both interviews and workshop. Designing a template aimed at collecting LL and searching for LL could help deal with this issue. Not being able to find LL SharePoint or the right LL in SharePoint, is another root-cause. The following countermeasures can ease this problem: 1) information about LL process in FPX training, 2) construction of a separate LL database, and
3) adding the name of contact person to collected LL. Participants also indicate the need for giving follow-up to important LL. Intervision teams where LL can be verbally exchanged with peers, is seen as a possible solution. Participants of such sessions can determine what type of follow-up is needed for LL.

The above given findings, together with the insights from literature, are used in chapter 7 to formulate improvement proposals to the present LL process.
Chapter 7: Design of an improved LL process

Chapter 5 and 6 provided insight into activities of the Engineering department and functionality of the Lessons Learned (LL) process. Strengths and weaknesses of this process are identified and potential countermeasures in dealing with these shortcomings are formulated. In this chapter we concentrate on design of improvement proposals. We identify constraints that define the boundaries of our design and requirements this design needs to meet. Theoretical findings of chapters 2 and 3 and case study results of chapters 5 and 6 are the building blocks used in formulating improvements.

In section 7.1 design constraints and requirements are identified. Design of an improved LL process can be found in section 7.2 and future improvements are given in section 7.3. Design decisions are given in section 7.4 and a summary of this chapter can be found in section 7.5.

7.1 Design constraints and requirements

At Engineering, LL of past projects are seen as an important source of knowledge for future projects. LL exchange regarding undocumented LL which is ad hoc and informal, functions well. Documented LL sharing has a formal process and is more structured and resilient. This process can therefore complement informal LL exchange. Documented LL process, however, is in need of improvement. It was found that documented LL stored at SharePoint storage location (chapter 6.2.3) are not used as a source of knowledge in new projects (JBV B, 2015).

Using in-depth interviews (table 5) and the LL process workshop (table 8) the root-causes of this problem are identified. Also the steps a project goes through during its lifetime and the current LL process are defined (figures 6 and 7). These findings are the initial building blocks used in designing improvement proposals for the LL process. Scientific literature findings of chapters 2 and 3 are another source of inspiration and they are the second building block used.

In designing improvement proposals, it is important to identify which process steps and activities are constraints and outline the boundaries of our design space. We also need to define requirements our design has to meet to satisfy our knowledge-customer (Sage & Armstrong, 2000). These aspects are addressed below.

7.1.1 Design constraints

Two constraint categories can be identified for improvement proposals of the LL process:

1. **Formal processes and activities**: this category entails all those project steps and activities that are formal and cannot be skipped or changed. Peer review of the Project
Brief and the Project Review documents is a formal activity. So is presenting the Project Brief document during the definition phase and the Project Review document during the operation phase at the Portfolio Review meeting (figure 6). These project activities are a given and cannot be modified in the short run (JBV B, 2015).

2. **Formal documents and systems**: using the Project Brief and the Project Review documents for gathering information during the project lifetime, is also a given. Their content, however, can be modified. The current storage location of LL, SharePoint, is another constraint. Information about closed-out projects needs to be stored in this location to prevent fragmentation of knowledge. Modifications within SharePoint are possible (JBV B, 2015).

These formal aspects cannot be changed or modified within the scope and restrictions of our study. Improvement proposals we formulate in the following sections need to take this fact into consideration.

### 7.1.2 Selection criteria

As given above, different sources of requirements for improvement proposals are identified in chapters 2, 3, 5, and 6. In order to select the most important and relevant requirements, selection criteria are defined:

1. **Study scope**: we only consider those requirements that are within our study scope.
2. **Budget, time, and resources**: our study is constrained by limited budget, time, and resources. Selection of requirements needs to take this fact into consideration.
3. **Change management**: during in-depth interviews and the LL-process workshop many suggestions are made for improving the LL process. A selection of these suggestions is used for initial improvement proposals and others need to be addressed in the future. The reasons behind this decision are:
   a. Making too many changes at once makes their monitoring and evaluation difficult. It is less clear which causes bring about certain effects.
   b. Implementing too many changes at once can also overwhelm users and form a barrier to change in behaviour which is essential for improving the LL process.
   c. Expert advice from Engineering indicated that some changes are not feasible in the time span of our study (e.g. changes to formal procedures of projects).
4. **Expert guidance**: In order to formulate suitable improvement proposals, expert guidance is arranged. This expert is a Project Manager (PM) who has extended experience in the field of project management, is a Flawless Project eXecution (FPX)
subject matter expert, and is daily involved in various projects at the Engineering department. This individual is referred to as the “FPX expert” from here onwards. His expert advice helped in verifying the improvement proposals.

### 7.1.3 Countermeasure categories

In formulating requirements for our design, results of the LL-process workshop (chapter 6.4) are considered together with the FPX expert. These findings are the starting point of formulating requirements for improvement proposals. Let us revisit them. Table 9 gives an overview of countermeasures identified during this workshop in dealing with root-causes of not using documented LL in new projects. For each category, measures with the highest scores are selected as possible improvements.

<table>
<thead>
<tr>
<th>Countermeasure</th>
<th>Score</th>
<th>Improvement type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Make a template that can be used for collecting LL and searching for LL.</td>
<td>15</td>
<td>LL collection tool</td>
</tr>
<tr>
<td>2. Include information about LL process in FPX training.</td>
<td>15</td>
<td>Future</td>
</tr>
<tr>
<td>3. Make a separate LL database with searching options.</td>
<td>16</td>
<td>LL storage</td>
</tr>
<tr>
<td>4. Add contact person name to collected LL.</td>
<td>15</td>
<td>LL collection tool</td>
</tr>
<tr>
<td>5. Set up intervision teams to verbally share LL.</td>
<td>9</td>
<td>LL process</td>
</tr>
</tbody>
</table>

These countermeasures are re-evaluated with the help of the FPX expert to assess their feasibility. All countermeasures but one (number 2) are seen as feasible within the budget, time, and resource restrictions of our study. Including information about LL process in the FPX training is expected to require more time than is available in this study as the content of these trainings needs to be modified. Hence, this measure needs to be addressed in the future.
The above given countermeasures tackle all three categories of root-causes identified during the LL-process workshop. They are divided into three improvement categories:

1. LL collection tool
2. LL storage
3. LL process

### 7.1.4 Design requirements defined through interviews

In this section we consider root-causes identified during interviews and we address them per category. Initially we look at factors related to searching (table 10). Each factor is either a constraint or a (future) requirement. As can be seen, the number of times an issue was mentioned during interviews is not the decisive factor for selection of a root-cause. Formulating requirements is based on feasibility according to the above given selection criteria and design constraints.

<table>
<thead>
<tr>
<th>Searching</th>
<th>Root-cause</th>
<th>Number (17)</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>There is a lack of overview and categories.</td>
<td>11</td>
<td>Considered</td>
</tr>
<tr>
<td>2.</td>
<td>Working with SharePoint is difficult.</td>
<td>8</td>
<td>Not considered</td>
</tr>
<tr>
<td>3.</td>
<td>There are too many SharePoints.</td>
<td>4</td>
<td>Not considered</td>
</tr>
<tr>
<td>4.</td>
<td>Not everyone has access.</td>
<td>5</td>
<td>Considered</td>
</tr>
<tr>
<td>5.</td>
<td>A link is needed to get to the right SharePoint.</td>
<td>5</td>
<td>Considered</td>
</tr>
<tr>
<td>6.</td>
<td>LL are scanned and saved as PDF; searching via keywords is not possible.</td>
<td>7</td>
<td>Not considered</td>
</tr>
<tr>
<td>7.</td>
<td>Name of document does not correspond with content of LL.</td>
<td>6</td>
<td>Not considered</td>
</tr>
<tr>
<td>8.</td>
<td>Directory contains both project close-out and project review documents.</td>
<td>3</td>
<td>Not considered</td>
</tr>
<tr>
<td>9.</td>
<td>These documents are not only used for LL purposes.</td>
<td>3</td>
<td>Not considered</td>
</tr>
</tbody>
</table>

**Requirements** - given the considered root-causes of table 10, we formulate the following requirements:

1. Provide overview and categories for LL.
2. Give access to modification engineers working on projects, Project Engineers (PEs), and PMs.
3. Set up a link to LL storage that can easily be found.
Improving Knowledge Management by means of Lean Thinking

**Not considered** - as mentioned earlier, SharePoint is the storage location of LL and hence a design constraint. A *Project Review* document containing LL needs to be scanned and saved. These documents are saved according to project name and/or number. They are not only used for safeguarding LL but also for other purposes. Next to this document, a *Project Close-out* document is also used. These are formal steps in closing-out a project and therefore cannot be changed within the scope and restrictions of our study.

<table>
<thead>
<tr>
<th>Roles and responsibilities</th>
<th>Root-cause</th>
<th>Number (17)</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>10. FPX guidelines with regard to roles and responsibilities are not known to all.</td>
<td>5</td>
<td>Considered</td>
<td></td>
</tr>
<tr>
<td>11. I don’t know what is expected of me.</td>
<td>2</td>
<td>Considered</td>
<td></td>
</tr>
<tr>
<td>12. I don’t know what I can expect of others.</td>
<td>2</td>
<td>Considered</td>
<td></td>
</tr>
</tbody>
</table>

**Requirements** - next we look at roles and responsibilities category (table 11). In consultation with the FPX expert, two further requirements are formulated:

4. Make FPX guidelines regarding roles and responsibilities within LL process known to Engineering.

5. Provide information on roles and responsibilities in FPX training. This requirement needs to be addressed in the future (see section 7.1.3).

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Root-cause</th>
<th>Number (17)</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.</td>
<td>Organization and/or form of LL/evaluation session is PM dependent.</td>
<td>7</td>
<td>Considered</td>
</tr>
<tr>
<td>14.</td>
<td>Participants of this session are not predefined.</td>
<td>5</td>
<td>Considered</td>
</tr>
<tr>
<td>15.</td>
<td>When LL documentation or retrieval should take place, is not predefined.</td>
<td>3</td>
<td>Considered</td>
</tr>
<tr>
<td>16.</td>
<td>There is a lack of trigger in project documents for LL retrieval.</td>
<td>6</td>
<td>Considered</td>
</tr>
<tr>
<td>17.</td>
<td>There is a lack of consistency in implementation of FPX guidelines.</td>
<td>4</td>
<td>Future</td>
</tr>
</tbody>
</table>

**Requirements** - finally, we consider aspects with regard to LL procedure (table 12). Based on the above given root-causes we formulate the following design requirements:

1. Make organization of *LL/evaluation* meeting consistent in all projects and redefine participants.
2. Provide a trigger for retrieval of LL and make both documentation and retrieval of LL part of the LL process.

3. Make implementation of FPX guidelines consistent in all projects. We decide that this requirement should be addressed in the future based on the FPX expert’s advice. Recall chapter 5.4 where we saw that the FPX methodology provides no guidelines with regard to LL retrieval. Initially these steps need to be built into the LL process and the FPX training should be adjusted accordingly. It is only then that consistent implementation of FPX guidelines can be addressed.

An overview of the above identified requirements is given in table 13. They have been arranged according to improvement categories of section 7.1.3.

<table>
<thead>
<tr>
<th>LL collection tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Provide overview and categories for LL.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LL storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Give access to all modification engineers working on projects, PEs, and PMs.</td>
</tr>
<tr>
<td>2. Set up a link to LL storage that can easily be found.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LL process</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Make FPX guidelines regarding roles and responsibilities within LL process known to Engineering.</td>
</tr>
<tr>
<td>2. Make organization of LL/evaluation meeting consistent in all projects and predefine participants.</td>
</tr>
<tr>
<td>3. Provide a trigger for retrieval of LL and make documentation and retrieval part of LL process.</td>
</tr>
</tbody>
</table>

7.1.5 Design requirements identified through literature research

When designing proposals for improvement of LL process, scientific literature findings can be a great source of inspiration. We therefore consider: 1) potential challenges a LL process may face and possible remedies for them (table 2 of chapter 2) and 2) Lean Knowledge Management (LKM) insights (table 4 of chapter 3). A number of requirements are formulated based on these findings. Also here the selection criteria given earlier are applied. Initially we look at countermeasures found in the literature in dealing with potential challenges of LL processes (table 14).
Improving Knowledge Management by means of Lean Thinking

Requirements - the following requirements are specific to the LL process:
1. Incorporate LL documenting, storing, distributing, and reusing in the LL process.
2. Use of models and simulation.
3. Use of 5 Whys method in finding root-causes of LL. In consultation with the FPX expert, we decide not to consider Storytelling method for providing context for LL. Contrary to 5 Whys, this method is not as known at Engineering.
4. Organizational knowledge maps.
5. Use of Facilitator and Scribe in LL sessions.
6. Definition and implementation of systematic LL collection process.
7. Making time and coupling milestones to LL sessions.

Not considered - use of models and simulation is out of the scope of our study and therefore not considered. Having an external Facilitator and Scribe present during all LL sessions is not feasible due to resource limitations.

Next we consider factors that can be of importance in applying LKM to the LL process.

Requirements - Table 15 gives an overview of formulated requirements based on literature findings. Here, we shortly explain the reasons behind our decisions:
1. As informal manners of exchange are found to function well, we only concentrate on formal processes (chapter 6.1).
2. Providing opportunities to eliminate outdated LL is not considered based on advice of the FPX expert. Too many changes to the LL storage system can make their management challenging (section 7.1.2).
3. Offering feedback opportunities to knowledge customer is only considered via social contact and not via LL storage system due to the above given reason.
Not considered - Learning from KM activities from within and outside the organization is out of the scope of our study.

Table 15: Requirements identified through literature: LKM insights (table 4 adjusted)

<table>
<thead>
<tr>
<th>Value of knowledge</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Provide context for tacit knowledge via discussion groups.</td>
<td>Requirement</td>
</tr>
<tr>
<td>2. Enable opportunities for creation of common knowledge via formal processes.</td>
<td>Requirement</td>
</tr>
<tr>
<td>3. Offer storing, organizing, and retrieving opportunities for acquired and created knowledge.</td>
<td>Requirement</td>
</tr>
<tr>
<td>4. Recognize that knowledge has a shelf life and enable elimination of outdated and irrelevant knowledge.</td>
<td>Future</td>
</tr>
<tr>
<td>5. Offer feedback opportunities to knowledge-customer.</td>
<td>Requirement</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Knowledge flow</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>6. Create positive memories through dedicated involvement of Management.</td>
<td>Requirement</td>
</tr>
<tr>
<td>7. Learn from KM activities both within and outside the organization.</td>
<td>Not considered</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Knowledge pull</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>8. Use wish for learning by knowledge-customer as a trigger for pulling knowledge.</td>
<td>Requirement</td>
</tr>
<tr>
<td>9. Create formal interaction opportunities within the organization.</td>
<td>Requirement</td>
</tr>
</tbody>
</table>

An overview of the above identified requirements is given in table 16. They have been arranged according to improvement categories of section 7.1.3.

Table 16: Design requirements defined through literature study

<table>
<thead>
<tr>
<th>LL collection tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Use 5 Whys method in finding root-causes of LL.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LL process</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Construct a LL process for documenting, storing, distributing, and reusing LL.</td>
</tr>
<tr>
<td>2. Define and implement a systematic LL collection process.</td>
</tr>
<tr>
<td>3. Make time for LL and couple milestones to LL sessions.</td>
</tr>
<tr>
<td>4. Provide context for tacit knowledge via discussion groups.</td>
</tr>
<tr>
<td>5. Enable opportunities for creation of common knowledge via formal processes.</td>
</tr>
</tbody>
</table>
A combination of requirements of tables 13 and 16 gives us the final set of design requirements (table 17). Note that those requirements addressing the same issue have been combined.

**Table 17: Final design requirements**

<table>
<thead>
<tr>
<th>LL collection tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Provide overview and categories for LL.</td>
</tr>
<tr>
<td>2. Use 5 Whys method in finding root-causes of LL.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LL storage</th>
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<tbody>
<tr>
<td>1. Give access to all modification engineers working on projects, PEs, and PMs.</td>
</tr>
<tr>
<td>2. Set up a link to LL storage that can easily be found.</td>
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<tbody>
<tr>
<td>1. Make FPX guidelines regarding roles and responsibilities within LL process known to Engineering.</td>
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<tr>
<td>2. Make organization of LL/evaluation meeting consistent in all projects and predefine participants.</td>
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<tr>
<td>3. Provide a trigger for retrieval of LL and make documentation and retrieval part of LL process.</td>
</tr>
<tr>
<td>4. Use wish for learning by knowledge-customer as a trigger for pulling knowledge.</td>
</tr>
<tr>
<td>5. Construct and implement a systematic LL process for collecting, documenting, storing, distributing, and reusing LL.</td>
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<tr>
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<tr>
<td>9. Offer feedback opportunities to knowledge-customer.</td>
</tr>
<tr>
<td>10. Create positive memories through dedicated involvement of Management.</td>
</tr>
<tr>
<td>11. Provide formal interaction opportunities within the organization.</td>
</tr>
</tbody>
</table>

### 7.2 Design of LL process improvements

In designing improvements for the LL process of the Engineering department, we mainly focus on countermeasures defined during the LL-process workshop given in table 9. We make sure our design covers requirements formulated in table 17. In this section each improvement category is discussed and proposals are formulated.
7.2.1 Design proposals regarding LL collection tool

Making a template that can be used for collecting and searching for LL is the countermeasure with the highest score for this improvement category. Such a template should provide overview and categories for LL. The second requirement our design needs to meet is the use of 5 Whys method in finding root-causes of LL. Initially categories of LL are considered.

**Identified categories** - recall chapter 6.2.2 where categories of LL valuable to new projects are identified. The total number of times a category was mentioned during in-depth interviews is assumed to represent its importance. We make no distinction between different categories of interviewees (chapter 6.1) as they are all our knowledge-customers. In consultation with the FXP expert five LL categories are chosen for the *LL Template*. The first four are given in table 19 and were mentioned by all categories of interviewees. Safety is selected as the fifth category as it was the fifth most mentioned category for the PEs and the PMs. It should be noted that vendor evaluation and safety, health, and environment (SHE) need to be evaluated according to the *Project Review* document (appendix 11).

### Table 18: Categories of LL valuable to new projects (recap of table 6)

<table>
<thead>
<tr>
<th>Topic</th>
<th>PE (9)*</th>
<th>Mod. Eng. (4)*</th>
<th>PM (4)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Communication &amp; collaboration</td>
<td>9</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>2. Project coordination &amp; roles and responsibilities</td>
<td>8</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>3. Planning</td>
<td>7</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>4. Vendor selection &amp; evaluation</td>
<td>5</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>5. Safety</td>
<td>4</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>5. Resources</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>5. Technical aspects</td>
<td>-</td>
<td>2</td>
<td>-</td>
</tr>
</tbody>
</table>

Using the above findings, we formulate the following five categories for the *LL Template*:

1. Communication
2. Coordination
3. Planning
4. Vendor evaluation
5. SHE

**Steps in collecting LL** - the *LL Template* should also provide steps to be taken in gathering LL. As we wish to make these steps as specific as possible, we consulted LL templates/steps found in the literature that are public such as LL process step of NATO (2011) and NASA (2005). These
findings together with the 5 Whys method result in the following steps to be take in collecting LL from projects:

1. **Observation**: What happened? (In what way was this different from what should have happened?)
2. **Discussion**: Why did it happen? (Were these circumstances foreseen or not? Why?)
3. **Conclusion**: What did you learn? (Were these lessons specific to your project or can they be beneficial to future projects?) If lessons were project specific, the process ends here.
4. **Recommendation**: How can problems be prevented in future projects? (Describe the steps to be taken.)

Next to these four steps, also the contact person of LL needs to be noted. The **LL Template** designed for collecting LL from projects can be found in appendix 12. This template is included in the **Project Brief** document.

### 7.2.2 Design proposals regarding LL storage

Currently not only information about LL is saved at SharePoint but also other information regarding project close-out (chapter 6.2.3). This is the reason why project name or number is used for storing the **Project Review** documents which does not correspond with the content of LL of this document (JBV B, 2015). As given in section 7.1.1, using SharePoint for storing project LL is a design constraint. However, making changes within SharePoint is possible.

Let us revisit countermeasures defined during LL-process workshop (table 9) and address them in detail:

1. Make a separate LL database with searching options.
2. Add contact person name to collected LL.

**LL Directory** - within SharePoint used for saving information about closed-out projects, a **LL Directory** is constructed appendix 13. This directory has five categories that provide overview of LL and make searching easier. These LL categories correspond to those defined in the **LL Template**. For each category: contact person LL, LL topic, observation and discussion, conclusion and recommendation, project name and number, and date of closure needs to be noted.
Improving Knowledge Management by means of Lean Thinking

The first requirement our design has to meet (table 17) is: give access to all modification engineers working on projects, PEs, and PMs. With the help of the SharePoint administrator both viewing and editing access is granted where needed. The second requirement is: set up a link to LL storage that can easily be found. On the FPX intranet site a link to the LL Directory is set up to make finding the directory easier.

7.2.3 Design proposals regarding LL process

In designing the LL collection tool and storage we mainly focused on the findings of the LL-process workshop. Setting up intervision teams to verbally share LL with peers is the countermeasure formulated in this workshop regarding LL process. This measure however, does not take the LL process steps into consideration. Therefore next to intervision sessions, we also concentrate on improving the LL process and adding new steps where needed.

Before formulating improvement proposals for the LL process, let us revisit the requirements our design has to meet (table 17). Each of these requirements is addressed below.

1. Make FPX guidelines regarding roles and responsibilities within LL process known to Engineering.
2. Make organization of LL/evaluation meeting consistent in all projects and predefined participants.
3. Provide a trigger for retrieval of LL and make documentation and retrieval part of LL process.
4. Use wish for learning by knowledge-customer as a trigger for pulling knowledge.
5. Construct and implement a systematic LL process for collecting, documenting, storing, distributing, and reusing LL.
6. Enable opportunities for creation of common knowledge via formal processes.
7. Make time for LL and couple milestones to LL sessions.
8. Provide context for tacit knowledge via discussion groups.
9. Offer feedback opportunities to knowledge-customer.
10. Create positive memories through dedicated involvement of Management.
11. Provide formal interaction opportunities within the organization.

**LL retrieval in definition phase** - as given in figure 7 the current LL process does not have a retrieval step. We propose the following improvements. Prior to the Kick-off meeting of a project, core team members retrieve LL of past projects. In this phase knowledge about different aspects of the project is collected and LL can be one of them. This wish for learning is used as a trigger for pulling knowledge (requirements 4). In order to make LL retrieval a formal
step of the LL process, the Project Brief document is improved to include LL in the project case section (appendix 14). This triggers gathering of LL from past projects which can be beneficial to the project at hand. Individuals are free in choosing the manner of collecting this knowledge; be it through databases, personal conversations or other ways (requirement 3).

During the Kick-off meeting these LL can be exchanged with other core team members, extended team, and sponsor. Before the PM can share his/her findings of the Project Brief document with resource managers at the Portfolio Review meeting, this document needs to be reviewed. This peer-review is an extra opportunity where retrieved LL are shared. The Project Brief document is discussed during this meeting where among others retrieved LL are given attention. The above steps link LL retrieval to formal project steps and milestones in the definition phase (requirement 7).

**LL retrieval, collection, and storage during project lifetime** - LL of past projects can also be a source of knowledge during project lifetime where challenges are faced. Therefore LL retrieval is also included in the execution phase. As given in chapter 2.4.1, LL should be collected during project lifetime and by those who face them. Therefore in the execution phase of a project, LL need to be collected and stored. As mentioned in section 7.2.1, the LL Template is included in the Project Brief document. This template can be used by core team members during project lifetime to collect LL.

LL should be put on the agenda of each Core Team meeting (weekly). Both LL retrieval and collection need to be given attention. Core team members are given the LL Template beforehand and are asked to fill in LL they faced in the past week. They are also asked to consider challenges they may face in the future and retrieve LL about them. These issues are discussed during the Core Team meeting. The PM takes on the role of the facilitator through which he/she aims at finding the root-cause of problems (via 5 Whys method) and formulating future recommendations. Also best practices are given attention. These LL are then documented by the PM in the Project Brief document. Discussion of LL during the Core Team meeting provides room for sharing context of tacit knowledge (requirement 8) and allows core team members to give feedback to each other (requirement 9). Hence, interaction regarding LL exchange becomes formalized (requirement 11).

After each project step is executed (e.g. detailed design or Factory Acceptance Test) collected LL can be transferred by the LL contact person to the LL Directory. This prevents LL to be forgotten and knowledge about them to fade (chapter 2.3.3).
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Figure 9: LL process after improvements
**LL collection after project termination** - LL process after project termination is similar to the current situation given in figure 7. The PM organizes an LL/evaluation meeting where core team, extended team, and sponsor are present. LL collected during project lifetime are discussed and the most important ones are identified and saved in the LL Template. The PM attaches this template to the Project Review document by which rework and duplication of activities is prevented (requirement 2). These LL are discussed in the Portfolio Review meeting as well as in the Cross Functional meeting. After project close-out the Project Review document is saved by the SharePoint administrator at SharePoint.

The improved LL process is visualized using SADT technique (chapter 4.2.2) in figure 9. In this figure those steps that have been proved are highlighted. This improved process provides systematic guidelines regarding LL retrieval, collection, documentation, and storing (requirement 5). All these steps are formalized through which common knowledge can be created (requirement 6).
The above formulated improvement proposals were presented to our knowledge-customers during the monthly Departmental meeting. Attention was given to roles and responsibilities (requirement 1) as well as to the role of Management in enforcing the LL process (requirement 10). It should be noted that creation of positive memory can only be measured in the long run. As we can see in figure 10 LL process is now an integrated part of the project steps. Also in this figure proposed improvements have been highlighted.

Next to the above given improvement steps, a LL Intervision session should be organized where LL can verbally be exchanged. In consultation with the FPX expert, we initially propose to organize such a session for PMs on a quarterly basis during the Cross Functional meeting. This session needs to have an external facilitator and a predetermined agenda. PMs can indicate which topics should be given attention during this session. For the first session we suggest to consider a project in the conception or definition phase where project PM can pull knowledge (LL) from his/her peers about different aspects of the project. Based on experiences of this session organization, frequency, and topics of future sessions can be determined.

During a LL Intervision session, participants can indicate what type of follow-up they consider suitable to the discussed LL. It is advised to make a distinction between LL that are essential to well-functioning of future projects and those that can be of importance. Essential LL should be translated into guidelines and standards. Once experiences of PMs regarding LL Intervision sessions are satisfactory such sessions can also be set up for the PEs and the modification engineers that take part in projects.

7.3 Future LL process improvements

The above given proposals are a part of changes needed to improve the LL process. During this study we mainly concentrate on the process and making it known and consistent within Engineering. Less attention is given to the LL Template and the LL Directory tools with regard to advancement of technology. The reason for this choice is that it is only after defining the process, implementing, monitoring, and evaluating it that we can determine what type of technology is best suitable to meet knowledge-customer demand (chapter 2.3.1 and 2.3.2). Therefore, investment in advanced and costly technology in initial improvement stages would have been premature. In the future, additional improvements need to be made to, for example make searching easier and ranking and filtering of LL possible.

The current improvements are the initial steps in facilitating LL collection and determining value of knowledge. Future improvements need to pay more attention to this value determination process through for example providing feedback options in the LL Directory. This way users can indicate whether or not LL are useful and valuable. Our process does not take removing of
invaluable, irrelevant, or out-dated knowledge into account. This aspect should also be given attention in the future.

Another point of attention is monitoring and evaluating the LL process. Also content of formulated LL and their value for future projects needs to be evaluated. It is advised to conduct such evaluations on a regular basis (e.g. every year). In our improvement proposals we did not take this aspect into consideration and it needs to be addressed in the future.

It should be mentioned that during our study we did not look at possibilities of misinterpretations of LL categories. It is possible that different individuals have different understanding of each category which can result in LL ending up in a different part of the LL Directory. This aspect is important and needs to be taken into account in future improvements.

7.4 Discussion regarding design decisions

Recall chapter 6.3, where we saw that value of knowledge is given less attention during interviews than process related issues. As this aspect is given much attention in the scientific literature (chapter 2.3.3, 2.4.1) we anticipate difficulties in formulating valuable LL for future projects. To overcome such potential difficulty, we formulate steps to be taken in collecting LL in the LL Template.

We use Microsoft Excel to construct the LL Template and the LL Directory as our study has budget restrictions. This program offers searching options and is well-known at Engineering. This way our design builds on familiar principles (chapters 2.4.1) and no training is needed in working with these tools (chapter 2.5.3). As both tools are designed in the same program transferring of LL from one to the other is easy and rework is prevented.

Initially five LL categories are defined for the LL Template and the LL Directory. Our aim is to guide LL collection efforts to specific LL categories and prevent possible discussions about abstract situations. If in the future additional categories are seen as important, they can be included.

Currently, project PM is the contact person for LL. However, other core team members also face challenges during a project. The contact person of a LL should be he/she who faces a challenge and deals with it. This person knows best how such situations can be dealt with in future projects. In case of tacit knowledge this individual can provide the context to LL. Therefore for each formulated LL, contact person information needs to be documented.

In the LL Directory we include name/number of a project where the LL originated as well as its date of closure. Recall 6.2.3, where we saw that the Project Review documents of terminated
projects are saved based on the year of their closure and according to project name/number. In cases where an individual is inspired by a LL and wishes to learn more about the project, this information can be used to facilitate searching.

The LL Intervision sessions are initially proposed for PMs. This decision is made in consultation with the FPX expert. For PMs a formal knowledge exchange meeting (Cross Functional) is in place which can be used for implementation of such intervision session. The PEs do not have a formal manner of knowledge exchange with peers which makes implementation of such sessions more challenging. Therefore, initially LL Intervision sessions should be set up for the PMs and when results are seen as satisfactory they can also be implemented for the PEs.

Improvement proposals formulated above were communicated with our knowledge-customers regularly and through different channels. This way changes are made known and their acceptance is made easier. Improvements were announced in the Departmental meeting, FPX subject matter experts meeting, by email to those involved as well as in personal conversations.

7.5 Chapter summary

Based on theoretical findings of chapter 2 and 3 as well as case study findings of chapters 5 and 6, the LL process of projects at the Engineering department is improved. The wish for learning by knowledge-customer is used as a trigger for pulling LL of past projects in the initial project phases. The Project Brief document is modified to include retrieval of LL in the project brief section. An extra section was added to collect LL during project lifetime by means of the LL Template. The manner of collecting LL (via databases, individuals, etc.) is not specified as the aim is to connect knowledge demand with knowledge source.

The LL Template designed contains five LL categories and steps to follow in collecting LL in a structured manner. The Project Brief document (and hence the LL) are discussed with important stakeholders during the project Kick-off meeting and also with resource managers during the Portfolio Review meeting. During project lifetime LL are a point on the agenda of weekly Core Team meetings and identified LL are documented in the LL Template. These LL are stored at the LL Directory after each project step is executed.

After project termination, collected LL during project lifetime are discussed during the LL/evaluation meeting with important stakeholders. Collected LL are attached to the Project Review document to prevent rework and duplication of activities. During the Portfolio Review meeting these LL are discussed with resource managers. They are also a topic of discussion at the Cross Functional meeting with PMs of all departments. The Project Review documents of terminated projects are stored at SharePoint by the SharePoint administrator.
LL Intervision sessions should be organized on a quarterly basis where LL are verbally exchanged with peers. Initially such sessions can be organized for PMs during the Cross Functional meetings where they can decide what type of follow-up can be given to LL. When results of these sessions are seen as satisfactory such sessions can also be organized for the PEs and the modification engineers that take part in projects.

In order to see if these improvements are applicable in practice, a six weeks pilot is organized through which our improvement proposals are validated. More on this pilot can be found in chapter 8.
Chapter 8: Application of LL process improvement proposals at Engineering

In chapter 7 proposals for improvement of the LL process at Engineering have been formulated. To test their applicability in practice, a pilot study with a duration of 6 weeks was organized. Through this pilot we wish to detect potential problems, find effective and workable solutions, and create acceptance for change (van Teijlingen & Hundley, 2001). Furthermore, as these proposals are customized to the needs and wishes of our knowledge-customers at Engineering, we would like to examine their applicability in other settings. Therefore a “generalization workshop” was organized, where representatives of other Janssen Biologics (JVB) departments participated. Findings of this workshop provide more insight into general applicability of Lean Thinking (LT) to Knowledge Management (KM) efforts. Outcomes of the pilot and generalization workshop guide us in formulating the final improvement proposals.

Section 8.1 concentrates on the organization and findings of the pilot study and section 8.2 on the generalization workshop. In section 8.3 the final improvement proposals for the LL process of the Engineering department are given. Chapter summary can be found in section 8.4.

8.1 Organization and findings of pilot study

In order to examine the applicability of formulated improvement proposals in practice, a 6 week pilot study was organized. Through this pilot our design of chapter 6 is validated. Our aim is to examine which design aspects are applicable and which need further improvement to meet the needs and wishes of our knowledge-customer. In this section we describe the organization and results of this pilot study followed by a discussion of these findings.

8.1.1 Pilot organization

Knowledge-customers who took part in the in-depth interviews: modification engineers working on projects, Project Engineers (PEs), and Project Managers (PMs) were invited to participate in the pilot study. These knowledge-customers work on different projects which are all included regardless of their stage. In preparation for the pilot, the LL Template (chapter 7.2.1 and appendix 12) is made and the LL Directory (chapter 7.2.2 and appendix 13) is constructed. LL of terminated projects from 2014 and 2015 were transferred to this directory. This way our knowledge-customers get an idea of how LL can be structured and stored. As this directory provides an overview of LL, participants can also assess their value to their own projects. Where needed, both viewing and editing access to the LL Directory is granted.

Initially, information about the pilot was announced during the monthly Departmental meeting. The LL Template and the LL Directory were introduced and our knowledge-customers were given the opportunity to ask questions and give feedback. Prior to the pilot, participants were
notified about the purpose and the type of information needed from them (appendix 15). All participants were provided with the *LL Template* and a link to the *LL Directory*. They were requested to discuss all LL during every *Core Team* meeting and document those that can be of value to future projects in the *LL Template*. We emphasized that LL should be a point on the agenda during project lifetime. LL of value to future projects should then be transferred to the *LL Directory*. This directory connects valuable LL to the *Project Review* document of the project where it originated. This way when an individual is inspired by a LL, they can consult this document or seek interaction with the LL contact person.

Participants were requested to provide feedback on their experiences regarding: gathering, discussing, documenting, and retrieving LL. We wish to examine if discussing LL on a regular basis is found valuable and whether the manner of LL exchange we suggest is feasible. Data collection during the pilot study took place via email correspondence, personal conversations, and participation in *Core Team* and *LL/evaluation* meetings. By personally taking part in meetings, we also made observations about differences in the manner of implementation of the above given guidelines in practice.

It should be noted that in consultation with the FPX expert, setting up of intervision sessions (chapter 7.2.3) was not included in the pilot study. Next to time restrictions, this pilot was conducted during the summer holiday season which meant that not all knowledge-customers were present during the six weeks period. We should also mention that in cases where we participated in meetings, we actively took part in discussion and asked questions (5 Whys method) to find the root-cause of issues.

### 8.1.2 Pilot findings

In this section the results of the pilot study can be found. Initially we address feedback received on the *LL Template*, followed by the *LL Directory*, and finally the LL process will be reviewed. We aim at answering research sub-question 3.1 given in chapter 1: which aspects of LT are (not) applicable to project LL and why (not)? Also research sub-question 3.2 is addressed: what are the drivers, opportunities, and barriers to applying LT to KM and in particular project LL?

**LL Template** - is found to be simple and easy to work with. Some appreciate the fact that Microsoft Excel is used in making this template as they are familiar with working with this program. Others find searching options to be limited and express the need for a more advance IT tool to be used in the future.

The steps described in the *LL Template* for collection of LL are found to be helpful as they provide structure. Most respondents see this tool as a systematic way of gathering knowledge.
One participant recommended adding project phase and factors that often cause challenges to the template. However, after a conversation with this individual and application of the 5 Whys method, the conclusion is reached that most of the challenges he/she was facing in his/her project were caused by continuous change of team members. This problem was then categorized to be a communication challenges between new team members and those leaving the project.

Many participants indicate the need for a technical aspects category. During meetings technical challenges are often discussed and the LL Template offers no category to save this knowledge. Categories communication and coordination are found to overlap in many cases and feedback is to merge them into one category. In some projects, contractors are part of the core team. In such cases it can be difficult to conduct vendor evaluation which is one of the categories of the template. Some participants (including the FPX expert) suggest using the vendor evaluation tool called ESSET instead of the vendor selection category. This tool was introduced at Engineering a few years ago but is rarely used. Including this tool in the Project Review document is expected to improve its application.

LL Directory - receives mixed responses. Those who are not a fan of using SharePoint for knowledge storage, indicate that another location should be used such as the Engineering intranet site. Others see a specific location dedicated to LL on SharePoint as a step in the right direction. The latter indicate that searching is made easier via this LL Directory and state that LL categories provide overview. None of the participants transferred collected LL to the directory during the six weeks period of the pilot. The main reason given here is lack of time and other issues having priority.

Participants find the quality of LL collected in past projects to vary. Some LL are formulated as evaluation without recommendations for future projects, some are too generic which makes them less valuable and some are seen as important knowledge input. Here, participants indicate the difficulty of identifying valuable LL for future projects. LL are currently gathered at the end of a project and this can be seen in the type of LL stored at the LL Directory. One respondent misses LL that can be of importance for different sub-phases of a project.

LL Process - during the six weeks of this pilot no projects were started or in the initial phases. Therefore, LL retrieval step could not be examined. However, participants indicate that proposed improvements to the LL process can trigger LL retrieval in future projects. As these changes are linked to the Kick-off meeting and are anchored in the Project Brief document their applicability is estimated to be substantial. Some participants suggest linking LL retrieval during
project lifetime to defined milestones as well. Such a link makes this step less abstract and the LL process guidelines become more specific.

Many participants were not able to put LL on the agenda during every Core Team meeting. The main reason given here was lack of time. They propose to limit LL discussion in these meetings to once a month. When LL are put on the agenda, there should be enough time for interaction. In cases where core team members have taken the time to gather LL, they expect to be given the opportunity to discuss their findings. Deliberations during one Core Team meeting we attended and where LL were on the agenda, took about 30 minutes. During this session valuable LL were formulated as core team members took the time to identify root-causes and formulated recommendations.

Many participants find collecting LL that could be of value in future project challenging. In LL meetings we participated, the quality of collected LL depended on:

1. Participants having formulated LL beforehand and using the meeting to discuss root-causes and formulate recommendations.

2. The role of the PM, as he/she guides discussions towards finding root-causes of problems through asking the right questions (5 Whys method). For example, the PM can change the flow of the meeting from evaluation (what went well or not) to LL (why and what can future projects learn from these findings).

3. Taking sufficient time for LL sessions. There should be room for reviewing formulated LL by all members but also for discussion.

Almost half of the participants did not manage to integrate this pilot study in their project. The main reason for this fact was lack of time. Some indicate that they tried putting LL on Core Team meeting agenda, however, other urgent matters needed to be given priority. Their suggestion is to organize specific LL sessions between peers on a regular basis outside individual projects. They believe this way of cross project LL exchange can be more valuable.

8.1.2 Discussing regarding pilot study findings

Results of the pilot study highlight two great challenges: lack of time and difficulties in formulating valuable LL. This in contrast to the findings of in-depth interviews where process related issues are seen as the main barrier to a successful LL process (chapter 6.3). Results of the pilot are in line with findings of the literature study given in chapter 2.4.1. It seems that when process related difficulties were removed (by constructing a LL Template, setting up the LL Directory, and improving the LL process) these underlying challenges can be identified.
Advice in dealing with these challenges is to keep LL on the agenda and make time for them (chapter 2.4.1). By practicing and providing feedback on formulated LL, the challenge of defining value can be somewhat overcome (chapter 3.2.1).

Formulating valuable LL was seen as a great challenge. Finding a balance between LL that are specific to the project and those that are general can be difficult. Once LL have been identified, formulating pragmatic advice on how to prevent or deal with them is the next challenge. In the LL session where this difficulty was somewhat overcome, the following aspects were considered. The target group for collected lessons was kept in mind, aim of collection was identified before attempting to identify LL, and the type of knowledge to be collected was defined. Here, the structure provided in the LL Template was used as a facilitator.

Categories defined in the LL Template are useful; however, technical aspects category needs to be included. Let us revisit in-depth interview results to see if this category is given attention (appendix 7, 8, 9). This category is mentioned a number of times by all knowledge-customer categories. However, the modification engineers working on projects and the PEs mention categories that are related to technical aspects such as: civil, mechanical, electrical, etc. Different decisions in coding interview data could have resulted in this category being selected for the LL Template.

As mentioned in chapter 7, using SharePoint as a storage location for LL is a design constraint. In the pilot study experiences with the LL Directory on SharePoint were not always positive. Furthermore, this location cannot be visited by everyone and special access needs to be grated for each individual. Lack of access can form a barrier to storage and retrieval of LL. Therefore, storing LL at SharePoint needs to be evaluated in the future.

Manner of organizing Core Team and LL/evaluation meetings is of great importance to the success of LL process. Keeping LL on the agenda, reserving time for discussion, asking the right questions in finding root-causes, and formulating recommendations are some of the aspects in need of attention. The role of the PM as the chairperson of these meetings is decisive. Much has been written in the literature on leading effective meeting. Their purpose, frequency, organization, participants, structure, agenda, etc. has a great influence on how effectively knowledge is exchanged (Ries, 2011). In cases where participants are kept engaged, their contribution is of value, and they are offered learning opportunities, effective knowledge exchange can take place (Harnish, 2014). As organization of effective and disciplined meetings is not part of our study, we do not consider it any further and recommend examining its benefits in the future.
During the pilot study, emphasis of LL discussions were mainly on problems and challenges participants faced in projects. Less attention was given to best practices. This was also the case during in-depth interviews as given in chapter 6.3. It seems that many knowledge-customers associate project LL with challenges and not best practices. Literature findings indicate the need of addressing positive and negative LL as both are a great source of knowledge (chapter 2.4.1).

As no projects were in the initial phases during the pilot study, we were unable to examine LL retrieval improvements proposed for these phases. LL retrieval during project lifetime only took place in a number of cases. Linking LL sessions to milestones could help improve LL retrieval. For example when basic design step is completed and core team moves to detailed engineering they could not only look back to collect valuable LL but also identify aspects in need of extra attention in the next project phase and retrieve LL. Such alterations to our design of chapter 7 could improve both LL collection and retrieval during project lifetime.

8.2 Organization and findings of generalization workshop

In order to examine applicability of the improvement proposals to other departments of JBV, a generalization workshop of two hours was organized. Through this workshop we aim at examining the wider applicability of our proposals with the aim of answering research sub-questions 4.1 of chapter 1: to what extent can results of the Engineering department be generalized to all cases of LKM? Under which circumstances can this approach be used in other cases? In this section generalization workshop organization, its results, and a discussion of these findings are given.

8.2.1 Workshop organization

For the generalization workshop, individuals with different backgrounds and levels of expertise and experience were invited. We aim at having a diverse group that represents as many departments and working processes as possible. In total representatives from seven JBV departments attended this workshop, including: production and operations, logistics, research and development, and IT and automation. The level of expertise of these participants varied from junior to site leadership member.

As these participants are not as familiar with the topic of our study as our knowledge-customers at Engineering, the first hour of the workshop is used as an introduction. Participants were asked to identify manners of knowledge exchange in their department, both formal and informal. Next they were asked to determine which manners they find most effective.

The second hour of the workshop stared off by an introduction to working processes at Engineering, namely project. A high level description of the improved LL process was described.
and participants were asked to assess whether such a process would be applicable in their departments. The generalization workshop was concluded by evaluating the experiences of participants and whether knowledge exchange with colleagues had led to learning. The results of this workshop can be found below.

### 8.2.2 Workshop findings and their discussion

Both formal and informal manners of knowledge exchange are identified during the first hour of the workshop. In some departments these processes are more structured than others. The majority of the participants find face to face knowledge exchange to be most effective. This result is in line with findings of literature given in chapter 2.3.2. In all departments explicit knowledge (standards, guidelines, etc.) is seen as equally important as tacit knowledge (experience, know how, etc.). This result can also be seen at the Engineering department (chapter 5.4). The nature of JBV’s activities seems to be the reason behind this phenomenon.

In the second hour of the workshop, the improved LL process was the topic of discussion. Some participants indicate that this process would not be applicable in their departments. Others could see such improvements being implemented to their working processes. The latter category are those participants that, among others, work on projects. Our improvement proposals are found to be less useful for everyday (not project related) activities. Also in research and development oriented departments, the proposed structures are seen as restricting. Such departments indicate that freedom in the manner of acquiring, using, and safeguarding knowledge is essential to their activities. Those departments that work on projects indicate that our improvement proposals could help improve their LL process. From the above we can conclude that our design is mainly of value to project-based activities. This finding is in line with literature (chapter 2.3.3) where it is stated that when it comes to KM ‘one size fits all’ is not applicable.

All participants find KM important and would like to dedicate more time and resources to it. The general consensus at the end of the workshop is that connecting individuals with the aim of sharing is the most effective manner of knowledge exchange. Systems and IT tools can facilitate such exchange and should be used to connect knowledge demand with knowledge source.

### 8.3 Final LL process improvement proposals

The above given findings of the pilot study and generalization workshop are used to improve our design formulated in chapter 7. In this section these improvements are highlighted.

**LL Template** - is modified to include a technical aspects category. Categories communication and coordination are merged into one category, namely communication. Vendor evaluation
category is removed as ESSET tool is to be used for this purpose. The steps formulated for LL collection remain unchanged. The improved version of the LL Template can be found in appendix 16.

**LL Directory** - remain at SharePoint. The LL categories of this directory are modified according to changes made to the LL Template. LL of coordination category are transferred to communication and a technical aspects category is made. Vendor evaluation category is not removed as it contains LL of past projects. However, users are advised to use the ESSET tool for selecting and evaluating vendors (appendix 17).

**LL process** - the Project Brief document is modified to include the improved version of the LL Template. The project case section remains unchanged (appendix 18). LL are topic of Core Team meetings once a month and both challenges and best practices are discussed. This meeting should be linked to termination of a project step so that LL of this step can be collected and those LL needed for the next step can be retrieved. Prior to this meeting, core team members collect and retrieve LL and during the meeting they are discussed. The PM has a facilitator role and by asking questions according to the 5 Whys method, root-causes are identified. The PM makes sure the character of the session is not only evaluation but that attention is also given to formulating recommendations for future projects. The Project Review document is modified to include ESSET tool for vendor evaluation. LL collected in the Project Brief need to be attached to this document and uploaded to the LL Directory (appendix 19). Other process steps described in chapter 7 remain unchanged. This improved LL process is mainly of value to project-based activities at JBV.

### 8.4 Chapter summary

A pilot study was organized to examine the applicability of improvements proposals formulated in chapter 7 in practice. Our aim is to detect potential problems, find effective and workable solutions, and create acceptance for change. Lack of time and difficulties faced in formulating valuable LL are the most important outcomes of the pilot. This in contrast to the findings of in-depth interviews where process related issues are identified to be the main barrier. In dealing with these challenges the following advice can be followed. Keep LL on the agenda and make time for them. Practice formulating valuable LL and through feedback of others improve your understanding of value of knowledge.

Categories of the LL Template and the LL Directory are changed to include technical aspects. Communication and coordination are merged into one category and ESSET tool is used for vendor evaluation. The Project Brief document is modified to include the improved version of
the LL Template and the Project Review document now contains a section for transferring of LL to the directory and evaluating vendors through ESSET tool.

LL collection and retrieval during project lifetime is to be linked to completed project steps. The PM pays attention to positive and negative LL during Core Team meetings once a month. Through application of the 5 Whys method, root-causes are identified and recommendations for future projects are formulated.

As improvement proposals of chapter 7 are customized to the needs and wishes of our knowledge-customers at Engineering, their applicability in other settings was examined through a generalization workshop. A diverse group of representatives of other JBV departments participated. The main outcome is that improvement proposals to the LL process are mainly of value to project-based activities at JBV.
Chapter 9: Discussion and study limitations

Knowledge is an important asset to organizations and finding effective ways of managing it receives great attention both in the scientific literature and the industry. Learning organizations seek to improve all aspects of their activities requiring effective application of knowledge (chapter 2.1.1). These knowledge assets and their management is also of great importance to project-based organizations whose activities are project-based. One way of safeguarding and exchanging project knowledge and know-how is through project Lessons Learned (LL).

In this study, we look at opportunities that Lean Thinking (LT) can offer to improve Knowledge Management (KM) and specifically project LL. We focus on LT steps of: defining value, creating flow, and establishing pull. In order to examine applicability of Lean Knowledge Management (LKM) in practice, we consider the case study of the Engineering department of Janssen Biologics (JBJ). Engineering can be categorized as a learning organization that applies LT principles to its project-based activities.

Final proposals for improving the LL process at Engineering are formulated in chapter 8. They are based on literature findings (chapters 2 and 3) as well as outcomes of in-depth interviews, workshops, and the pilot study (chapter 6 and 8). In this chapter a general discussion on these findings can be found. We also consider the limitations of our study by looking at methodologies used and general applicability of improvement proposals. We aim at addressing sub-question 4.2 given in chapter 1: to what extent can results of the Engineering department be generalized to all cases of LKM? What are possibilities of such application?

Section 9.1 concentrates on opportunities and barriers of applying LKM to LL process, identified throughout our study. By means of this, research sub-question 4.2 is partially addressed. Study limitations are the topic of section 9.2 where the second aspect of sub-question 4.2 is considered.

9.1 Discussion

The scientific literature pays much attention to the challenges of determining value of knowledge due to its special characteristics (chapter 2.3.2 and 2.3.3). These characteristics include: 1) knowledge being explicit or tacit, 2) knowledge fading with time, 3) knowledge having a shelf life and becoming irrelevant and outdated, and 4) knowledge at times being subjective. Findings of in-depth interviews at Engineering are not in line with literature on this topic. Our knowledge-customers indicate process related challenges to be the main barrier to successful LL exchange. By improving the LL process through construction of the LL Template and the LL Directory these barriers are partially removed. It is only then that determining value
of knowledge is seen as a great challenge. During the pilot study participants faced difficulties in formulating LL that are of value to future projects.

In the literature, some experts emphasise that IT should only be seen as a tool for improving KM and not becoming the main goal of KM efforts (chapter 2.1.1). The final aim should be connecting knowledge demand with knowledge source and using IT tools to facilitate such connections. In formulating improvement proposals for the LL process we tried to follow this advice. This refrained us from using cutting edge technology for developing the LL Template and the LL Directory. This decision at times was against the expectations of some of our knowledge-customers who though IT should play a more prominent role. When we think of improving LL processes, initially a workable process should be set up, barriers to its implementation should be removed, and only then investment should be made in expensive technology (chapter 2.1.1).

In this study we found the ‘wish for learning’ to play an important role in pulling knowledge from the knowledge source (which can be an individual or a database) (Chapter 3.4). In the initial phases of a project this wish for learning is high and can be used as a trigger for knowledge pull. By linking this wish to formal project steps, retrieval of LL of past projects can be encouraged. As the manner of gaining such knowledge is less important, individuals are free to retrieve LL in the best way they find suitable.

Keeping LL on the agenda is essential to the success of the LL process. Talking about LL during various meetings, giving attention to them in trainings, and making sure their collection and retrieval is embedded in project steps are examples of how this can be achieved. During trainings attention can be given to the importance of LL, how the process is organized, and what the roles and responsibilities of different individuals are. This information should be part of the training all knowledge-customers receive.

The best incentive for using LL of past projects in new projects is found to be individuals experiencing benefits themselves (chapter 6.3). Experiencing such benefits can, however, be very difficult to achieve. When collecting and formulating LL for future projects direct benefit to the current project is not always clear. In cases where other more urgent issues occur during the project lifetime (which is often the case), attention of core team members shifts away from collecting and retrieving LL. We saw this clearly during the pilot where, even with the best of intentions LL were often set aside as more urgent matters needed attention. A possible solution to this challenge can be facilitated intervision sessions aimed at exchanging LL with peers on a regular basis. During these sessions those who formulated LL can receive feedback from their peers which can be of value to their own projects.
A factor of importance to successful exchange of LL according to our knowledge-customers is how LL are followed up. This issue is not covered in the reviewed scientific literature. Even though exchanging knowledge and know-how is important, attention should also be given to follow up findings of LL sessions. In cases where issues are of great importance, LL need to be translated into guidelines and standards. In other cases where LL can be of importance, less formal follow up steps can be taken. In both cases the role of participants is essential, as they are the ones deciding the future importance (value) of LL.

During in-depth interviews, workshops, and LL sessions, focus was on the challenges faced in projects. Less attention was given to positive aspects and best practices. In some scientific literature (chapter 2.4.1) it is emphasised to pay equal attention to both negative and positive LL as they both can contribute to success of future projects. The facilitator of LL sessions plays an important role in guiding discussions and the flow of meetings.

Another important role for the facilitator, be it an external individual or a Project Manager (PM), is trying to find root-causes. The 5 Whys method can be helpful in determining underlying issues. In collecting LL, attention should be given to evaluating the project as well as identification of underlying reasons. In cases where participants find LL to be beneficial for future projects they should not stop there but try to formulate how future projects can profit from these findings. This aspect is found to be difficult as determining future value of knowledge is challenging. More practice and if possible defining criteria for formulating such recommendations can help ease this difficulty.

An essential aspect of the LL process and determining value of knowledge for future projects, is providing manners of evaluating LL and giving feedback. Even though this aspect is not part of our improvement proposals, some knowledge-consumers emphasise such a need for success of the LL process. This need is also identified in the literature (chapter 3.2.1). When sharing LL takes place through LL sessions such feedback can be provided directly. When using the LL Directory, the role of IT tools becomes important. Automated systems must be simple and easy to use and offer manners of ranking, evaluating and giving feedback.

IT tools that offer possibilities of evaluating value of LL can help determine which LL are less valuable and relevant. However, next to this aspect attention should also be given to out-dated knowledge that at times can be wrong (think of complying with old regulations instead of the current ones, for example). Such knowledge needs to be removed from the LL Directory together with irrelevant LL. It can be that using IT tools alone is not sufficient for this purpose and an expert review is needed. This can be a subject for future research.
In order to implement the final improvement proposals successfully, attention should be given to change management. In this study we decided not to implement too many improvements at once as this could have resulted in resistance to change. We also made sure to communicate our activities and findings during various steps of the study through different channels (such as meeting, emails, posters, personal conversations, etc.).

As we have seen in this study knowledge exchange takes place through both formal and informal channels. Formal processes can harmonize the manner and frequency of exchange providing possibilities of monitoring, evaluation, and improvement. Both approaches of sharing knowledge are valuable and can complement each other.

LT focuses on the needs and wishes of the customer in producing products and services. KM can benefit from this guideline by making the knowledge-customer the focal point of decisions. Paying attention to the following aspects can lead to knowledge collection and sharing that is of value to the knowledge-customer:

1. Why is knowledge being collected.
2. For whom is it being collected.
3. Does the knowledge-customer have a need for this knowledge.
4. Is the manner of documentation and storing suitable to the wishes of this customer.
5. Is the knowledge-customer aware of knowledge collection and storage location.
6. Does he/she have access to this location.
7. For which amount of time is knowledge being stored.
8. Who is the owner of knowledge (process) and ensures its value.

9.2 Study limitations

Given time and scope constraints, this study has its limitations and in using the results of our work these limitations should be taken into consideration. These limitations also apply to generalization of our findings to all cases of LKM (sub-question 4.2 of chapter 1).

Interviews are one of the main methods used for collecting data during our study. One of the great limitations of interviews is receiving politically correct answers as individuals may feel that they cannot share their true opinion. In our study we tried to overcome this challenge by making interviews and processing their results anonymous.

We also used various workshops for collecting data. In all these workshops a selection of the target group was invited to participate. This can lead to some factors relevant to knowledge-customers not being taken into consideration or views of those present to be highlighted. Even
though workshops are a great way of collecting data as they provide interaction, attention should be given to issues such as groupthink (chapter 2.4.1) which makes finding problems and their root-causes difficult. We tried to overcome this difficulty by having an external facilitator in each workshop. This individual made sure all those present could express their opinion and by asking questions in a 5 Whys manner root-causes are identified.

Generalization of our improvement proposals for the LL process was conducted within JBV. We did not examine their applicability to other companies or organizations (organizational bias). The results of the generalization workshop indicate that the formulated improvements can be applicable to other JBV departments working on projects. However, this may not be the case for other project-based organizations.

Our study is constrained by limited time, budget, and resources. The time available is predefined, there is no budget available for changes, and the time our colleagues from both within and outside Engineering could dedicate to this study is limited. These aspects influenced our design choices and the way we conducted our study.
Chapter 10: Conclusion

Lean Thinking (LT) can offer an increase of value to end-customers through identification and elimination of waste and its root-causes. Some believe LT philosophy can be applied to other sectors than the manufacturing sector where it originated and offer them significant process improvements. However, others do not agree with this ´one size fits all´ notion and argue that more research should be done before one can speak of wide applicability of LT.

In this study, we set out to examine the applicability of LT principles to Knowledge Management (KM) activities. Management of knowledge assets within an organization with the aim of making the organization aware of its individual and collective knowledge and finding ways to make the most effective and efficient use of it, is known as KM. We wish to examine if and to what extent LT principles could contribute to process improvement of KM activities. We specifically look at the process of project Lessons Learned (LL) within a project-based organization. By selecting a case study we not only look at possible theoretical benefits LT can offer KM but also examine its applicability in practice.

Before stating the findings of our study, we return to our main research question and address it in section 10.1. Section 10.2 concentrates on the scientific contribution of our work followed by recommendation to the Engineering department in section 10.3. Recommendations for future research are formulated in section 10.4 and this chapter comes to an end with personal reflection given in section 10.5.

10.1 Main research question

The objective of this study is narrowing the knowledge gap found in the literature with regard to application of LT to KM, also known as Lean Knowledge Management (LKM). We address this issue not only from a scientific perspective but also by looking at LKM’s applicability in practice. In doing so, the following sub-questions are used as a guideline:

1. What is Lean Knowledge Management?
2. What are the characteristics of the Engineering department case study?
3. What are the effects of applying LKM to the Engineering department case study?
4. To what extent can results of the Engineering department be generalized to all cases of LKM?

Through these sub-questions, the main research question can be addressed.

To what extent can Lean Thinking principles be applied to Knowledge Management processes of a company with the aim of improving exchange of project Lessons Learned?
In this section we take a closer look at the sub-questions given above and shortly address them.

1. What is Lean Knowledge Management?

In applying LT principles to improve KM processes, the specific characteristic of knowledge should be taken into consideration. In this study we concentrate on three steps of LT that we consider to be most challenging to apply to KM, namely: 1) define value, 2) create flow, and 3) establish pull.

When attempting to determine knowledge value, the following aspects need to be considered:

1. Provide context for tacit knowledge via discussion groups.
2. Prevent knowledge from fading by providing opportunities for storing, organizing, and retrieving of acquired and created knowledge.
3. Recognise that knowledge has a shelf life and enable elimination of out-dated and irrelevant knowledge.
4. Offer feedback possibilities to knowledge-customer to deal with possible subjectivity of knowledge.
5. Enable common knowledge creation via formal and informal processes.

In case of creating knowledge flow: 1) effects of organizational memory should be considered especially if these memories are negative. Role of Management in creating positive memories can be essential in dealing with ‘burden of the past’. 2) As there are no standards for creation of knowledge flow, learning from KM activities both within and outside the organization are advised.

Knowledge pull concentrates on providing knowledge if and when it is demanded by the knowledge-customer. Wish for learning by this knowledge-customer can trigger knowledge pull from a database or an individual. The most effective manner of learning is through social interaction as accessibility and sustainability of knowledge is increased. Formal and informal manners of learning both within and outside an organization need to be considered.

2. What are the characteristics of the Engineering department case study?

The Engineering department as part of Janssen Biologics (J BV) can be considered to be a learning organization. JBV offers its employees opportunities of learning and development. This learning is not just limited to development of individual employees as attention is also given to overall improvement of business and production processes throughout the company where LT plays an essential role.
The Engineering department is a project-based organization that supports JBV’s manufacturing activities through improvements, modifications, and substitutions of production installations and facilities. The majority of these activities are project-based in which this department participates via its Project Managers (PMs) and Project Engineers (PEs). Management at Engineering is responsible for overall optimal functionality of all the department’s activities. The PMs, the PEs, and Management are our knowledge-customers.

One manner of sharing knowledge across projects is through exchange of project LL. LL exchange within the Engineering department can be divided into two categories: documented LL and undocumented LL. Undocumented LL are exchanged in an informal and ad hoc manner which functions well.

The process of documented LL of projects is as follows: after project termination, LL are collected during the LL/evaluation meeting by the PM and are documented in the Project Review document. This document is presented by the PM at the Portfolio Review meeting, where among others LL are discussed with resource managers. After closing out a project, the Project Review document is scanned and saved at the project close-out location by the SharePoint administrator. At this storage location these documents are saved according to their year of closure. Project LL selected for sharing during the Cross Functional meeting are presented by the PM to his/her peers. During this meeting there is room for questions, feedback, and knowledge exchange. The current process reaches some PMs and few PEs and does not have a trigger for retrieval of LL of past projects.

3. What are the effects of applying LKM to the Engineering department case study?

The difficulty of determining value of knowledge (specially its future value) is initially not seen as a challenge by the most of our knowledge-customers. Based on literature, interview, and workshop findings the following improvements are made. The LL process is modified and made known to all. The LL Template is made and the LL Directory providing an overview of LL of 2014 and 2015 projects is set up. It is only then that the challenge of knowledge value determination becomes more apparent. During the pilot we received feedback from various participants on the difficulty of formulating LL with the aim of using them as valuable knowledge in future projects.

The ‘wish for learning’ is found to play an important role in pulling knowledge from its sources (which can be an individual or a database). As in the initial stages of a project this wish for learning is high, linking it to the formal process of a project can trigger LL retrieval. This pulling of knowledge, however, becomes more difficult during the lifetime of a project. Keeping LL on the Core Team meeting agenda is found to be challenging. To insure that LL exchange would
also take place during a project lifetime, setting up intervision sessions (initially for the PMs and afterwards also for the PEs) is proposed.

The best incentive for using LL of past projects in new projects is found to be individuals experiencing benefits themselves. Experiencing such benefits can, however, be difficult to achieve. When collecting and formulating LL for future projects, their direct benefit to current projects is not always clear. Organizing LL sessions on a regular basis with the help of a facilitator can overcome this difficulty as feedback about the formulated LL can be received. This feedback can be valuable to those who collected LL during their projects.

4. To what extent can results of the Engineering department be generalized to all cases of LKM?
Generalization of our findings is conducted within JBV with the help of colleagues from different departments with various backgrounds. Our aim is to have a diverse group that represents as many departments and as many working processes as possible. However, we did not examine the workability of our proposals in other companies which as lead to organizational bias. This is one of the limitations of our study.

Many of the proposed improvements are considered applicable to departments working on projects. Our proposals are found to be less useful for everyday (not project related) activities. Also in research and development oriented departments, the proposed structures are seen as restricting. These departments indicate that freedom in acquiring, using, and safeguarding knowledge is essential to their activities. Those departments that work on projects indicate that our improvement proposals can help them improve their LL process.

Using the above given answers to the sub-questions, we can now address our main research question:

To what extent can Lean Thinking principles be applied to Knowledge Management processes of a company with the aim of improving exchange of project Lessons Learned?

Formulating LL for future projects is in essence a traditional push process. Knowledge is being collected based on predictions of the future needs of knowledge-customers. At the time of collection, the nature of future projects can be unknown. Hence, estimations need to be made about the type of possible challenges one can face during a project. Unlike manufacturing processes where predictions of future demand can be based on past data, making such predictions is difficult due to the nature of knowledge (not discrete and at times subjective).
The composition and members of future project teams can be undefined at the time of LL collection. In cases where knowledge-customer is known, he/she can only make an estimation of the type of knowledge that can be of value to future projects. In formulating LL, conducting the voice of the customer in the manner intended by LT philosophy (direct conversations and feedback) can hence be hindered. Therefore, the application of LT to KM and specifically to project LL is limited.

Having said that, this does not necessarily mean that some aspects of LL process cannot become more Lean. By considering aspects such as preventing duplication of activities and rework, linking wish for learning to pulling knowledge, and providing evaluation and feedback opportunities, LL process can benefit from LT principles.

Duplication of activities can be prevented through a thorough consideration of the LL process, identification of steps that add value to the knowledge-customer, and removal of those that do not provide such value. LL process steps need to be linked to formal project steps that have to be taken in conducting a project. By harmonizing these steps rework can be prevented. For example, if documenting LL is a formal step in closing out a project, the LL process designed for collecting LL during project lifetime should correspond to this formal step as much as possible. In this study, we propose to document LL during project lifetime in the LL Template and to attach this document to the Project Review document so no rewriting needs to be done. Such design decisions prevent rework and make the LL process more lean.

Determining if and when knowledge is demanded by the knowledge-customer can be difficult. This is especially the case for the use of LL in future projects and can make knowledge pull challenging. Considering the nature of sharing knowledge of any kind, provides us with insights into the mechanisms needed for pull. People tend to look for (pull) knowledge in phases where there is little known about a project and they are eager to learn. This is the case in the initial project phases but can also become part of the project during each sub-phase. When starting to work on a new sub-phase the wish for learning about specific topics of that sub-phase can lead to retrieval of LL. Linking this wish to the LL process can trigger knowledge pull both in the initial phases of a project as well as throughout its lifetime. In this study, we provide this trigger by modifying the Project Brief which is a formal document used in projects.

Evaluation and feedback opportunities on formulated LL can help determine their value. As we saw in this study determining the value of knowledge is a great challenge and this is more so for future value of knowledge. Both social interactions and IT tools can provide the knowledge-customer with the means to give feedback on value. In the long run, value determination criteria can be identified based on such feedback and through practicing. At Engineering we
suggest setting up intervision sessions where peers exchange LL on a regular basis and provide each other with the much needed feedback on value of identified LL.

Achieving cross-project learning through exchange of project LL is challenging. We saw this both in the literature and the case study. The silver bullet for successful management of this type of knowledge has yet to be found. As given above, application of LT principles can contribute to improvement of the LL process but is limited by the nature of knowledge and its special characteristics.

10.2 Scientific contribution

The main scientific contribution of this study is establishing knowledge pull. Providing knowledge if and when it is demanded by the knowledge-customer can be challenging as it is difficult to determine what type of knowledge is needed at which stage. We found that the ‘wish for learning’ by this knowledge-customer can trigger pulling knowledge from its source (either a database or an individual). As the most effective manner of learning is via social interaction, both formal and informal opportunities need to be created.

Next to this insight, we also found that determining value of knowledge can be made less challenging through feedback opportunities. It is difficult to define what valuable knowledge (and especially future valuable knowledge) is. This difficulty is related to special characteristics of knowledge including the need for context for tacit knowledge and value being time, individual, and purpose dependent (hence at times subjective). Making predictions about future value of knowledge becomes difficult due to these characteristics. Providing feedback opportunities either directly (during LL intervision sessions) or indirectly (via IT tools) can make the process of value determination less challenging.

Moreover, we found that knowledge flow creation can be negatively influenced by ‘burden of the past’. In cases where past KM efforts were less successful, it is important to create positive memories to motivate individuals. Also organizations need to keep investing and improving their KM processes and be open to best practices from both within and outside the organization.

10.3 Company recommendations

The changes we made to the LL process during our study are the initial steps in LT’s strive for perfection. Continuous investment in KM is needed to achieve effective and efficient use of knowledge assets within the Engineering department. In this section some recommendations on continuous process improvement can be found.
During the course of this study, we found that all at the Engineering department found KM and sharing LL of past projects to be important. We also found individuals to be open to sharing their knowledge with their colleagues. Both of these aspects are of great importance for successful KM efforts and resulted in active participation of the PMs and the PEs in our study. This present momentum needs to be utilised to achieve long-term successful exchange of LL. The advice to Management is hence to keep LL on the agenda during various meetings and in all projects. We also advise appointing a KM owner to ensure that needed time and attention is given to all KM activities at Engineering including the LL process.

It is important to apply the changes made to LL process in practice, monitor their success and shortcomings, evaluate the process, and where needed make changes to improve it. Some aspects of the LL process are challenging, such as formulating valuable knowledge for future projects. The advice is to keep practicing and share best practices in this regard. In the future identifying criteria for formulation of LL could help ease this challenge.

Attention should also be given to knowledge exchange with regard to Business Improvements (BIs). These types of projects were left out of the scope of this study but can be a great source of knowledge for all at Engineering. We also advise sharing of KM best practices with other departments of JBV as this is a great potential for learning and collaboration.

In our study, we concentrate on the process of LL and making it known and consistent within the Engineering department. This in line with findings of interviews and workshops. Less attention is given to IT tools and how the present advancements in these technologies can contribute to process improvement. This aspect should be addressed to, for example, improve the searching and filtering options in the LL Directory.

Making sure formulated LL remain valuable in the long run is important. Knowledge has a shelf life and can become out-dated and irrelevant. During our study we paid less attention to this issue and our proposals did not take removing of invaluable, irrelevant, or out-dated knowledge into account. Expert evaluation of formulated LL and determination of their relevance is one way of ensuring value of LL. Feedback opportunities for knowledge-customers via IT tools can also contribute to value determination. Advice would be to review LL on an annual basis and to remove those lessons that are out-dated and irrelevant.

Another point of attention is actions to be taken based on results of LL (follow up). This issue is not taken into account in our improvement proposals. It is advised to make a distinction between LL that are essential to well-functioning of future projects and those that can be of importance. Essential LL should be translated into guidelines and standards and designing this
process should be given attention in the future. This issue is found to be of importance in motivating individuals to collect and share LL in the future.

Formal knowledge sharing opportunities for the PEs are rather slim in comparison with the PMs. The PMs exchange knowledge via peer-review options and attendance of the Cross Functional meetings. Such possibilities should also be considered for the PEs.

Organizational knowledge maps are a great way of identifying knowledge sources within an organization. Such maps can provide an overview of individual's area of expertise, projects they have participated in, and their contact information.

10.4 Recommendation for future research

Given time and scope constraints, we are not able to take all necessary aspects of LKM and their applicability to Engineering into account in this study. However, these aspects remain important and should be given attention in the future. As we saw in the prior chapters, there are many aspects in need of future consideration both at Engineering and in the scientific literature. Here a selection of the most interesting topics, according to us, is made which includes both scientific and case study related issues:

1) The role of Management and project sponsor can be key for the success of the LL process. This issue is not the main focus of this study and needs extra attention.

2) Another aspect that is found to be influential to success of LKM efforts is company culture. Norms and habits of individuals within organizations influence how knowledge is exchanged. We do not consider this issue in our study and future research should investigate its importance.

3) During our study we concentrate on larger projects and left BIs out of scope. At Engineering BIs currently do not have a LL process and management of these projects is different from larger projects. Applicability of our LL process improvement proposals need to be examined for BIs.

4) In our case study a LL process is present and project activities are defined on a high level. Applicability of LKM in setting up a LL process can be investigated.

5) In this study we consider everyday projects of a project-based organization. One-of-a-kind projects have different processes and organizations. It should be investigated to what degree these aspects influence the findings of our study.

6) In this study we look at three of the five LT steps and leave the other two steps out of scope. Steps 2) identify value stream and 5) strive for perfection, need to be examined.
7) In our study we mainly concentrated on improving the LL process and gave less attention to the role of IT tools. However, they can be a great facilitator of knowledge exchange and therefore their role in improving LL processes needs future research.

Now that the initial steps in improving the LL process at Engineering have taken place, we recommend examining how they can be enforced in the long run. In such examination, the role of Management and project sponsor can be key. Therefore, we advice Engineering to consider this aspect as the next step in the improvement of the LL process. This topic can also be an interesting subject for future graduation projects.

10.5 Personal reflection

This graduation project has been a wonderful journey and a great learning experience for me. In this section, I would like to reflect on the work I have done in the past months and what this process has thought me.

The subject of LKM has intrigued me from the start of my thesis and the more I learned about this subject matter the more I wanted to learn. The complexity of issues such as knowledge, knowledge sharing, and learning, continues to fascinate me. Great efforts have been done in the past (both in science and industry) in overcoming these complexities and getting a better understanding of them. The subject of KM and in particular LKM remains a great challenge, however, which needs future attention.

The process of conducting this study has been a great joy. Being able to work on an independent research, was both exciting and challenging. The independent aspect gave me the opportunity of designing my own way of tackling the problem with guidance from my supervisors. I learned a great deal about the importance of good organization and effective communication. I got the opportunity to test theoretical findings in practice and examine their applicability and limitations. At times this independent aspect, however, also brought about challenges. As the subject matter is of great interest to me and as I wanted to contribute as much as possible to the Engineering department, the decision of which issues to take on was not easy. Time limitations required me to make a selection of issues I wanted to focus on. Here, my supervisors provided me with the much needed guidance, for which I am grateful.

The time I spent on my graduation project flew by in a blink of an eye. It seems just yesterday that I started my work at the Engineering department. Now, in the final phases of my study I see many opportunities of improvement within JBV as well as science with regard to LKM. I hope to be able to continue working on improving KM through LT in the future.
The subject matter of my graduation project is a great example of the need for multidisciplinary studies such as Systems Engineering, Policy Analysis, and Management. I believe technology can only contribute to effective problem solving if the human aspect is taken into consideration. In all problem solving endeavours, effective organization and management is of great importance and needs attention. Lasting success can, in my opinion, be reached through enabling different scientific disciplines to complement each other.

Finally, I hope my work has contributed to better understanding of knowledge, KM, and LKM both in theory and in practice. Hopefully, improvements made to the LL process at Engineering can help improve the great work my colleagues do every day. I also hope others get to know this subject matter and get as intrigued by it as I did. This graduation project gave me the opportunity to get a better understanding of LKM but also to develop skills such as good communication and organization, flexibility, independent decision making, critical thinking, and clear articulation both verbally and in writing. I have also made valuable contacts within JBV and at TU Delft which I hope will be lasting. I would greatly advise students to conduct their graduation project at a company and hopefully they can have a great experience as I did.
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Appendix 1: Interview questions for Modification Engineers

Algemeen

1. Kan je ajb kort toelichten wie je bent? Wat je functie/rol binnen FME is en hoe lang je bij Janssen Biologics aan BIs werkt? Contractor of niet?

Kennisuitwisseling specifiek BI

1. Deze stappen samen doen:
   b. Wat voor gedocumenteerde informatie heb je bij elke stap gebruikt? Zo specifiek mogelijk!
   c. Waar wordt deze informatie bewaard? Zijn er andere locaties waar soortgelijke informatie wordt bewaard?
   d. Wie beheert deze opslag locaties?

2. Welke niet JBV derde partijen waren bij je BIs betrokken? Waar staat informatie over deze partijen opgeslagen? Gebruik je wel eens Esset?

3. Heb je tijdens je BI kennis gecreëerd? Wat heb je hiermee gedaan?

4. Had je behoefte aan bepaald type informatie die je in de huidige database niet kon vinden? In welke locatie had je deze informatie verwacht?

5. Wie vanuit Maintenance was betrokken (zowel system owner en maintenance owner) bij jouw project? Wanneer? Waarom?

6. Hoe deel je gedocumenteerde informatie met Maintenance?

LL specifiek BI

1. Heb je ervaring en kennis opgedaan tijdens deze BI gedeeld met andere collega’s? Zo ja hoe?

2. In welke stappen van deze BI had je behoefte aan kennis van eerdere BIs?
3. Wat voor informatie had je willen gebruiken? Wat had je met deze informatie willen doen?
4. Er is op dit moment geen systeem en proces voor het opslaan en opvragen van de LL van BI's. Denk je dat dit nodig is? Zou je zo'n systeem willen gebruiken?

**LL SharePoint (indien WEL projecten)**

1. Documenteer je zelf LL wanneer je deelneemt aan projecten? Wanneer begin je hiermee?
2. Heb je naar de huidige opslag van LL van projecten gekeken? Wat waren jouw indrukken hiervan?
3. Gebruik je gedocumenteerde LL op dit moment? Waarom? (LL niet te vinden, niet user friendly, niet de juiste informatie, geen behoefte)
5. Wat zijn de voor- en nadelen van het huidige LL systeem?
6. Hoe deel je kennis op dit moment?

**Algemeen**

1. Wat vindt je van de huidige aanpak van KM bij Engineering? Wat gaat goed/niet goed?
2. Wat zou je aan de huidige situatie willen veranderen? Wat is de ideale situatie?
3. Wat valt je op m.b.t. nieuwe medewerkers? Met welke problemen worden ze geconfronteerd?
Appendix 2: Interview questions for Project Engineers

Algemeen


Kennisuitwisseling specifiek project

1. Deze stappen samen doen:
   a. Zijn alle standaard stappen in jouw project uitgevoerd? Extra stappen? Waarom?
   b. Wat voor gedocumenteerde informatie heb je bij elke stap gebruikt? Zo specifiek mogelijk!
   c. Waar wordt deze informatie bewaard? Zijn er andere locaties waar soortgelijke informatie wordt bewaard?
   d. Wie beheert deze opslag locaties?

2. Welke niet JBV derde partijen waren bij je project betrokken? Waar staat informatie over deze partijen opgeslagen? Gebruik je Esset (leveranciers)

3. Heb je tijdens dit project kennis gecreëerd? Wat heb je hiermee gedaan?

4. Had je behoefte aan bepaald type informatie die je in de huidige database niet kon vinden? In welke locatie had je deze informatie verwacht?

5. Wie vanuit Maintenance was betrokken (zowel system owner en maintenance owner) bij jouw project? Wanneer? Waarom?

6. Hoe deel je gedocumenteerde informatie met Maintenance?

LL specifiek project

1. Heb je ervaring en kennis gedeeld met je project team? Hoe?

2. Heb je in dit project LL gedocumenteerd? Wanneer ben je hiermee begonnen? Heeft iedereen hieraan bijgedragen?

3. In welke stappen van dit project hadden LL waardevol voor je kunnen zijn?

4. Wat voor LL had willen gebruiken? Wat had je met deze informatie willen doen?
LL SharePoint

1. Heb je naar de huidige opslag van LL van projecten gekeken? Wat waren jouw indrukken hiervan?
2. Wanneer zou je LL wel gebruiken? Criteria? Welke categorieën zouden belangrijk zijn?
3. Wat zijn de voor- en nadelen van het huidige LL system?
4. Gebruik je gedocumenteerde LL op dit moment? Waarom? (LL niet te vinden, niet user friendly, niet de juiste informatie, geen behoefte)

Algemeen

1. Wat vind je van de huidige aanpak van KM bij Engineering? Wat gaat goed/niet goed?
2. Wat is volgens jou de ideale situatie? Wat zou je willen veranderen?
3. Wat valt je op m.b.t. nieuwe medewerkers? Met welke problemen worden ze geconfronteerd?
Appendix 3: Interview questions for Project Managers

Algemeen

1. Kan je a.j.b. kort toelichten wie je bent en wat jouw functie/rol binnen Engineering is en hoe lang je PM bent?

Doelen en plannen

1. Heeft Engineering lange termijn doelstellingen m.b.t. KM? Zo ja, wat zijn deze doelstellingen? Is het belangrijk om doelstellingen te hebben?

2. Heeft Engineering een actionplan m.b.t. KM? Zo ja, welke aspecten worden hierin meegenomen?

3. Wat zijn volgens jou de belangrijkste aandachtspunten?

Kennisoverdracht

1. Hoe deel je op dit moment kennis met je collega’s? Met welke collega’s deel je kennis? Waarom op deze manier en met deze collega’s?

2. Hoe wordt kennis uitgewisseld met anderen wanneer een collega een andere functie krijgt of met sabbatical of pension gaat?

3. Hoe zouden we kennis en expertise kunnen overdragen aan anderen? Wat zou volgens jou de ideale situatie zijn?

4. Wat valt je op m.b.t. nieuwe medewerkers? Met welke problemen worden ze geconfronteerd?

5. Hoe zou jij een nieuwe PM inwerken?

Contractors

1. Engineering werkt met contractors voor zowel projecten als BIs. Waarom?

2. Heeft het werken met contractors invloed op het niveau van kennis en ervaring binnen Engineering?
3. Hoe wordt de samenstelling van project teams bepaald: hoeveel % JBV en hoeveel % contractor?

4. Hoe lang werkt engineering met deze samenstelling? Evaluatie?

5. Heeft Engineering een strategie voor kennisoverdracht als het om contractors gaat? Is een dergelijke strategie belangrijk?

**LL SharePoint**

1. Wat vindt je van het huidige systeem en proces van LL? Is dit een goede manier om kennis te delen?

2. Vind je het belangrijk om LL te documenteren, op te slaan en te gebruiken? Waarom?

3. Wat zijn volgens jou de grootste hindernissen van Engineers met het huidige systeem van LL?

4. Wanneer zou een systeem en proces van LL geslaagd zijn volgens jou?

**Algemeen**

1. Kunnen we gebaseerd op wat we boven besproken hebben doelstellingen formuleren?

2. Welke doelstellingen hebben prioriteit?
Appendix 4: Interview questions for Management

Algemeen

1. Kunt u a.u.b. kort toelichten wie u bent en wat uw functie/rol binnen Engineering is?

Doelen en plannen

1. Heeft Engineering lange termijn doelstellingen m.b.t. KM? Zo ja, wat zijn deze doelstellingen?
2. Heeft Engineering een actionplan m.b.t. KM? Zo ja, welke aspecten worden hierin meegenomen?
3. Wat zijn uw belangrijkste zorgen over de huidige situatie? Aan welke aspecten moet aandacht gegeven worden?

Kennisoverdracht

1. Hoe wordt kennis op dit moment uitgewisseld met anderen wanneer een collega een andere functie krijgt of met sabbatical of pension gaat?
2. Hoe zouden we de kennis en expertise van Engineers kunnen overdragen aan anderen? Wat zou volgens u de ideale situatie zijn?
3. Zijn er programma´s om vakinhoudelijke kennis van Engineers op pijl te houden?
4. Wanneer een Engineer een nieuwe functie krijgt in het kader van FPX, wordt er ook aandacht besteed aan zijn/haar communicatie- en organisatievaardigheden?

Contractors

1. Engineering werkt met contractors voor zowel projecten als BIs. Waarom?
2. Heeft het werken met contractors invloed op het niveau van kennis en ervaring binnen Engineering?
3. Hoe wordt de samenstelling van project teams bepaald: hoeveel % JBV en hoeveel % contractor? Wat is de strategie hierachter?
4. Hoe lang werkt engineering met deze samenstelling? Evaluatie?
Improving Knowledge Management by means of Lean Thinking

LL SharePoint

1. Wat vindt u van het huidige systeem en proces van LL? Is dit een goede manier om kennis te delen?

2. Vindt u het belangrijk om LL te documenteren, op te slaan en te gebruiken? Waarom?

3. Wat zijn volgens u de grootste hindernissen van Engineers met het huidige systeem van LL?

4. Wanneer zou een systeem en proces van LL geslaagd zijn volgens u?

5. Er is op dit moment geen systeem en proces voor LL van BLs. Zou een dergelijk systeem belangrijk kunnen zijn?

Algemeen

1. Kunnen we gebaseerd op wat we boven besproken hebben doelstellingen formulieren?

2. Welke doelstellingen hebben prioriteit?
# Appendix 12: LL Template 1.0

In gathering Lessons Learned think of the following aspects:

1. **Observation:** What happened? (In what way was this different from what should have happened?)
2. **Discussion:** Why did it happen? (Were these circumstances foreseen or not? Why?)
3. **Conclusion:** What did you learn? (Were these lessons specific to your project or can they be beneficial to future projects?) **If lessons were project specific, the process ends here.**
4. **Recommendation:** How can such problems be prevented in future projects? (Describe the steps to be taken.) **Document points 1 to 4 in the corresponding category of lessons learned.**

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<th>Contact person LL</th>
<th>Topic</th>
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## Appendix 13: LL Directory 1.0

Transfer the documented Lessons Learned from the template to this registry according to the given category.

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Appendix 16: Improved LL Template

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