CHALMERS

Securing knowledge reuse in a New Product Development organization

- A case study at Emerson Process Management

Master of Science thesis in Quality & Operations Management

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Abstract

Knowledge has since a few decades back been recognized as a corporate asset, meaning that it also needs to be managed as any other corporate asset. The field of Knowledge Management has therefore evolved during the last decades and became something that many companies around the world are working with in order to manage the way knowledge flows through the organization. Simultaneously, it is crucial for knowledge-intensive organizations, such as product development organizations, to manage the knowledge with the aim of keeping the knowledge in-house and being able to reuse it for future development projects in order to stay competent and competitive.

This thesis has been conducted at Emerson Process Management and their site Rosemount Tank Radar in Gothenburg. As the company has not been working with Knowledge Management before, there is a need of findings ways of managing the knowledge, making sure that it is shared among employees and finding ways of securing that it is reusable for future development projects. Furthermore, to reach a conclusion about how to make knowledge reusable, the ways an engineering checksheet can be applicable have also been investigated, using Volvo GTT and Toyota as references. The research has been conducted as a case study, including semi-structured interviews with ten employees, additional informal discussions and interviews with two external companies. Moreover, a workshop has been held in order to investigate how an engineering checksheet could look like for one of the company's mechanical components.

The study has concluded that in order for knowledge to be reused, it needs to be shared among employees, even though sharing knowledge does not automatically mean that it will be reused. However, factors such as organizational culture, time- and resource restrictions and design of working environment can strongly affect how well knowledge can be shared within an organization. Furthermore, as much of the knowledge that needs to be captured is tacit in nature, it is vital to enhance social interaction between people to foster a tacit-to-tacit knowledge transfer. Simultaneously, having the experienced and skilled employees focusing on capturing actionable knowledge, meaning to keep a future recipient of knowledge in mind, is crucial for the reusability of documentation. To accomplish reuse of previously acquired knowledge, an engineering checksheet for a component or a product could be a suitable way to capture knowledge that is more tacit in nature, while simultaneously decreasing the knowledge gap between seniors and juniors in an organization. Furthermore, enhancing a learning process and standardize Knowledge Management activities into already existing processes is recommended. Lastly, securing that what is documented is actionable information for a recipient, as well as having supporting activities such as mentorship is important to secure knowledge share and reuse.

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List of abbreviations

CoP – Community of Practice
KM – Knowledge Management
LL – Lessons Learnt
NPD – New Product Development
PD - Product Development
PPR – Post Project Reviews
RTR – Rosemount Tank Radar

1. Introduction

This chapter starts with a background of the field of Knowledge Management and why it has become important for companies to work with it. It further describes the case company, the purpose of the research and the research questions on which this thesis is based. Lastly, the delimitations of the research are discussed.

1.1 Background

It is an indisputable fact that in modern society and organizations, knowledge has a very crucial role to play. According to Davenport and Prusak (2000), knowledge has since a few decades back been recognized as a corporate asset, meaning that is needs to be managed as any other corporate asset. Consequently, creating, capturing as well as reusing knowledge is of great importance for any individual, organization or the society per se (Nonaka, 1994). Davenport and Prusak (2000) further state that the knowledge is increased when it is being used, in contrast to the tangible corporate assets, and therefore the usage of knowledge can be seen as a sustainable advantage.

The field of Knowledge Management, according to Frost (2010), is about ensuring that the right knowledge is provided to the right person at the right time. He further states that while this does not seem to be so complex in itself, the connection to the overall corporate strategy, the understanding of where the knowledge exists and in what forms as well as the challenges of creating processes that connects different functions in the organization, make it more difficult.

Companies have been trying to investigate a variety of ways to effectively manage the knowledge. Simultaneously, in Product Development (PD) organizations where project work is the main way of working, capturing and reusing the knowledge can prevent making the same mistakes in new projects (Crossan, Lane and White, 1999). In knowledge-intensive environments, such as PD organizations, managing knowledge is not only about staying competitive in the market with strong competitors, but also about staying competent in the area (Goffin and Koners, 2011). This leads to a need for organizations to find ways of ensuring that the knowledge resided in-house is being utilized.

This thesis has been conducted as a case study at Emerson Process Management and their site Rosemount Tank Radar AB in Gothenburg, Sweden. The following section gives a brief introduction to the company and the problem description on which this thesis is based on.

1.1.2 Case company

Rosemount Tank Radar AB (RTR) is part of Emerson Process Management, which provides companies all over the world with tank management systems for refineries and tank terminals. Rosemount Level is the part of the company that offers radar-based transmitters to the process industry. In Sweden, the company is mainly situated in Gothenburg where they have production and all supporting functions in-house, but they also have engineering departments in Linköping and Jönköping.

While the company has been working in project teams since many years and has an organization that supports it, there have been various ways of capturing knowledge from each PD project. The company has now got into a situation where the main part of the acquired knowledge and the lessons learned that they capture in the end of the projects are stored in various formats in the company's hard drives, but they are rarely utilized for other projects. Simultaneously, RTR has seen the potential of having a systematic way of utilizing the acquired knowledge in order to speed up the PD process and avoid doing the same mistakes as in past projects. Hence, their main future goal is to create an environment where continuous as well as organizational learning is enabled and knowledge sharing between employees is fostered. This currently leads to a need of enabling the reuse of knowledge and make it easily accessible to those who need it in order to use it for future decision-making, design solutions and development processes.

1.2 Purpose

The purpose of this thesis is to investigate how Rosemount Tank Radar AB can ensure that knowledge and experience acquired from projects is being transferred among the employees as well as utilized in future projects. Furthermore, the utilization of engineering checksheets for knowledge reuse will be investigated for the company's product development process.

1.3 Problem analysis and research questions

Based on the identified need for securing that knowledge is being reused in future projects in combination with the preconditions of the project, the first research question will address different ways to reuse knowledge, based on the current situation in the organization. Furthermore, it is important to investigate different types of tools, mechanisms and supporting functions that may be useful for the company. Consequently, the first research question is;

RQ1: In what ways can knowledge acquired from projects be reused in future projects?

In order to reuse knowledge, it is initially necessary to ensure that it is shared among the employees of the organization. This does not mean that when knowledge is shared it is certainly reused; however, ensuring that knowledge sharing really occurs in the organization is a precondition for knowledge reuse. Consequently, it is important to identify the factors that can affect knowledge sharing in order for the organization to consider or deal with them and secure knowledge reuse. So, the second research question is;

RQ2: What are the factors influencing knowledge sharing that the organization needs to consider in order to enable knowledge reuse?

As there has been extensive research within the field of Lean manufacturing, based on Toyota's best practices, there are several tools that can help companies manage the knowledge flow. One of these tools that companies such as Volvo GTT has started using and found it suitable for a PD organization is the engineering checksheet. The desire of trying out a concrete tool that may enable knowledge reuse in the PD leads to the third question;

RQ3: In what ways can an engineering checksheet be applicable for knowledge reuse at Rosemount Tank Radar?

1.4 Delimitations

This thesis focuses on Rosemount Tank Radar AB and although it is a part of Emerson Process Management and Emerson in general, the research and outcome of the thesis are based only on the specific company and may not be applicable for the whole Emerson concern. Furthermore, the time limit of the thesis makes validation and testing of the recommended actions and proposed tool not feasible for the particular project. In addition, proposing an implementation plan for the Knowledge Management initiative is not part of the scope, however the intention is to give recommendation about what actions to take.

2. Method

This chapter describes the scientific approach that has been used. It starts with describing the strategy, design and method used for the study, including how data has been collected and assessed. Lastly, ethical considerations are being discussed and how the validity of the research is assessed.

2.1 Research strategy

The general orientation of the conduct of a research is called a research strategy. There are two distinctive strategies; qualitative and quantitative. The qualitative strategy is oriented to an inductive approach, which is done by generating theory and emphasizing an understanding of the social world by seeing how individuals interpret and see it (Bryman & Bell, 2011). Quantitative strategy is however more oriented to a deductive approach, focusing on testing of hypotheses based on data in numerical form and in large scales (Bryman & Bell, 2011). Thus, the inductive approach aims at developing new theory based on empirical findings while the deductive approach starts with theory, developing hypotheses and then gather data to test it (Bryman & Bell, 2011). Since this research is about knowledge management (KM) and organizational learning, it requires opinions from the organization's members, entails perceptions of the situation and is therefore not based on numerical data. Hence, this research has been based on a qualitative approach with an abductive view upon it, meaning that theory and the empirical data gathered are used in an iterative process in order to develop theory. Furthermore, the theory is serving as a foundation for an understanding and guiding in what areas to focus on during the study.

2.2 Research design

The design of the research focuses on frameworks used for data collection and analysis. Since this research has been based on examining a single company, Bryman & Bell (2011) proposes a case study, which can provide an in-depth understanding of the company. Due to the nature of the research with only one company and the goal of gaining a deeper understanding of the environment, the research has been conducted as a holistic single case study (Yin, 2003). While there are possibilities of making generalizations from single case studies, they do not mainly strive for it. However, it is important to note that generalizations within qualitative research has not had the same priority as in quantitative research as quantitative research usually focuses on testing hypotheses using e.g. sampling, while quantitative research focuses on rich descriptions of the context and may therefore need a theoretic generalization in the context of transferability from case to case (Polit and Beck, 2010). This issue of transferability, as well as validity of the research, is further discussed in section 2.4.

Furthermore, there are elements of action research included. Avison et al. (1999) describe action research as a unique method because it associates research and practice in a way that it creates a synergy by research informing practice and the opposite way around. It is further described as an iterative process involving both the researchers and practitioners acting together on one or more particular activities which not only includes the particular activities, but also problem diagnosis and reflective learning (Avison et al., 1999). For this research, there has been a workshop held, which according to Oxford Dictionary (2015) is *"A meeting at which a group of people engage in intensive discussion and activity on a particular subject or project"*. The workshop included people both from the organization and external people from one of the reference companies, Volvo GTT, as well as researchers from Chalmers University. The workshop was conducted because of two main goals; providing a feedback-loop of the findings to the organization and creating an engineering checksheet as a potential tool for knowledge capture and reuse. This element of an action research therefore serves both as a way of collecting more data by discussing findings and getting the organization involved in developing a tool that might be useful for them, but also a way of making the researchers be involved in a practical way and try out some of the findings, in this case the use of an engineering checksheet.

2.3 Research method

2.3.1 Literature review

Firstly, the researchers conducted a thorough literature review in order to gain a deep understanding of the field in knowledge management. The knowledge gained through this served as the foundation of the researchers' further work and shaped the way the researchers approach the problem. The literature was found on various databases and keywords that were used were e.g. Knowledge management, Knowledge transfer, Knowledge management in New Product Development (NPD), Knowledge reuse etc. The literature review was performed both in an early phase of the research but was also conducted iteratively with the interviews and data analysis for further understanding of the situation.

2.3.2 Data collection

The data collection constitutes of both primary and secondary data. The primary data was collected mainly by semi-structured interviews. Interviews are widely used in qualitative research in order to gather data. Opdenakker (2006) states that one advantage of personal interviews is the possibility of gathering data from social cues, which can be expressed in the interviewee's body language or voice. Data of this kind can lead to valuable input for the researchers if the interviewee is seen as a subject (Opdenakker, 2006). Semi-structured interviews are according to Bryman & Bell (2011) a good way of discussing issues and ask

questions during the interview while having the possibility to adjust the interview according the interviewees' answer. This can be done by having follow-up questions in order for the interviewee to give more thorough answers, which can help the researchers in gaining a better understanding. The interviewees that were chosen for this study were employees involved from different functional areas who are involved in project teams on a regular basis. There was ten interviews held and each interview was recorded and transcribed for further analysis. See appendix A for the interview guideline. The secondary data that has been used has mainly been gathered by reading documentation and information stored in the company's intranet. Among the documents studied, there have been post-project learning's as well as NDP processes and routines.

Another method used for data collection was participant observation, meaning that the researcher is observing a setting or a specific context of interest, usually in an overt role by the employees knowing that they are being observed (Bryman & Bell, 2011). For this study, a participant observation was done at a meeting for discussing Lessons Learnt (LL) for a project that was run for three years. The researcher that attended the meeting listened, wrote full field notes and asked some questions for the closure. The data collected from that session is a part of the empirical data that has been analyzed in this thesis.

2.3.3 Data analysis

The interviews were recorded and the data gathered through them was transcribed for further analysis. After each interview, there was a short reflection done individually by the researchers to capture valuable data such as observations that might not have been captured by the recordings. All the data was gathered in accordance to what type of information was needed to answer the research questions. It was codified and labeled at an early stage, using the literature as a support. Hence, the codification was done by essence-capturing words that describe the essence in a large amount of data. The labeling of the data was also done in accordance to the concepts reviewed early in the research. The aim was mainly to secure that what data has been collected could also be supported by the literature and vice versa. In some cases, further literature needed to be reviewed and concepts were being revised during the analysis. Additionally, it was sometimes required to gather more data in order to further develop what has been found.

2.3.4 Ethical considerations

When conducting business research, there are four ethical considerations that need to be considered. These ethical considerations are: harm to the participants, lack of informed consent, invasion of privacy and deception (Diener & Crandall 1978 in Bryman & Bell, 2011). As these issues have been addressed in this study, the following section will briefly describe how these issues were taken into account.

Firstly, regarding harm to participants, the consideration lies in ensuring that interviewees in no way are directly harmed or negatively affected. In this study, the main risk has been to ensure that the anonymity is kept and that the respondents feel safe and can express themselves without feeling scared of potential consequences. This is especially a problem if the respondents are being critical about the company, managers or colleagues that might lead to negatives consequences such as losing their job. To avoid this, each interviewee was guaranteed anonymity and ensured that no answers can be traced back to the person. Furthermore, all data and transcriptions were kept anonymous in order to not have any names or statements that can be traced.

The lack of informed consent is about thoroughly explaining the study to the interviewees in order to get consent of participation (Bryman & Bell, 2011). Each interviewee got the information needed to make a decision whether to participate or not. The information was including what the study is about, how data is collected and used, the option of not answering a question or stop the interview at any point. Lastly, they were also promised complete anonymity.

During the interviews, it is of great importance to protect the privacy of the interviewees. This means that despite their consent to participate, they need to be reminded during the interview of their right to not answer specific questions or stop the interview. Moreover, as the interviews were recorded, the interviewees were firstly asked for consent and they were aware of how the data would be used. Furthermore, they were also given the opportunity to get in contact with the researchers at any point if they had any questions or comments.

Lastly, to avoid deception, it is of importance as a researcher to be honest about the purpose of the study. In this case, the purpose was clearly stated by the researchers and the questions asked during the interviews were exclusively connected to the purpose of the study. The interviewees were also given the opportunity of participating in the final phase of the study regarding the presentation of the findings.

2.4 Validity and transferability

Firstly, triangulation has been used for the study as different methods for data collection and analysis have been used. In this research, previous research has been used to support the findings. Data has been gathered in several ways. Interviews were held in the case company, documentation on the intranet has been read and participation in a workshop as well as in a closing discussion for a project. Moreover, observations have been made throughout the research and interviews were held with external companies. All data has been analyzed according to previous research in order to increase validity of the research.

As far as external validity is concerned, it may be difficult to generalize a case study in the same sense as generalizing a quantitative research and ensure that it is representative for other cases (Bryman & Bell, 2011). In this research, there is no intention to generalize the findings beyond the context of knowledge transfer and utilization in PD organizations. However, the researchers believe that in future case studies, there may be a possibility to look into how the research has been conducted to be able to draw conclusions in future cases. This is merely a question of transferability, which Polit and Beck (2010) state as the ability of using the findings in a research in a completely different group or setting. For this thesis, it is believed that by the rich descriptions of the method, but more essentially the company and context in which the research has been conducted, the transferability could be increased. Furthermore, it needs to be noted that the abductive approach of this thesis, by iteratively combining theory and empirical findings to draw conclusions, may be seen as a way of confirming what theory and previous research has shown. This may also increase the transferability. Moreover, potential utilization of the way the reference companies have been working with Knowledge Management practices may also increase the transferability from case to case.

Regarding internal validity, it may be difficult to estimate how the usage of different theory, tools and frameworks may shape the researcher's way of conducting the research. However, in order to try to increase the validity of the data collected, the researchers had a variety of people to interview. By feeding back the gathered data, both by workshops and minor, less informal discussions, the researchers could receive confirmations or disproof about whether or not certain things have been understood correctly. Lastly, as the testing of the engineering checksheet as a tool cannot be done within the time limit of the thesis, there had be a validation by acceptance, meaning that the employees in the organization accept the tool regarding its usefulness in the particular setting. This was done by discussion of the usefulness and if there are some preconditions for it. To conclude, all employees asked about the tool were positive about it and could imagine the tool working for the organization. However in order to evaluate the effects of it requires a usage for a longer period of time.

3. Theory

This chapter includes a literature review on research done in the field of Knowledge Management and Product development. The chapter starts with an introduction to the field, followed by sections describing its role PD organizations, the lifecycle and nature of knowledge, the factors influencing knowledge sharing and the tools/mechanisms for knowledge share and reuse.

3.1 Introduction to Knowledge Management

3.1.1 The concept of Knowledge Management

There are numerous definitions of knowledge management (KM) that can be found in the literature and all of them highlight most of its important aspects. Generally, as Alan Frost (2010) state, the essence of KM is to make the right people reach and use the right knowledge and ensure that the knowledge acquired by an organization is accessible and usable when needed. Sveiby (2003) presents KM as *"The art of creating value from an organization's intangible assets"* (seen in Ghani, 2009). Furthermore, one of the most descriptive definitions of KM has been given by Frost (2010) who states that *"KM is the systematic management of an organization's knowledge assets for the purpose of creating value and meeting tactical & strategic requirements; it consists of the initiatives, processes, strategies, and systems that sustain and enhance the storage, assessment, sharing, refinement, and creation of knowledge."*

The same author also highlights what organizations need to be aware of and understand the KM theories or practices that they are going to implement. He specifically states that companies need to understand what they want to know, how to promote a culture of learning, generating and transferring knowledge as well as the type and place of knowledge that is acquired and stored. Frost (2010) further discusses the importance of identifying which people need to know what and when they need to know it, while managing all these practices should be done according to the main business objectives and strategy of an organization and by taking into account possible opportunities and threats (Frost, 2010). Moreover, the importance of identifying what competence exists in an organization was also mentioned by Alänge and Sjölander (1986). They developed a way of mapping competence and the networks between employees and provided an empirical analysis of what kind of knowledge they have and how to reach them.

McDermott (1999) argues that the difficulty that most companies face in KM efforts is when changing the culture of the organization and the work habits of the employees. He further states that the challenge is to make people take time to articulate and share what they know and that if groups of people do not already have a habit of sharing knowledge with each other, have plenty of contact and discussions as well as insights in what kind of information might be good for

others, then information technology such as databases and other systems, will most likely not be able to create it.

3.1.2 Learning organization-organizational learning

In order to better understand and implement the concept of KM, it is important for companies to realize the value of learning at an organizational level. The notion that organizations are social systems of logic that are able to change in order to deal with various situations and learn from experience was initially discussed in the middle of the previous century (Visser, 2007). Researchers started trying to identify possible ways to encourage organizational learning, and until nowadays, there are a lot of difficulties both in defining the theory as well as in practical implementations (Visser, 2007).

According to Shani et al. (2009), the concept of a learning organization describes an organization that is managed and organized in a way that its culture fosters activities of continuous improvement and learning as a main part of the daily work. In other words, a learning organization is one that owns the capacity for creating, capturing and sharing the knowledge in a continuous manner in order to improve products, services or processes (Garvin, 2000). An organization of this kind is adaptive to the needs of the markets and able to successfully change when it is required in order to satisfy the customer (Shani et al., 2009).

On the other hand, organizational learning is a concept that deals with the issue of "how" to become a learning organization (Shani et al., 2009). Consequently, it includes all the activities, procedures, necessary actions and organizational as well as managerial practices that support the idea of learning and the value of knowledge (Shani et al., 2009). The focus is on the human aspect and people are seen as entities that have experiences from which learning and improvement in individual and organizational level can create a successful firm (Shani et al., 2009). Furthermore, according to Crossan et al. (1999), organizational learning can be seen as a dynamic process where thoughts and ideas from individuals are shared with groups and the whole organization and have an impact on them, while simultaneously, the learnings from previous work in the organization influence the behavior of individuals and groups and they act as feedback.

3.1.3 The DIKW hierarchy

The distinction between the meaning of the terms data, information and knowledge is discussed in the literature for many years now and it is something that every organization should be aware of when working with KM. Rowley (2007) discusses the "knowledge pyramid", see figure 1, also known as the data-information-knowledge-wisdom (DIKW) hierarchy, that was initially presented by Ackoff (1988) and is used in order to describe the nature of all these terms in

relation to each other and the procedures taking place when one of these is transformed into another. The philosophy is that organizations or individuals can use data to generate information, information to produce knowledge and this knowledge can, in the end evolve into wisdom (Rowley, 2007). Moreover, Ackoff (1989) states that every term in the pyramid includes all the other terms that are situated below it. This means that if, for example, an individual acquires knowledge, that person has definitely received data and information as well.

Figure 1 The DIKW hierarchy (Rowley, 2007)

Rowley (2006) criticizes the transformation processes between the stages, as they are not always very clear. One discussion point is what differentiator there is between data and information, as many authors suggest that information on its basic level is structured data intended for a specific purpose. Rowley (2006) however argues that data per se needs to "made sense of" by people gathering it in order for it to be stored. Moreover, as far as the differentiator between information and knowledge is concerned, it seems that information is data that is processed into something meaningful and valuable, while knowledge is "actionable information", as Jashapara (2005) in Rowley (2006) state. In other words, knowledge is information combined with an understanding and capability. Lastly, Rowley (2006) concludes that if it is argued that knowledge resides in the heads of people and is based on understanding and experience, then codifying that into explicit characters, such as documenting it for others, makes it difficult to argue against that documentation in the end will only be information and not knowledge.

Hence, while KM is about the "Know-how", experiences, comprehension, understanding and a set of actions for making decisions, it goes further than any practice of Information Management, which is about the "Know-what" and providing the right information to the appropriate people when they need it. But, in order to effectively manage the knowledge in an organization it is necessary to have a good foundation of data and information on which knowledge can be built (Knoco Ltd, 2011).

3.2 NPD and the role of Knowledge Management

In New Product Development (NPD), projects are often used to either change existing products or invent new ones. Catic (2011) presents the three basic objectives for researching and improving PD processes which are shorter lead times, decreased costs and high quality. Furthermore, Clark and Fujimoto (1991) states that if a company's long-term success in terms of economic growth and competitive advantage relies on technical and knowledge-intensive activities, having effective NPD processes is crucial. In this type of environment, the ability to manage knowledge is of great importance not only to stay competitive, but also to stay competent in the area (Goffin and Koners, 2011).

As far as the structure of a PD process is concerned, it can include many activities depending on the organization, the product and its complexity. The stage-gate process model proposed by Cooper (1990) is one of the most popular that are used in PD and it was developed as a response to the strong competition in the market and the need to decrease the development time and improve the products. The stage-gate model, depicted in figure 2, represents a way of thinking and designing the whole process of PD based on simplicity, but it includes some concepts that are complicated and tricky in implementation (Cooper, 1990).

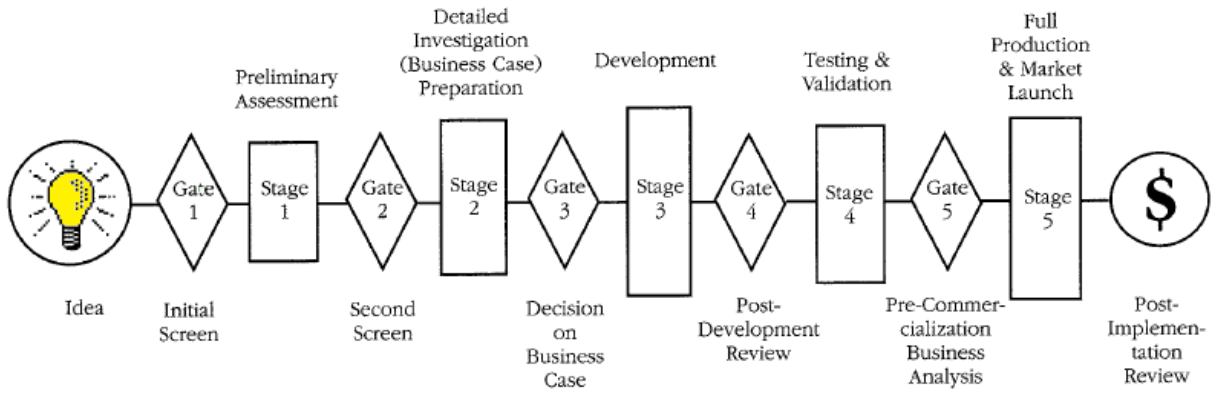

Figure 2 Overview of the stage gate system (Cooper, 1990)

As the name reveals, the model divides the development process into a number of stages and gates according the needs of the organization (Cooper, 1990). The stages are similar to workstations with a number of activities, while the gates serve as checkpoints where criteria and deliverables are checked to decide if the process will move to the next gate (Cooper, 1990). The stages/gates are usually four to seven; the stages become gradually more extensive when moving forward in the model, while each gate has its own special deliverables that need to be met (Cooper, 1990). There are also "gatekeepers" who are senior employees responsible for the gates, their deliverables and the allocation of resources, while there is also a project leader who

acts as a manager and coordinator that prepares the team in order to succeed in meeting the deliverables of each gate (Cooper, 1990).

Ottosson (2009, p. 88) stated that "*all innovation and New Product Development (NPD) activities are learning processes for both team members and the collective in which they are part in*". This leads to a need for companies to make sure that the learning's and knowledge that are created is captured and shared and finally getting it across the organization to be used in future projects.

Organizations working with NPD often use cross-functional teams, also called multidisciplinary teams, which include individuals from different departments working for the same goal. Each individual brings diverse competence into the team, which Parker (1992) describes as essential in order to achieve an optimal outcome that matches the goals. However, as teams often are temporary, completion of a project can consequently lead to knowledge not being shared between employees within and between functions. Due to the fact that NPD creates more context-specific knowledge than in processes that are repetitive, in combination with temporary teams, it can be argued that organizations working with NPD face more difficulties with ensuring knowledge transfer between different projects.

Clark & Wheelwright (1992) state that in PD, learning from experience means learning from development projects. They further state that organizational learning is not a natural outcome of NPD, despite successful development efforts and that there are two fundamental problems to deal with. Firstly, the performance that matters in a project is usually a result of high and complex interaction within the overall development system. This often leads to a gap between cause and effect meaning that there is a need of identifying mistakes and causes of problems through systematic investigations and analysis. Consequently, this can be interpreted as a need of going back and reflect on previous steps in the development process to capture and understand underlying causes of mistakes. The second problem that Clark & Wheelwright (1992) identified is that natural incentives in organizations tend to create a setting where finishing projects and starting up new ones as soon as possible is favored. They argue that this most likely leads to very limited learning from past problems if special effort and high concentration on learning from the newly completed projects is not devoted.

3.3 Knowledge Management lifecycle

There are various models for KM lifecycle found in the literature both for PD and other organizations. Table 1 is taken from Nissen et al. (2000) and includes four different knowledge lifecycles models suggested by various authors and a general amalgamated process model that is the result of the combination of all the others that already have many things in common.

Table 1 Life cycle models (Nissen et al., 2000)

Model	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6
Nissen	Capture	Organise	Formalize	Distribute	Apply	
Despres and Chauvel	Create	Map/ Bundle	Store	Share/ Transfer	Reuse	Evolve
Gartner Group	Create	Organise	Capture	Access	Use	
Davenport & Prusak	Generate		Codify	Transfer		
Amalgamated	Create	Organise	Formalize	Distribute	Apply	Evolve

As seen on the table 1, and according to Nissen et al. (2000), all the models start by creating or generating knowledge, apart from Nissen who starts with capturing. The second phase is generally about organizing or mapping the knowledge, while phase three refers to various ways of making the knowledge more explicit. The fourth phase deals with sharing and transferring the knowledge that is acquired through the organization and make it accessible to the people that need it. The fifth phase is about using the knowledge to make decisions or take actions according to it, while only one author adds one last phase for evolution of the knowledge that is about continuous development. The amalgamated model on the other hand, includes six phases starting with create and continuing with organize, formalize, distribute, apply and, also, evolve (Nissen et al., 2000).

As far as PD is concerned, Kennedy et al. (2008) are discussing the main principles of Lean PD, while they present the concept of Lean KM, including processes, mechanisms, tools and methods. In particular, they are stating the importance of continuous learning for PD by ensuring that the knowledge is created, captured and, then, reused by the people that need it. According to the same authors, PD organizations must, firstly, be able to effectively learn by using structured problem solving processes, while for effectively capturing the knowledge, there is a knowledge owner that has a crucial role to play in assessing the quality and value of the knowledge, organize it and ensure that it can be effectively and efficiently reused. For knowledge reuse Kennedy et al. (2008) highlight the need for having skilled and well-educated managers and designers, while they suggest the use of knowledge checksheets. Figure 3 shows the knowledge value stream in connection with the product value stream, where PD project A is the source of knowledge creation, while PD project B is reusing this knowledge in order to develop a better product (Kennedy et al., 2008). Kennedy et al. (2008) suggested that the product value stream, meaning the flow of responsibilities, human resources, equipment and processes necessary to create a product should be integrated with the knowledge value stream which includes capturing and reusing the knowledge in order to create an efficient flow between projects and organizations.

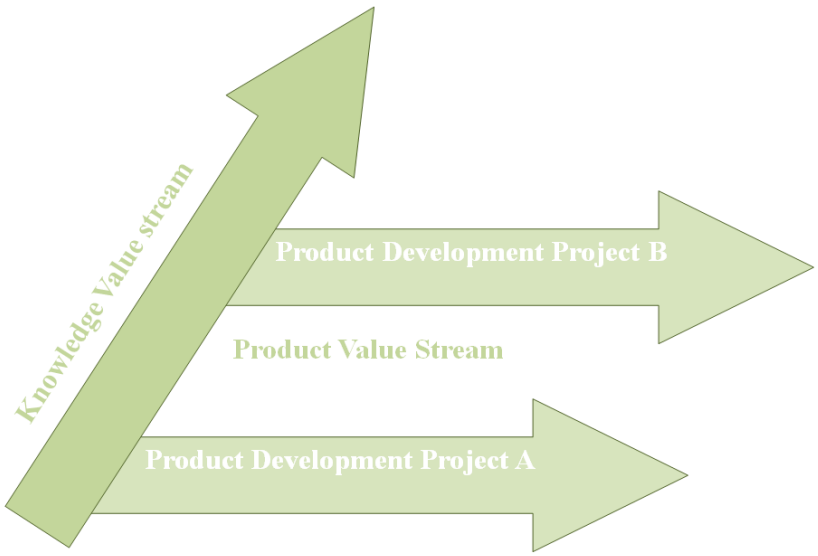

Figure 3 The Knowledge Value Stream and the Product Value Stream based on Kennedy et al., (2008)

For this research, the authors will use the terms create, capture and reuse, depicted in picture 4, that are used in the Lean KM model of Kennedy et al. (2008), as they specifically refer to PD processes and the employees of the case company are more familiar with them. Creation is about doing things in a way that leads to new knowledge. Capturing the knowledge includes making it expressible, retaining the knowledge and taking it from an individual in order to later share it with others (Gartner Group, 1999). The phase of reuse is about applying or including the knowledge that is captured into the daily work, decision-making or development procedures (Gartner Group, 1999). Finally, this research mostly focuses on the phase of reuse as it was found to be the most important for the case company to improve, and also on the phase of capture as it strongly affects the way that the knowledge can be reusable. Knowledge sharing is also taken into consideration, as they can be a crucial part for both capture and reuse phases as Ghaedian and Chen (2012) state.

Figure 4 The phases of the knowledge lifecycle, based on the terms used by Kennedy et al., (2008)

3.4 The nature of Knowledge

3.4.1 Tacit and explicit knowledge

In order to effectively manage the knowledge in an organization, it is necessary to understand the type of knowledge and information that may exist, which is presented by Nonaka (1994) as the epistemological aspect of knowledge. Polanyi (1966, p. 4) describes two types of knowledge namely tacit and explicit. Explicit is the type of knowledge that can be easily documented, communicated or transferred between people by using systematic language (Polanyi, 1966). This is also the type of knowledge that in many cases becomes codified for storage in databases. Tacit knowledge on the other hand, has both a philosophical and practical dimension and is connected to the personal characteristics, emotions, values and experiences of an individual (Polanyi, 1966). Furthermore, Nonaka (1994) describes it as difficult to be written down, symbolized or transferred and people may not realize that they possess it or how significant it is as it shapes the way they perceive the world around them. Kingston (2012) discusses three types of tacit knowledge, see summary in table 2 below.

Table 2 Summary of tacit knowledge and how to capture it (Kingston, 2012)

Type of tacit	In the form of	Can be verbalized or recorded	How to capture
Symbolic experiential knowledge *(gained from experience and the owner knows that he/she possess it)*	Words or concepts	Yes, but it probably never has been	Structured interviewing techniques
Non-symbolic experiential knowledge *(gained from experience and the owner knows that he/she possess it)*	Not symbols, but other forms such as numeric, geometric, perceptual etc	Sometimes, often it cannot, but if can, the owner may probably find it difficult and supporting multimedia might be necessary	Knowledge owner describes the knowledge such as describing the shape of an egg. Difficult, but if it is verbally explained, supporting materials such as diagrams, photographs etc can be used.
True tacit knowledge *(owner possess it but does not know about it)*	Unknown as the owner does not know about it	In some cases yes, as it is very difficult	May be possible if finding elements similar to symbolic or non-symbolic knowledge. However, it is very difficult and in some cases impossible

While many authors are arguing that tacit knowledge in any form cannot be verbalized, recorded or documented, there are other authors, including Kingston (2012) arguing that it is possible, but depending on what type of tacit knowledge it is, see table 2. Kingston (2012) states that much of the research during the last decades has been classifying experience-based knowledge as tacit

and organizations need to focus on knowledge sharing activities in order to have the tacit knowledge transferred between individuals. However, Kingston (2012) strongly argues against this by identifying an inconsistency in the research; if research is arguing for tacit knowledge not being able to be articulated, how can a tacit-to-tacit transfer between individuals happen? Consequently, Kingston (2012) suggests that if tacit knowledge is articulated by using socialization between individuals, it should also be able to be written down and captured.

Nonaka (1994) also describes another aspect of knowledge, which is called the ontological dimension of knowledge and is related to the ways people interact with each other in order to create or transfer knowledge. The foundation of this theory suggests that it is impossible to develop knowledge in an organization without involving the people who are actually the only creators of knowledge (Nonaka, 1994). Consequently, in order to develop organizational knowledge, there is a need for social interactions that will support the organization to absorb and transform the ideas and knowledge created by individuals and then shares it by developing a knowledge network (Nonaka, 1994). Informal communities that share ideas within the organization can be connected to formal procedures in order to share the knowledge through the whole organization (Nonaka, 1994).

By combining the epistemological and ontological aspect of knowledge, Nonaka (1994) identifies four different ways of knowledge transformation, namely socialization, combination, externalization and internalization, which support the development of new knowledge through social interactions. Socialization is about developing tacit knowledge from tacit knowledge that results from the interaction between people and from sharing their experiences without using a systematic language. Combination is about developing explicit knowledge from explicit knowledge, for example through regular meetings or discussions. Externalization means transforming tacit knowledge to explicit, for example by describing something in a way that a comparison with something else is used in order to symbolize the similarities and create comprehension, a process called metaphor. Finally, the conversion of explicit knowledge into tacit is internalization and bears resemblance to the usual learning process where people get knowledge, for example from a book, and then try to absorb it in order to make it their daily working routine. The four modes for knowledge creation are depicted in figure 5 (Nonaka, 1994).

Figure 5 Modes of knowledge creation (Nonaka, 1994)

3.4.2 The role of the Source and the Recipient of knowledge

When it comes to knowledge transfer, Cumming and Teng (2003) stated that the objective of any transfer, regarding the setting, is to successfully transfer knowledge from a source to a recipient. In practice, this means that the source always needs to be aware of who the recipient is in order to have a successful transfer, see figure 6. In addition, the higher the involvement between source and recipient, the higher the probability of a successful transfer becomes (Cumming and Teng, 2003).

Furthermore, Allen (1984) discussed the "Law of least effort", which he states is about people not always finding the source who can provide the most qualitative information or knowledge, but rather chooses to go to the source that requires the least effort. He refers to the "cost" of getting the right information and that people want it to be as low as possible. However, Allen (1984) argues that it is the psychological cost included, meaning the psychological cost of feeling the need to ask someone about something and that there is a tendency of asking the same person as before than someone new.

As organizations tend to think that accessibility to documentation and information is enough, Davenport and Prusak (2000) argue that without absorption of knowledge by the recipient, a successful transfer cannot even be considered. Cumming and Teng (2003) have a similar view upon it but they refer to what they call internalization of knowledge, meaning that the recipient internalize and make ownership of it, a commitment to it, but also a satisfaction with it, and at that point make it usable.

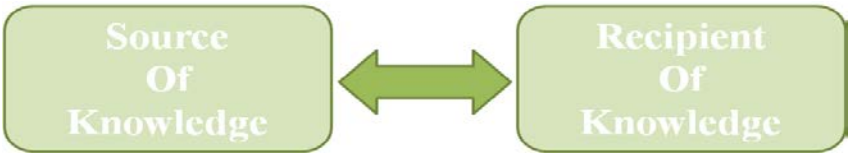

Figure 6 The interaction between source and recipient of knowledge

3.5 Factors influencing knowledge sharing

In this section the authors wish to present the role of organizational culture as a factor that influences knowledge sharing and can serve both as a facilitator and hinder depending on the characteristics of the organization. Then, some additional individual, organizational and technology factors that organizations need to consider in order to foster knowledge share and reuse are going to be presented.

3.5.1 Organizational culture

A lot of the research within KM practices is including organizational culture as an important factor to consider. Many authors that have done their research on KM practices have derived their views on culture and its impact on organizations and KM practices from the work of Edgar Schein, a researcher who has come to affect much of the research done in recent decades. Schein defines culture as *"a pattern of basic assumptions-invented, discovered, or developed by a given group as it learns to cope with its problems of external adaptation and internal integration-that has worked well enough to be considered valid and therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems*" (Schein, 1992, P.9).

Schein (1992) did a classification of organizational culture into three levels. The first one is observable artifacts, which represents the visible culture of the company. This could include elements such as language, visible behavior patterns, technologies etc. The second level is espoused values, which are embodied in the values and strategies that are articulated in the organization. It can be explained as a visible identification of what is or can be important for a particular group culture, and it is also something that the members are conscious of. The last level, and the one that is considered to be the deepest level of culture, is the basic, underlying assumptions. These assumptions are invisible and unconsciously rooted in the people in the way of what they believe, how they perceive certain things and all thoughts and feelings that come with it (Schein, 1992). The relation between the different levels can be seen in figure 7 below. The author further argues that these assumptions are forming the way people behave in the organization. Schein (1992) also states that among these three levels, it is the last one that mostly affects and influence people's behavior.

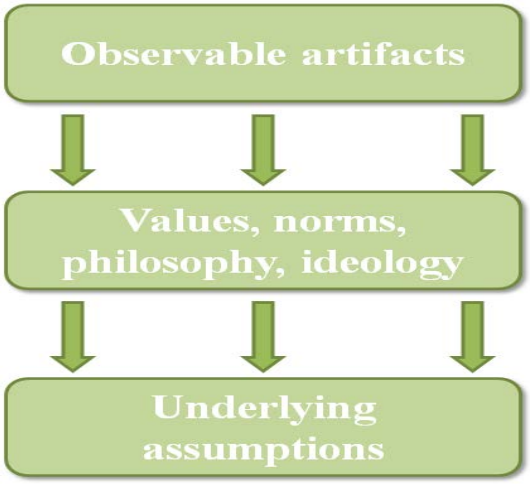

Figure 7 The three levels of organizational culture (Schein, 1992)

As been stated, a lot of recent research has been based on Schein's idea of organizational culture and when it comes to knowledge sharing, there are some critical success factors that organizations should keep in mind. Al-Alawi et al. (2007) stated five success factors based on the findings of several researchers.

- Trust: such as interpersonal or between co-workers, which is required for people to feel that they want to share knowledge with each other.
- Communication between staff: refers to human interaction by conversations. Social networking usually enhances this.
- Information systems: referring to the arrangement of people, data and processes.
- Reward systems: considered important due to an unrealistic assumption that all employees in an organization will share knowledge with others without feeling that they are gaining anything from it.
- Organizational structure: bureaucratic structures are nowadays being seen as constraining information flows and consume more time for knowledge to be disseminated, which in practice might encourage an organizational structure that enables knowledge sharing in an easier way.

Gold et al. (2001) concluded that organizations that have an open and supportive value orientation are more likely than organizations doing the opposite to foster knowledge sharing behavior among employees, such as sharing insights with each other. These values, they argue, also shape the knowledge infrastructure capability, such as the organization's capability of being innovative; rapidly respond to change and new market demands. DeLong and Fahey (2000) concluded in their research that value orientations such as trust and collaboration between employees will most likely lead to a greater willingness to share insights and knowledge in

people's expertise areas whereas an emphasis on individual power, or even competition between employees, will probably lead to the opposite.

What is more, according to DeLong and Fahey (2000) who have also highlighted the strong connection between culture and knowledge, there are four cultural factors that affect knowledge-related behavior and they can be found in many organizations. Firstly, the culture of a company strongly influences the perception of the employees of what knowledge is good, useful, significant and connected to their work and, consequently, the ways people will search for that knowledge and put their focus on it. The authors provide an example of a PD organization that has LL as a part of the process, but in the beginning many employees denied to reflect upon their work because they thought that they have no time for that until there was a charge put on the time for creating the LL. Subcultures and special characteristics of small groups or departments may also affect the perception of what knowledge is significant as an engineering department and a marketing department may have different opinions on what is important or where to focus, for example (DeLong and Fahey, 2000). Consequently, as the authors exemplify, in any company, one department may be in favor of informal interactions, interpersonal relationships and communication for transferring knowledge, while another department may always ask for standardized, technical or IT solutions.

The second knowledge-related behavior that culture affects is the relationship between levels of knowledge as it determines whether the ownership of knowledge is individual or organizational (DeLong and Fahey, 2000). An example is when companies try to extract knowledge from their people and make them share it in order to structure it in a better way and be able to control it. Thirdly, culture supports the generation of an environment that fosters social interaction, it determines the time, places and ways people will interact as well as how specific knowledge will be utilized for specific circumstances (DeLong and Fahey, 2000). In particular, culture can also affect the way a firm reuses existing knowledge for current work and how people will look for previous knowledge and build on that. For example, a company may considers every new project as something completely new and encourage designers to refuse to look for previous solutions thinking that this will hinder innovation. On the other hand, a US company has set an annual reward for the employees that have reused successful and good ideas (DeLong and Fahey, 2000). Lastly, culture influences the ways a firm creates or adopts new knowledge internally or from interactions with the external environment, how it shares it among the whole organization and how this will influence the business strategy (DeLong and Fahey, 2000). Figure 8 below summarizes the four knowledge related behaviors.

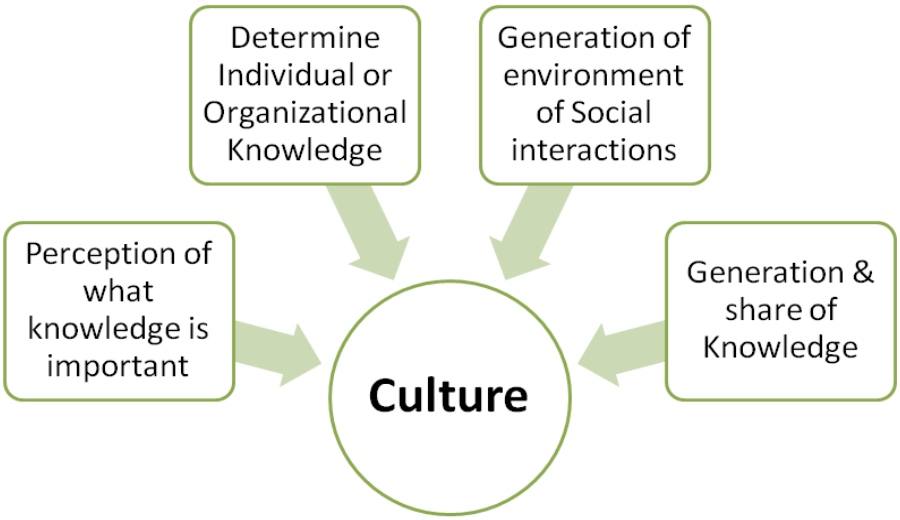

Figure 8 The four knowledge related behaviors that culture affects (DeLong and Fahey, 2000)

3.5.2 Additional factors influencing knowledge sharing

As sharing the knowledge through an organization, including groups of employees and individuals, has many dimensions, there are a number of factors that need to be considered by any organization in order for organizational knowledge to be developed, shared and reused (Riege, 2005). In order to reuse knowledge, it is important to ensure that it is shared. However, sharing knowledge does not necessarily mean that it is reused, but in order for knowledge to become reusable, it needs to be shared, especially when it comes to the tacit dimension as was mentioned in previous sections, because this type is more difficult to articulate and codify compared to explicit. Riege (2005) presents the different levels of barriers to knowledge sharing and groups them into individual (or employee), organizational and technology barriers. The same author states also that while each and every barrier may be analyzed independently, in real organizations there is usually a combination of various barriers that can hinder knowledge transfer. However, it is the authors' firm belief that if an organization accomplishes to overcome the barriers to knowledge sharing, it can turn them into facilitators that will foster knowledge sharing. For this reason, it was decided that the barriers that Riege (2005) present and are supported by the research of other researches as well, will be presented in this thesis as factors influencing knowledge sharing.

Table 3 summarizes the factors influencing knowledge sharing, inspired by the research and categorization of Riege (2005) as well as the research of various authors mentioned in the particular section.

Table 3 Factors influencing knowledge sharing, based of the categorization of Riege (2005)

Factors influencing knowledge sharing		
Individual	**Organizational**	**Technology**
Communication & social skills	Adjustment of KM practices into the organizational culture	Adjustment to the organizational culture, way of working and needs
National/personal culture	Organizational culture	Well-designed databases
Hierarchy/different levels	Organizational structure	Old technology
Time & space	Hierarchical structure	Integration of KM to technology
Underestimation of tacit knowledge	Design of the working environment	Fear of new technology
Communication between source & recipient	Communication of KM importance from the management	Overestimation of technology
Ignorance or underestimation of the value of owned knowledge	Integration of KM to business strategy/objectives	Awareness of the realistic crucial benefits of technology
Awareness of who has and who needs the knowledge	Amount of time and resources invested in KM	Technological education by the organization
Inefficient management of past mistakes to achieve individual learning	Loyalty to the initial KM investment	Support
	Having formal/informal groups focusing on specific subjects	
	Having small units in big firms	
	Lack of incentives and motivation	
	Lack of guidelines, education and evaluation	
	Inefficient management of past mistakes to achieve organizational learning	

3.5.2.1 Individual factors

As far as the individual factors are concerned, it seems that communication and social skills have a crucial role to play, as employees need to have speaking and writing skills to successfully share their knowledge (Riege, 2005). The national culture of the individual can also influence knowledge sharing as people have developed specific behaviors in which some practices may seem acceptable or unacceptable (Riege, 2005). Employees in different levels of the organization and for different reasons may also be afraid of sharing the knowledge because they feel insecure about their position in the company and about how the knowledge may be used to harm them (Probst et al., 2000; Riege, 2005). Another common factor to consider is the time and space provided to the employees in order to reflect upon their work and share their knowledge because in today's competitive market the time is very limited and all the work must be done as quickly as possible to meet the delivery expectations (Riege, 2005). Furthermore, when the source and the recipient of knowledge are not together, communicating or interacting in any way, there is a possible obstacle that may arise in sharing the knowledge (Riege, 2005). The recipient may not be aware of who has the knowledge while the source may not know who desires his knowledge and ignore or underestimate the significance of their knowledge and the value of sharing it (Riege, 2005). Finally, in many organizations people tend to underestimate the value of tacit knowledge or the difficulty at which it can be transferred, as Nonaka and Takeuchi (1995) state, resulting in sharing only explicit kind of knowledge (Riege, 2005).

3.5.2.2 Organizational factors

On the other hand, the organizational factors influencing knowledge transfer are generally connected to the overall state, situation and environment of a firm (Riege, 2005). McDermott and O'Dell (2001) state that a main obstacle that has made a lot of KM initiatives to fail is the fact that many companies try to change their culture in order to force the introduction of knowledge sharing practices, while it would be more efficient to try to adjust the practices into their existing culture. The culture of an organization affects how employees interact with each other and how open the environment is for sharing, so it constitutes one of the main organizational factors (Riege, 2005). Furthermore, the structure of an organization also seems to be very important and, according to Probst et al. (2000), open and flexible structures that can adjust to continuous changes are the best enablers for knowledge sharing. In addition, Ives et al. (2000) suggest that possible restrictions on how the knowledge will flow and how the communication occurs, for instance top-down approaches or highly hierarchical structures, are other organizational issues that need to be considered. What is more, the design of the working environment can also be restricting as it is sometimes arranged according to the hierarchy and not according to which people need to work together, resulting in less opportunities for communication, sharing and cross-functional work (Riege, 2005; Probst et al., 2000). Allen (1977), argued that by promoting chance encounters, organizations can foster communication that in turn can lead to knowledge

sharing due to that traffic patterns within an organization are directly affecting the communication. This, he argues, can be done for instance by promoting intended contacts, such as walking to facilities and along the way, talking to people that are working along this path. In turn, this will give employees more than one reason for going in a specific direction while heading to the intended goal. Allen (1977) further argues that removing physical barriers, such as walls between employees, are leading to great possibilities for encounters and small chats, hence he is implying that the design of the workplaces is an important factor that needs to be considered.

Moreover, according to Riege (2005), it is important for companies to incorporate their KM practices into the overall business strategy and objectives and for senior managers to communicate these objectives to the whole personnel, in order to avoid misunderstandings among the employees about the reasons why these practices are used. The same author underlines the importance of devoting the appropriate time and resources, such as the right people, technology, etc., in order to foster knowledge sharing, while Gold et al. (2001) argues that without the necessary infrastructure and preconditions of sharing, many KM practices may fail. It is also important that the companies must be loyal to the initial investment of KM practices, which can be high, as it may take time to see the actual results (Davenport, 1997).

Riege (2005) also argues that having formal and informal groups which focus on specific subjects may make knowledge sharing easier as these groups can support knowledge creation and sharing as well as reflection and improvement. Also, very large companies may have difficulties in knowledge sharing if they do not have smaller units that can be effectively managed, while incentives, motivation and evaluation according to sharing activities provided by the company is also crucial (Riege, 2005). The managerial aspect of knowledge sharing was mentioned by Ives et al. (2000), and it seems that due to the voluntary nature of sharing, managers should provide guidelines, motivation and education to the employees in order to convince them to share and reuse knowledge effectively. Lastly, another organizational factor, which can also be individual as it influences both organizational as well as individual learning, is the attitude towards experiences and past mistakes. In many cases, people tend to ignore or not admit their own mistakes instead of reflecting and try to learn from them, which is something that can negatively affect knowledge sharing (Riege, 2005). As Nonaka and Takeuchi (noted in Riege, 2005) and Delong and Fahey (2000) state, realizing, admitting and learning from past mistakes is the way companies can avoid doing the same mistakes again while they encourage continuous learning.

3.5.2.3 Technology factors

The aspect of technology is also very important to effectively manage and transfer the knowledge while combining a right choice of technology with the overall culture, way of

working and needs of the personnel can encourage and ease knowledge sharing among employees (Ruby, 2000). Choosing the appropriate technology can offer databases with necessary information that can foster cross-functional and distance cooperation (Riege, 2005). There are many IT companies that provide IT solutions for KM, while new technology may motivate employees by eliminating numerous obstacles (Hendriks, 1999). Riege (2005) also states that many companies do not integrate KM technology into their own technology or systems successfully resulting in conflicting activities and goals between them, so early integration can ease a successful outcome. The same author underlines that while many people do not feel comfortable with new technology, others overestimate its value believing that technology can do everything and solve every problem. Hence, by balancing the way people trust or use technology and make them aware of the realistic, but crucial, benefits of using it, companies can avoid both over- and underestimation. Lastly, education on how to use technology and how to realize its importance should be offered and can facilitate the use, while the organizations simultaneously can offer some kind of support for technological or usage issues that may arise (Riege, 2005).

3.6 Tools and mechanisms for knowledge share and reuse

Knowledge sharing is basically the process of channeling knowledge between a source and a recipient (Cummings and Teng, 2006). To be able to ease knowledge share between people and foster an environment of reusing and utilizing knowledge, there are several tools and mechanisms that organizations can make use of.

Tools used for KM are, according to Ghani (2009), focused on three parts namely assimilation, comprehension and learning of the information by individuals that later transforms all data and information received to actual knowledge. As knowledge is very much linked and connected to the individuals or groups that create it, there can be doubts of whether or not there are tools to fully and effectively support KM (Ghani, 2009). However, Ghani (2009) states that depending on what type of knowledge is required, there are different tools that can be useful as can be seen in figure 9.

Figure 9 Tools proposed by Ghani (2009)

As most tools are IT-oriented, there are other aspects that should also be considered. In order to successfully manage knowledge transfer, there are different mechanisms that organizations should be aware of. Pitt and MacVaugh (2008) stated that standardized methods and practices have a significant effect on how organizations store, assess, recombine and mobilize the knowledge and information they have. Furthermore, it is stated that as far as knowledge-enabling processes are concerned, when organizations confine them to formal, managed mechanisms or any kind of standardized best practices, when searching for optimal performance, they should make sure to avoid locking people into a specific mindset and hinder the spontaneous social interactions and creativity (Pitt and MacVaugh, 2008). As no single approach will be appropriate and usable for every organization, there are different mechanisms that may be considered by organizations as they might help them foster an environment where knowledge can be created, shared and utilized. Depending on what type of knowledge is acquired, according to Goffin et al. (2010), there are different mechanisms, as seen in figure 10.

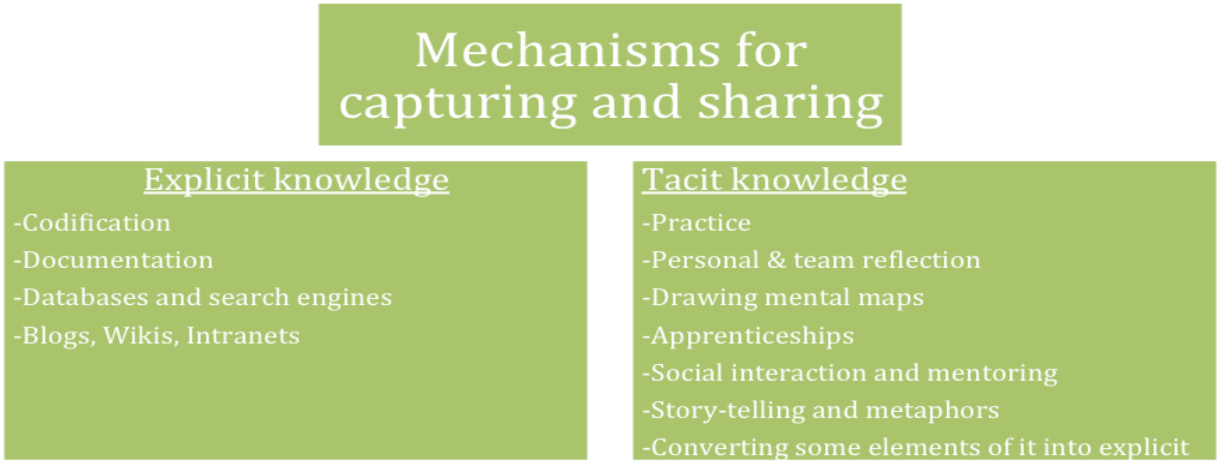

Figure 10 Mechanisms based on Goffin et al., (2010)

Hansen et al. (1999) discusses two main KM strategies; codification and personalization. While codification refers to codifying and storing knowledge into databases for future utilization, personalization assumes that knowledge is resided and tied to the person and therefore requires a person-to-person contact to be able to create a knowledge flow. As stated by Alänge and Sjölander (1986), a way that companies ease the person-to-person contact is by creating competence databases so people can more easily find appropriate persons to talk to. They further stated that there could be two different competence databases; either internal where the competence of people inside the organization is mapped, or an external where people outside the organization are mapped that can include contact persons from other companies, universities etc.

Compared to the findings of Goffin et al. (2010) in figure 10, one implication is that codification is more suitable for managing explicit knowledge while personalization is more suitable for tacit.

However, Goffin et al. (2010) state that a tacit knowledge flow can be aided by codification if some aspects of tacit knowledge are converted into explicit and thereby become able to be articulated by the provider of the knowledge but also captured in a way that it can be reusable. However, Kreiner (2002) states a concern that by emphasizing codification like this threatens and devalues the social processes that can be seen as complementary processes for knowledge creation.

3.6.1 SECI-model based mechanisms

Pitt and MacVaugh (2008) also discussed the four modes of knowledge conversion mentioned previously in combination with research conducted by Marchand (2008) and Nonaka and Takeuchi (1995). They argue that combination, explicit to explicit knowledge conversion, is about diffusion acquiring, analyzing and organizing documents for easy accessibility. When tacit knowledge is converted to explicit knowledge, it is a type of externalization by articulating personal knowledge and creation of, for instance, documents and databases that are derived from that knowledge (Pitt and MacVaugh, 2008).

In cases where the knowledge that needs to be transferred and shared is tacit, Pitt and MacVaugh (2008) discuss different mechanisms that can enable tacit-to-tacit transitions, focusing on socialization between people. There are some mechanisms that encourage an internal diffusion of "Know-How" and "Know-Who" and are directories of internal expertise. Such mechanisms are the competence databases as discussed before, or events and forums inside and outside of working hours as well as networking by individuals of NPD teams in both formal and informal contexts (Pitt and MacVaugh, 2008). Further, there are authors discussing the benefits of having Communities of Practice (CoP), as they provide a platform for employees to jointly share expertise, experience and ideas in order to share knowledge and come up with new solutions (Saint-Onge and Wallace, 2003). The same authors further discuss the benefit of having potential for new knowledge creation due to incremental improvements of ideas as a result from the synthesis of the members contributing in brainstorming and discussions. Another benefit is discussed by Newell et al. (2002) who argues that tacit knowledge, which is usually based on experience, may be transferred easier due to the members sharing a common experience of practice. By having that, CoPs can develop a shared meaning that has been derived from the common experience of the members. Furthermore, Pitt and MacVaugh (2008) state that it is important for working environments to enable interactions between individuals and small groups as well as "corridor conversations". This is in line with Kreiner's (2002) idea of the social processes and their significance in knowledge sharing. Lastly, explicit knowledge that needs to be transferred into tacit is done through internalization, which is done by individuals who can utilize documents, access databases, attend presentations and seminars and reflect upon them afterwards.

3.6.2 Documentation

Another subject that is widely discussed is documentation and repositories and in what way they contribute to the lifecycle of KM. Repositories in general have a quite central role in knowledge-intensive organizations. Markus (2001) state that one of the main reasons for documenting and store in repositories is to make the knowledge reusable. However, as stated before, there is a need of knowing who the recipient is and find ways of successfully transferring the knowledge between the source and recipient. Critiques such as McDermott (1999) however prove an important point by arguing that a common problem with document repositories is that they are expected to handle every kind of knowledge, also the tacit dimension, when in fact they only handle information, which constitute the explicit dimension of knowledge. Despite this, however, documentation cannot be avoided. Lindlöf (2014) has identified the "Documentation paradox", as he is calls it, which emerges when documents are produced when the source does not know who the recipient is while at the same time knowing the recipient is crucial in order for documents to provide a useful reuse. Lindlöf (2014) states that putting more emphasis on the creation of the document and finding out who the possible recipient is, instead of just document and figure out how it might be searchable in repositories, might increase the reusability of the document.

Furthermore, Ghaedian and Chen (2012) concluded in their master thesis that was conducted at Volvo Group Trucks Technology that by documentation, for example the white-books that they use, the knowledge cannot be totally codified and written down, so sometimes it is not completely understood by people that access it. They also argue that codification makes the procedure of utilizing the knowledge slower, and documentation by codification cannot be the only independent way of utilizing the knowledge that is captured. They instead believe that companies should struggle to create an environment that encourages interpersonal relationships, interaction and communication because people tend to learn from interactions, discussions and mutual understanding quickly and effectively.

3.6.3 Tools based on the concept of Lean

When the book "*The machine that changed the world"* was published 24 years ago, the whole world became aware of the unique PD process that Toyota is working with (Morgan and Liker, 2006). In particular, it was clearly stated in the book that this PD system was quicker in developing products, using less human resources and capital and producing less defective products. This whole approach of creating "more value with less time and effort" was the initial essence of the Lean concept that was further enriched with various principles and methods (Morgan and Liker, 2006).

The Lean manufacturing concept is focusing on the customer, meaning that every activity should add value to them because in any other way this activity as well as the time and resources it uses become waste (Alfredson and Söderberg, 2009). According to the same authors and Kennedy et al. (2008), the Lean concept in PD also focuses on removing any kind of waste from the phases of create, capture and reuse knowledge in order to continuously improve the products and the process per se. The concept of Lean KM in PD is presented by Kennedy et al. (2008), as already stated, and it is depicted in figure 3. Furthermore, according to Kennedy et al. (2008), there are some tools for knowledge creation, capture and reuse that are included in this Lean KM approach and are extensively used by Toyota's PD process. The majority of these tools and especially those that found to be useful for this research are presented in the following section.

3.6.3.1 Post-Project reviews and Lessons Learnt

As stated before, NPD organizations are knowledge intensive, which makes it important to continuously learn from previous projects and make sure to utilize the knowledge in a good way. One quite common way of reflecting upon experiences and learning that companies use today are Post-Project Reviews (PPR), formal meetings and discussions about key issues that can be good to know for the future. Goffin and Koners (2011) describe PPRs as a highly effective mechanism for stimulating learning in NPD organizations. The typical LL is usually an outcome of PPRs, however Schindler and Martin (2003) describe PPRs as a way of capturing key experiences that can be used or improved in future projects and that sharing this evolved knowledge with others can be seen as the main outcome. They further state that one advantage companies can gain is that sharing the evolved knowledge might not only be good for future projects, but might also be helpful for current ones by for example avoiding doing certain mistakes.

As many companies seem to have PPRs to capture key experiences, there are some problems that research has shown are important to solve. As projects end and team members leave for other projects or assignments, it may be problematic to recall experiences and lessons learned and effectively communicate them across team members of other project teams. It seems that Schindler and Martin (2003), as well as many other authors, find it crucial to reflect upon key experiences and lessons learned during a project after each milestone, such as gates in a stage-gate framework, instead of postponing it until the end of the project and only have one reflection.

3.6.3.2 Mentoring

The Toyota way of using mentorship is to consider the managers more like mentors instead of bosses, since they are usually seen as the ones with most knowledge within their respective field (Liker, 2004). The managers in many cases use a leadership style that encourages asking questions to the employees instead of giving a direct answer, or the "right" answers. It is a leadership style that Liker (2004) has chosen to call "Builder of learning organizations". Why

this becomes important for the functional managers at Toyota is that their responsibilities go beyond the responsibilities for the functional department and the daily work, they are also responsible for the knowledge that exists and needs to be disseminated within that department, which leads them to function as mentors and facilitators in a way (Liker, 2004).

However, Shani et al. (2009) discuss mentoring in a more conventional sense, saying that it can provide two types of support from a senior to a junior. The first one is career support with activities such as challenging tasks and coaching. The second one is psychosocial support, meaning counseling, friendship, confirmation, role modeling etc., in order for the junior to develop his/hers competence and professional identity. Furthermore, Shani et al. (2009) state that formal mentoring programs are favorable and should be aligned with the overall business strategy, include matching between senior and junior and foster good communication and training. While there is a perception that it is only the juniors gaining something from a mentoring program, Shani et al. (2009) state that it is a mutual learning process, but that seniors can gain a satisfaction of teaching what they know and a sense of feeling of "leaving a legacy". Lastly, they state that one good way of having mentorships is by "Intra Team mentoring" which fosters a knowledge acquisition by having people working closely together in teams with a common goal that can support knowledge sharing and personal development.

3.6.3.3 A3 reports

For Toyota, developing A3 reports is a way of dealing with problems and, simultaneously, creates knowledge that can be reused later (Shook, 2009). An example of an A3 is depicted in figure 11. The reason why this tool is called A3 is because it usually drawn in paper of the international A3 size and, according to Shook (2009) its strength lies in its limited size of two pages and its structure that makes it look like story-telling including categorization of things and specific steps. The managers of Toyota simply advise to *"Force yourself to filter and refine your thoughts to fit one sheet of paper in such a way that management has all of their questions answered by reading a single piece of paper-it is the essence of Lean"* in order to communicate the importance of this paper to the company (Morgan and Liker, 2006, page 269). According to Shook (2009), A3s offer people an easier and amusing way of learning by providing experiences and various ways of avoiding doing the same mistakes. Furthermore, the same author states that the managers use the A3 in order to mentor other employees in structured ways of thinking and analyzing root-causes, while it fosters active dialogue between people, sharing and learning from each other.

Figure 11 An example of an empty A3 report (Shook, 2009)

3.6.3.4 Databases

The reason why data is stored in databases is that people can organize them in such a way that they can produce information and knowledge based on this data, as depicted in the DIKW pyramid, figure 1 (Frost, 2010). Frost (2010) states that data as well as the information and knowledge they may lead to, can support decision making procedures and well-designed databases are important for the IT part of KM practices.

3.6.3.5 Checksheets

In order to describe the checksheet as a Lean tool for PD, the authors of this thesis are using references about the engineering checklists as these two are very similar and serve the same purpose, according to Catic (2015b). The same author that has done an extensive research on engineering checklists concludes that the checksheet is a better approach as it includes description of the "Know-How" and "Know-Why", which is not always the case with checklists, and they are of great importance for the reusability of the document. Consequently, all the information of this section that refers to the checklist are applicable for the checksheets as well. Despite that, many authors and companies are using both terms for the same thing, when the authors of this thesis are using the term checksheet, they refer to the one that includes detailed descriptions of "Know-How" and "Know-Why".

Table 4 below, shows the way a checksheet is usually structured according to Catic (2015b). In each column, the elements that are going to be included are shortly described, while a real checksheet can include numerous elements that need to be considered for the development of a

component. In addition, each "KNOW-WHAT" in the table can be combined with illustrations whenever it is necessary.

Table 4 The principle of checksheets for knowledge reuse

KNOW-WHAT	KNOW-WHY	KNOW-HOW	REFERENCES
Action/decision that needs to be taken	Why does this specific action need to be taken? Why is it important?	How will this action/decision be taken?	Where can someone find information about this action/decision?

As stated before and according to Kennedy et al. (2009), the engineering checklist is the main lean tool that is used by Toyota for knowledge reuse. Liker and Morgan (2006) state that they serve as reminders of the things that must be done including design standards and knowledge that is captured throughout the years of experience. Liker and Morgan (2006, p. 101) particularly state that the engineering checklists are about "*what a company has learned over time about good and bad design practices, performance requirements, critical design interfaces, critical to quality characteristics, manufacturing requirements as well as standards that communize design*". Although very simple, they can be a very strong tool for the companies that carefully work with them as they need updates as well as care and effort in how people can refer to them. On the other hand, if companies do not put any effort and just handle the checklist as a not-living document in a database, it can become a waste of time and resources (Morgan and Liker, 2006). The same authors state that the checklists at Toyota are designed in much detail, they are understandable and visual, while they focus on a specific product, component or process. The fact that many engineers are aware of the content of many checklists that are connected to their work and not only focusing on those that they are responsible for, shows that there is a lot of experience, consistency and comprehension of the tool at Toyota (Morgan and Liker, 2006).

Furthermore, according to Morgan and Liker (2006) the utilization of checklists is one of the ways for Toyota to standardize because without standardization it is very difficult to continuously learn from previous experiences, avoid doing the same mistakes and implement lean principles. The checklists are a standardized part of the PD processes at Toyota as the engineers are using them as guides that will lead to a successful development of a product (Morgan and Liker, 2006). The most crucial part of utilizing the checklists effectively is to identify the appropriate responsibilities and the people that will take them in order to continuously update the checklist, make sure that it goes to the right recipient and foster a "sense of ownership" without letting it end up as just another meaningless activity that has to be done because the management requires it (Morgan and Liker, 2006). While the overall responsibility of the checklists is taken by functional groups, the one who is primarily responsible for utilizing and updating a checklist for a specific component is the specific engineer that the company has

assigned and he must organize the other engineers working for this component in order to include all of their knowledge and learning in the specific checklist (Morgan and Liker, 2006).

As seen in Catic and Malmqvist (2013), there are three main ways of creating checklists that are presented by Kokkoniemi (2006):

1. Literature-adopting approach: the literature is used as a foundation for generating the checklists, which will be adjusted to their specific purpose.
2. Consultant-based approach: a person or consultant who is well aware of the practices of the company generates the checklists.
3. Workshop-based approach: before starting using the checklists, people who will use them form a group that creates them.

Kokkoniemi (2006) states that the workshop-based approach is the best compared to the others because the checklists that it creates are based on experiences, learning from the inspection process and knowledge taken from people that are going to use them. It is also stated by Catic (2015a) that for the workshop-based approach someone may need two to three meetings of two to three hours each with the Knowledge Owner. After that and when the checklist is created, it is good to show it to various engineers or people involved in the projects in order to ask their opinion and gather more knowledge. In total, a completion of a checksheet can take up to approximately 50 hours.

Kokkoniemi (2006) in Catic and Malmqvist (2013) also provides some suggestions on how to implement checklists:

- The checklists must be as extensive as necessary, but not excessively long.
- The checklists cannot take everything into consideration because they will stop being effective.
- When the checklists are expected to become too long, it is advised to divide them into a number of separate checklists.
- The checklists must be unique for every firm that uses them and adjusted to its specific needs.
- The checklists need to always be inspected after their creation.

Furthermore, Catic (2015a) also states that the checklist must be a document that follows the rule of “less is more” as it can be confusing and hard to understand if it is over extensive. The checklists along with hundreds of other documents are complementary to each other, but this is the only document that is being utilized for knowledge reuse. Moreover, the checklist has to be reusable, meaning that it must be a part of the process in the PD and not just a document in a database, and also easy to use, meaning that people should be able to read and follow it without putting too much effort (Catic, 2015a). Controlling the usage of it in the PD work is also good,

but Catic (2015c) states that ideally, the checksheet should be so good and easy to use that it makes people want to use it, so controlling that it is used will in the long run maybe not be necessary. Lastly, a challenge for the knowledge owner is also to ensure that it becomes updated with new knowledge, which is not always that easy as people do not always know when they have learned something new (Catic, 2015c).

3.6.3.6 Lean tools and the SECI-model

Alfredson and Söderberg (2009) presented in their Master thesis the connection between Nonaka's four modes of knowledge conversion and Toyota's Lean tools for PD. Figure 12, that is inspired by the one that Alfredson and Söderberg (2009) presented, illustrates Nonaka's model and a classification of the Lean tools that found to be of importance for this thesis according to the four modes of knowledge conversion.

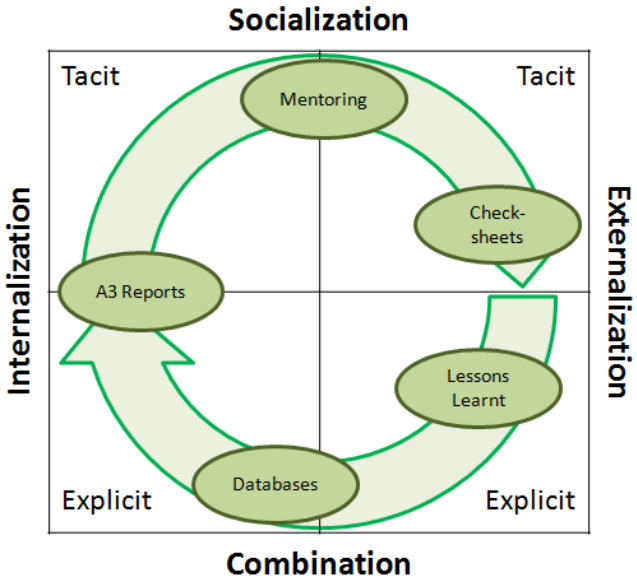

Figure 12 Nonaka's knowledge conversion and Lean PD methods (Alfredsson and Söderberg, 2009)

Consequently, as it is depicted on figure 12, and according to Alfredson and Söderberg (2009):

- Socialization is supported by mentoring systems, where experienced engineers share their knowledge that cannot be codified or written down easily, with less experienced.
- Externalization is achieved by the utilization of checksheets that can transform tacit knowledge to explicit.
- Combination is done through the A3 reports that include knowledge that can be easily codified and written down in an effective way without spending a lot of time.

- Internalization can be done by utilizing the codified information included in the A3 through discussion or explanation by the source to the recipient, giving opportunity to the recipient to ask questions and internalize the information and knowledge provided.

3.7 All in all

The focus of this research is on knowledge reuse, while sharing was thought to be necessary in order to secure knowledge reuse. The authors of this thesis have concluded that in order to make knowledge reuse to occur there are some crucial issues that need to be considered, factors that can facilitate or hinder it and tools/mechanisms that can support it. Initially, there is a need to identify and understand the characteristics of the organization including the NPD model that they use because KM practices or tools are better to be integrated there. The source and the recipient of knowledge along with the type of knowledge, meaning tacit or explicit, that they need to share or receive determines the overall nature of knowledge that the organization wish to share and reuse and the way they can accomplish it. In addition, the distinction between data, information and knowledge determines what of those is really shared and reused and by whom. All the above constitute the main issues for how to choose the appropriate tools and mechanisms for reuse and how to incorporate them in the NPD model and the lifecycle of knowledge that revolves around everything. Lastly, throughout the lifecycle of knowledge and all the crucial elements included there, there is the organizational culture to which any KM initiative should be adjusted that can be both a facilitator as well as a hinder. The other factors influencing knowledge share and reuse are categorized into individual, organizational and technology factors that the organization needs to consider. The theoretical framework on which the analysis/discussion of the empirical findings is also built, follows the logic described above and is depicted in figure 13.

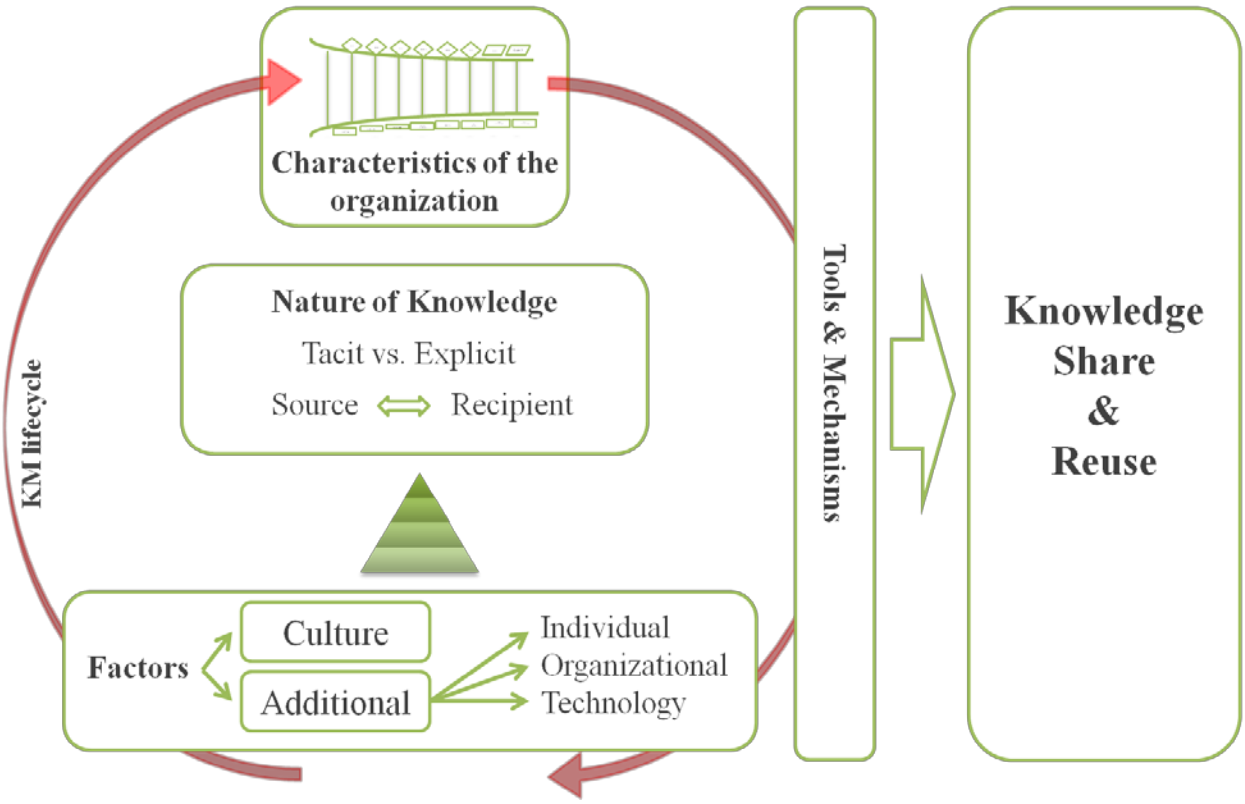

Figure 13 The theoretical framework of this thesis, created by the authors

4. Reference companies

This chapter includes two reference companies that have been doing an extensive research and work on Knowledge Management (KM) practices, where meetings and interviews took place in order to identify what processes, tools and mechanisms are enabling a successful knowledge transfer across Product Development projects. For each company there is an introduction, company description and KM initiatives. Furthermore, the findings in this chapter are being put in comparison to the case company in the analysis, supporting the theory and used as a way of showing how other large companies are working with KM.

4.1 Volvo Group Trucks Technology

4.1.1 Introduction

Since this research focuses on knowledge transfer across Product Development (PD) projects and the tools and mechanisms that can support it, it was the author's firm belief that visiting Volvo Group, that has been doing an extensive research and work on Knowledge Management (KM) practices for many decades now, and learning what processes, tools and mechanisms are enabling a successful knowledge transfer across PD projects, was of great importance. Through a two-hour semi-structured interview with Amer Catic, the KM Leader at Volvo Group Trucks Technology, the authors had the chance to get in touch with this extensive research and work and gain valuable input.

4.1.2 Company description

Volvo Group Trucks Technology has 9.000 employees and focuses on research, engine development, design, technology and PD of truck operations for Volvo Group globally (Volvo Group, 2015). The main activities are:

- Global Product Planning
- Advanced Technology & Research
- Range & Project Management
- Complete Vehicle
- Powertrain Engineering
- Vehicle Engineering
- Purchasing

4.1.3 Knowledge Management initiatives

To start with, Catic (2015a) described the process of knowledge flow at Volvo Group Trucks Technology by using the Kennedy et al. (2008) model, which is a part of the Lean PD practices that Toyota has been working with. The model that was drawn by Catic (2015a) on the board is visualized by the authors in figure 14.

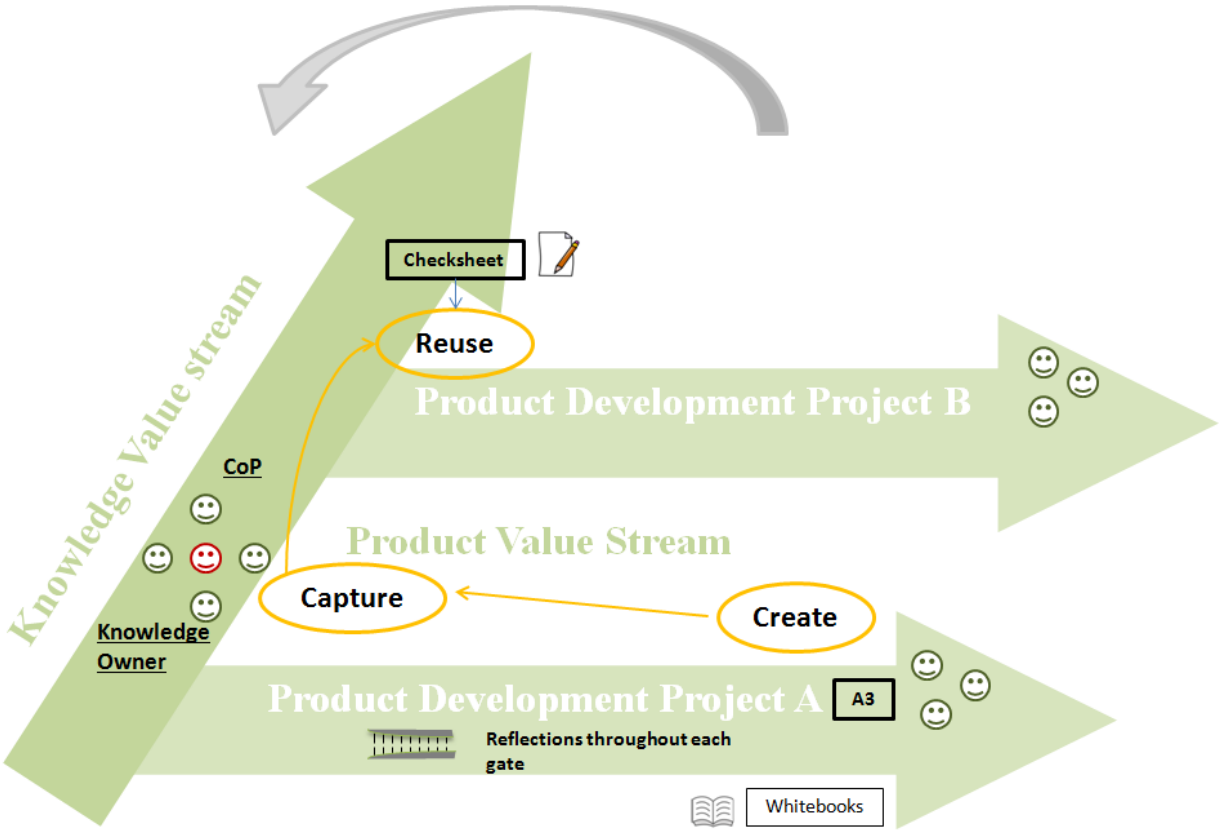

Figure 14 Model of knowledge flow used by Volvo GTT (adapted from Kennedy et al., 2008)

Within this model of knowledge flow there are roles, methods, processes and IT activities that are included (Catic, 2015a). The main roles include the Knowledge Owner and the Community of Practice, the methods used are Checksheets and A3s, the processes involve trigger knowledge creation and adjust PD to effectively reuse knowledge and the IT activity is about the user interface format. The process includes Product Value stream A and B that are incorporated with the Knowledge Value Stream. The Product Value Stream includes responsibilities, human resources, equipment and processes that are necessary to develop a product, while the Knowledge Value Stream includes activities of capturing and reusing the knowledge. Product Value Stream A represents one initial PD project, while Product Value Stream B represents

another that develops a better product compared to A. During the PD project A, there are continuous reflections in each gate of the stage-gate PD model, while there are also structured problem solving processes like the A3 reports. Volvo has a way of assessing the importance of a problem in order to decide whether or not to use an A3, so if the problem is very important to solve at the moment, there will definitely be an A3 to capture it. The A3 analysis is usually performed by the engineers themselves, meaning there is no need to always include the quality department for problem solving. The reflections as well as the A3s are the main ways of capturing the knowledge during project A because as Catic (2015a) states "*You learn when you get deviations and problems*".

After creating the knowledge, it is the Knowledge Owner that has the most significant role to play in keeping it, assessing its quality and value, organize it and ensure that it can be effectively and efficiently reused (Catic, 2015a). The Knowledge Owner is usually a trained line manager or a senior engineer. Hence, the knowledge owner is the one who takes the learning from the A3, supported by the Community of Practice (CoP). The CoP can include some designers that must be trained for these tasks and sets the requirements for the creation of knowledge, while there are regular meetings with the Knowledge Owner, usually once every month. The participating employees in a CoP can be chosen by the Knowledge Owner, but they also need to be approved by the top management in order to feel supported and see this role as one of their main responsibilities.

Finally, according to Catic (2015a), in PD project B, which can include totally different people, the knowledge is reused through the knowledge checksheets in the concept selection and in the end as well. The Knowledge Owner is the one who is in charge of the checksheet and that person must be a highly trustworthy because the people that are going to develop the next product are going to base their work on that person and the documents he or she provided. Lastly, as shown by the arrow in figure 14, in order to set the model at Volvo, there was a reversed engineering activity that started from the reuse phase in order to identify what is the previous step that is needed in order to make the reuse of knowledge successful.

According to Catic (2015a), one of the barriers he has faced is extensive documentation that is removed by this approach, as people usually do not read the documents when they are over-extensive. What is more, people will always think that delivering a product is more important than spending time on KM and sometimes they underestimate its value. The CoP, on the other hand, overcomes possible communication barriers, as they are those who make sure that knowledge is being transferred by communication. There is also a concept review included in the responsibilities of the CoP, where they can comment upon the concept, meaning that they are involved already in the early phases of the PD to be able to give their input before any decisions on how to proceed are taken.

Catic (2015a) also states that capturing the knowledge can become a waste of time, if this knowledge is not reused in any way, while people working on KM practices may have to leave the IT part of it slightly behind because there is a constant danger of getting stuck on it and neglect other more important parts. In addition, while the checksheet serves as a tool for transferring the knowledge, it does not really foster communication, so there are other ways to deal with communication issues as well (Catic, 2015a). In order for any company to start working with the model described and all the parts that it includes, there is also a need to have someone in charge and dedicated to this work, while a main challenge is to connect the KM activities with the overall strategy and business objectives of the organization. Another challenge is to make people understand the value of this KM process and how the knowledge is going to be reused in order to put time, effort and trust to contribute to this sharing (Catic, 2015a). Lastly, at Volvo in order to take advantage of the problems that they also faced in the past and capture valuable knowledge, they did retrospective A3s, which were included in the creation of the checksheets.

4.2 Cosmos-net

4.2.1 Introduction and Company description

Another multinational Swedish company that has done extensive research and work on KM practices for many decades now and have developed processes, tools and mechanisms that enable a successful knowledge transfer across projects is Cosmos-net[1]. Getting valuable input of Cosmos-net's work on these KM practices was found to be very important for this research and it was done through one thirty minutes semi-structured interview with one of the middle managers, responsible for KM and replication at a business line of the company.

4.2.2 Knowledge Management initiatives

While Cosmos-net has many different business lines, this particular business line is working with creating different offers to customers in different segments. Although this line is not formally a PD line, they still have contact with other business lines and stakeholders. Therefore, the KM initiatives taken within the department are applicable to other settings as well. The offers may include network equipment and software but also services for networks and business operations. Hence, the reuse of knowledge is connected to the offers provided to customers, customer experiences, settings where the products are used, etc., while the receivers of the knowledge transfer are PD units and business owners, as well as the sales and delivery organizations in the market regions. Cosmos-net calls this "replication", indicating that offers tailored to one or a few customers may be replicated and sold to other customers as well. There are two aspects of

[1] Fictional name for real company

replication, one is the structural asset such as documentation and the other is people, but while documentation is very important, there is also a need of involving people from past projects into new ones in order to have their experiences and input. The replication is also a KPI that the company is using on their balanced scorecards as a part of the objectives they set.

There are some KM initiatives related to this business over the recent years that are very interesting. In 2014, there was an initiative, where Cosmos-net research was the core, and the objective was to increase collaboration with the goal of decreasing the time between concept and idea to prototype. This was done by co-locating employees from several business lines and giving them the opportunity to work closely together, learn from each other as well as foster communication and knowledge transfer. The thought was to do a pilot where employees in a team working on a specific project were co-located for a certain time, and there was a positive outcome. The experience led to a shorter lead time, which occurred due to a faster buy-in from all parts of the organization because all business lines had representatives in the project team and the communication and close work led to people being very involved in each other's work and knowing what other departments required. The positive outcome was based on three factors:

- Prototyping activity: meaning that it was one component in focus throughout the project.
- Internal convincing: a result of collaboration with Uppsala University that is working with a concept of nine workshops, fostering a communication with internal stakeholders. The objective was to convince them about the process and have all of them agreed throughout the project, as the opposite is according to the interviewee one of the largest and most common pitfalls. Each line had a representative that was assigned the title of “Champion”, a type of spokesman who was responsible for their business line and the stakeholder involvement.
- Contribution of competence: a business assessment was done by Stockholm School of Economics in order to trigger internal discussions between business lines, making them share knowledge and experiences.

Another part of the business line’s focus is documentation handling. In the past, there have been several IT-tools and databases used for data storage in the form of documentation. Nowadays, there are several ways in which the different business lines of Cosmos-net are working. However, at the particular business line there are different crucial factors that the company is working with in order to support the processes of documentation handling:

- Objectives: making sure that the KM activities support the organization’s business objectives in the balance scorecard.
- Architecture: making sure to look into how documentation looks like today, what type of documents exists and which are necessary. Today, there is a substantial effort put into making templates for each document needed, and the employees have been assigned the

ownership of the documents in order to have someone in charge of updates and accessibility.

- Culture: a dashboard for how this works in different regions. Objectives are being set and each region is being supervised with regards to how they fulfill the objectives.
- Systems & Technologies: looking into what systems and technologies there are that supports the objectives. The focus is on making sure that there are tools and databases for easy storage and accessibility of documentation. Furthermore, there is substantial work needed to make sure that all documentation has a place to be stored, meaning that there are different databases for different purposes.

In practice, it is up to each owner to create and maintain the documentation and there is a high collaboration with the employees involved directly in the projects, as they are the ones that have the knowledge that needs to be codified and documented.

Lastly, as a part of capturing the knowledge, there are sometimes Lessons Learnt (LL) discussions among the members of project teams. As this is not a standard procedure, it is up to each project team to decide if and how they want to do it. However, there is effort put into creating a template and process for LL but it is not completed yet.

5. Empirical findings

This chapter includes the empirical data of this research found through interviews, observations, informal discussions and the company's website and intranet. The chapter starts with describing the current situation of the organization, followed by descriptions of knowledge share, capture and reuse and, finally, description of problem solving activities.

5.1 The organization

Emerson was founded in 1890 in St. Louis, Missouri, USA, as a small manufacturing company of motors and fans and has become after more than a century of experience a worldwide organization that provides technology solutions to industrial, commercial and consumer customers. Emerson has five business segments namely Process Management, Industrial Automation, Network Power, Climate Technologies and Commercial and Residential Solutions. The core offerings of Emerson Process Management are:

- Measure and Analyze, e.g. Tank Gauging, Marine Tank Management, Level Measurement, etc.
- Operate and Manage, e.g. Operations Management Software, etc.
- Final Control and Regulate, e.g. Actuation, Control Valves, etc.
- Solve and Support, e.g. Project Services, Lifecycle Services, etc.

Rosemount Tank Radar AB (RTR), which is the focus of this thesis, is part of Emerson Process Management and Rosemount Inc. that provides companies all over the world with radar based tank level gauging systems. It has around 360 employees in Sweden and was established in 1976, but was acquired by Emerson in 2001. The three primary markets that RTR focuses on are Marine Applications, Refineries and Tank Terminals and Process Industry. In Sweden, the company is mainly situated in Gothenburg where they have production and all supporting functions in-house, but they also have engineering departments in Linköping and Jönköping.

5.1.1 The NPD process

The core projects run at RTR are New Product Development (NPD) projects that follow the structure of the NPD stage/gate model that the company has introduced some years ago. This process is depicted in figure 15 Apart from them, there are maintenance projects as well as fault investigation, which are considered to be smaller in size and take less time to finish compared to NPD. Consequently, these projects are less complex, they can involve only one engineering discipline or even one single engineer and usually they do not require the involvement of any project manager.

On the other hand, the NPD projects usually involve seven to eight employees, but the range of people involved can vary from five up to twenty. In every project, there are always one or more senior engineers that have an overall responsibility of what the engineers are developing by checking, reviewing and giving inputs for what needs to be improved. The senior engineers are seen as the most experienced and skilled and have a lot of knowledge on which the organization relies on. RTR usually runs one to four projects at the same time and most of the people involved are located in Gothenburg, while there are some in Linköping as well as St. Petersburg, Russia. There seems to be a general idea that the projects run at Emerson are quite similar to each other when it comes to procedures and the basic structures of the components or products. Initially, the company and the NPD model set how the projects are run. What all interviewees have in common is that they believe that in the basic structure, the components and products are quite similar to each other, however the complexity of the development can significantly vary depending on technical specifications, what disciplines are involved and whether or not there are interfaces that need to be considered.

As far as the structure of the NPD model at RTR is concerned, the company uses a model that includes a number of stages and gates as well as deliverables that need to be met at every gate. RTR's NPD stage/gate model is depicted in picture 15. The majority of the interviewees believe that the NPD projects are always run according to the stage/gate model and that the structure and gate deliverables are strictly followed. The engineers are sometimes involved in the beginning up until gate two in the idea generation and mainly from gate three to gate four in the design and development of the product. When the time needed between stage three and stage five is between 10000 to 30000 hours the project is considered as small, for 30000 to 50000 hours large, for 50000 to 80000 hours huge and, finally mega projects require more than 80000 hours.

There are process guidelines included in the NPD, but some interviewees believe that there are gaps to fill within the guidelines, while some deliverables for specific gates, are not totally clear and understandable by the users. According to some interviewees there is a lack of design guidelines and when they exist they are not as satisfying as the engineers wish.

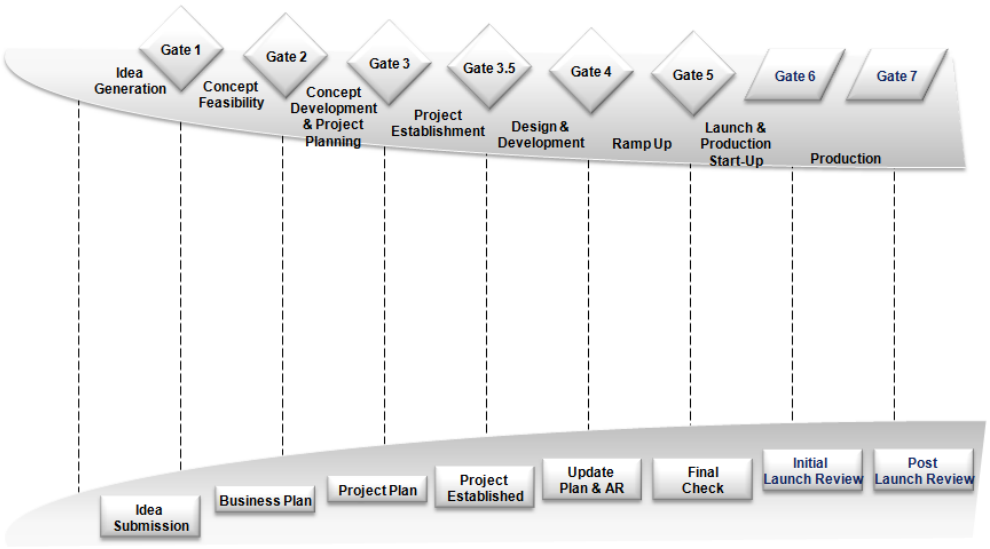

Figure 15 NPD model used by case company

5.2 The nature of knowledge at RTR

To start with, as far as the KM field is concerned, the employees of RTR state that they are not aware of the concept, while there are some who have been exposed to KM initiatives in other companies. However, the concept of organizational learning, is better known by the employees. As far as the value of knowledge sharing is concerned, it seems that the employees of RTR clearly understand that it is very important for the organization because numerous interviewees state that it can only bring benefits. However, these benefits are not clearly stated or identified by them. Some interviewees refer to increased efficiency, better problem-solving processes and increased productivity because the organization will be able to run more projects and launch more products. Other interviewees believe that knowledge sharing can improve cross-functional coordination by providing better information and understanding of the product and the disciplines involved in Product Development (PD).

5.2.1 Desired types of knowledge

Many interviewees state that in order to perform in their best way, they want to be able to find any information that they need easily and without spending a lot of time, while some believe that being aware of how things are supposed to work is really crucial. Furthermore, awareness of the resources needed, possible restrictions and problematic areas already known by previous experiences seems to be important for some interviewees. An interviewee states that all the employees need to have more knowledge about the customer, what they think about the products they are using, how they configure them and what is their general opinion.

Despite the fact that all interviewees are from different departments and have different roles, all of them stated that the main kind of knowledge they would like to be transferred is design related knowledge about the products, as there seem to be a general opinion that all other managerial issues connected to the projects should primarily be handled by the management. Many interviewees further stated a problem with difficulties of finding documentation from previous projects and all necessary information about a design, what was done or why certain things worked and others did not. Moreover, the interviewees ask for easy accessibility to product specific information without having to go through all the documentation of a project in order to find it as sometimes they may not even know or remember the name of this project. There seems to be a general idea that being able to reach all this information or knowledge easily, without necessarily having to rely on asking other people, could increase the PD efficiency.

5.2.2 Source and recipient preferences

When the interviewees were asked to provide their preferences if they are the source of knowledge and they have to distribute and share it with others, most of them stated that they would like to have some sort of personal interaction. Some interviewees provided examples such as presentations and workshops and when the interaction involves less people, having discussions, asking questions and explaining would be the most preferred way. One interviewee stated, *"I don't like to document things like this, I prefer a direct feedback on what I am communicating"*. A minority of the interviewees also stated that it would be good to have a way of storing documentation, such as a database for easy accessibility, however they also mentioned that it would not always work since not everything can be written down and there is a risk of over documentation.

On the other hand, when asked what they would prefer when being the recipient of knowledge, most interviewees stated that it would be good to have personal interactions, presentations or workshops. However, there were more people saying that as a recipient, they would also like to go through some documentation in some way. One interviewee referred to documentation saying, *"In this Just-in-Time environment, you cannot always wait for someone to talk to, even if that would be preferable"*.

5.3 Knowledge capture

The overall view the interviewees had about the process of capturing knowledge is that it is not a systematic, standardized or continuous process. Apart from informal discussions and reflections that occur during the projects, in the NPD model, a deliverable in one of the last gates states that a Lessons Learnt (LL) session should be performed, during which the project members reflect

upon the project. The two other types of projects, maintenance and investigation, do not involve LL sessions. A summary of the knowledge life cycle can be seen in picture 16 below.

Overall, it does not seem to be the LL that the interviewees are referring to when asked about knowledge capture. What is mainly identified is the documentation that is done throughout the project, and more specifically the design description document that each engineer needs to fill out. This document is supposed to act as a guidance of what has been done for the component or product, what kind of decisions have been made, what worked well, etc. The documents are later stored in the project folder and are supposed to be accessible for people in need of them in the future. The management of the majority of the documents is done through a web application called SharePoint, which also includes the company's intranet. However, the company used to work mainly with a project database system called Doctor that included all the project specific documents. Nowadays the Doctor is still used as a complementary project database to SharePoint because not all the documents are yet transferred to the new software. For the actual LL sessions, the general answer from all interviewees is that technical details about a project are not taken into consideration. This kind of information is expected to exist and been written down by the engineers in the design description. Consequently, the LL is including organizational issues and problems that might have been encountered during the project.

The LL session lasts usually for two-three hours. For very big projects it can take half a day or one day. However, since the LL session does not involve all project members, it is up to each line manager to make sure to have a discussion with the discipline members that were involved in the projects in order to make sure that their input is also taken into consideration. One interviewee said that each team member could spend maximum one hour for it, stating *"We actually put it in a reasonable level"*, not mentioning if that hour is always enough or not. When asked why the time is limited, the answer was that *"The ambition needs to be put on a reasonable level. If people are not told that this is the maximum time you may spend on it, you don't put the ambition on the right level"*.

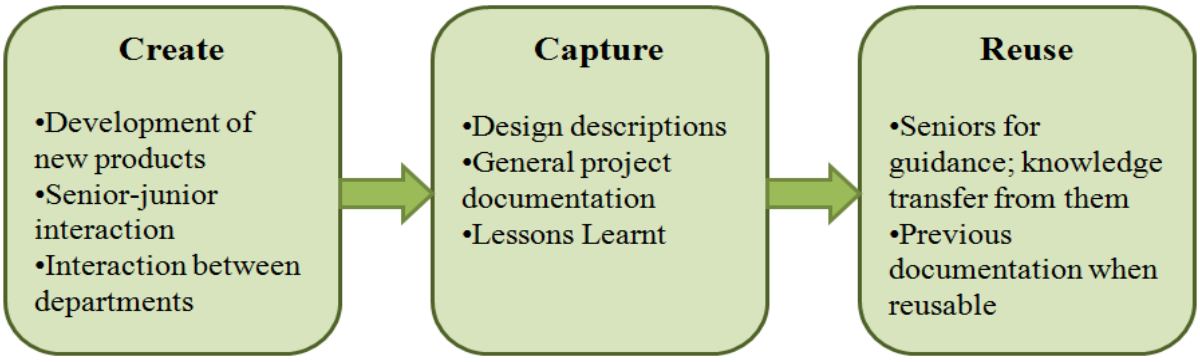

Figure 16 Summary of activities done in each phase of the Knowledge Management lifecycle

5.3.1 Observations from LL session

In order to see how a LL discussion is typically conducted at RTR, the researchers attended one session. The discussion was done for a project that had been running for approximately three years and the session was a deliverable to gate six in the NPD model.

The employees who attended the discussion were key people in the project. The functions that were represented can be seen in table 5.

Table 5 Attendees and their respective function in Lessons Learnt session

Function	Employee position
Project Management	PMO
Project Management	System architect/Product Manager
Business unit RTG	Manager Technology
Software	Engineer (Consultant)
Mechanics	Senior Engineer
Electronics	Line Manager
Testing	Senior Engineer
Tank Master	Technical Product Manager
Supply Chain	Project buyer + 1 Consultant
Operations	Project Manager Operations
Software	General Manager

The meeting started with the PM and the PMO giving a brief summary of the project and the execution. The PMO stated early on that everybody should go into this with a positive attitude and not blame anyone for potential mistakes that were made. Further, it was stated that the focus should be on the successes and failures and also try to indicate what strategies and decisions that led to them.

Prior to the discussion, as not all employees involved were participating, each line manager or person in charge of a team had a session with the engineers, discussing successes and failures that the team experienced. This compilation of bullet points was sent to the PMO and PM prior

to the discussion, who made a PowerPoint presentation with the comments from each function. The two questions raised were:

- What worked well and why?
- What did not work well, why, and how can it be improved?

The meeting then proceeded with each function representative presenting the conclusions and if anyone had anything to ask/add, a minor discussion followed.

The issues that were raised were mainly how the teamwork was, if there were any problems with coordination, communication between functions and individuals and other managerial issues that might have arisen. What everyone thought was good was that the co-location of some of the team members was one of the main reasons for why the communication was very successful, making the work easier for many people. Another point was that having early field tests is very important, and that the team could see many positive outcomes of it, while, according to the PMO, this is something that has been often raised during other projects. Many of the comments on the improvements that need to be done were addressed to everyone, referring to all the functions as being one team with common responsibilities.

The last part of the meeting was a summary of the most important lessons, done by the PMO and PM prior to the meeting. However, during this last discussion there was a possibility for the other participants to add more comments if they wanted to or if they felt that something important was missing. Furthermore, the outcome of the meeting, a PowerPoint presentation, was supposed to be sent out to the line managers and top management. It is then up to each line manager to make sure that his or her team receives the information.

5.4 Knowledge reuse

In order to identify the ways RTR reuses knowledge at the moment, the authors of this thesis tried to firstly identify if there are any ways of reaching information from previous projects. According to the interviewees, there are some, but none of them seems structured, systematic and satisfying for the employees. *"If you are lucky"*, as an interviewee said, you can find information under the name of the project in Doctor or SharePoint which are quite unstructured and one can never be sure that he reached the right information. Another interviewee says that it is not possible to find information without the help of some individual that knows where to look for it as the hard drives include huge amounts of data and there is no timeline for the events in the projects. Most interviewees state that the easiest way for them is to talk directly to people involved in the projects that may be useful for the current one. However, it has been stated by several interviewees that it is not always easy to know who to talk to. The people that are most often asked for previous experiences are the senior engineers, some of them working in the

company for 10-25 years and have a lot of experience and knowledge. If these people do not work in the company anymore, the engineers may have to do the same work again and again. It has however been stated by some interviewees that, especially for people who have not been in the company for a long time, the lack of easy access to documents in order to identify who has been working in specific projects, makes it sometimes very difficult to know exactly who to talk to.

The employees state that the problem of not being able to look for a specific product, but go through the project name is something very hard because they cannot know or remember what exact product was developed under every project name. Some engineers state that there are design documents and drawings from a product that can be found, but they lack the overall status of the product, how it performed and how it worked. Some interviewees also refer to the LL, stating that they went through them in the beginning of the project as part of a study of the specific area, while most of the times people do not devote any time reading them and they become just *"one more document in a folder"*.

For knowledge reuse, while it seems to depend on the individual and what knowledge he or she needs in order to perform well, the knowledge that is acquired is not introduced in any stage during the PD. The LL are usually not read by anyone after their completion, while an interviewee states that they do not even include all information that people may need from a project. What is more, according to many interviewees, people also underestimate the value of the LL and they just participate because it is a part of their responsibilities and one of the deliverables in the last gates of the NPD. One interviewee stated *"People tend to just forget what they have done in order to move to the next NPD project, especially when they had many problems and anxiety in the previous one*". A mega project that is currently run by RTR called Eagle was the only one that started with the LL from previous experiences being read by the whole team and a fault analysis to identify the current situation of the products and avoid doing the same mistakes. Usually, there is no follow-up activity after the LL is stored in the hard drives of the company. Some interviewees believe that this is something that the management should take into consideration.

5.4.1 Hinders for knowledge reuse

As the phase of reusing the knowledge is the one that needs special attention at RTR, the authors tried to identify the employee's opinion on the reasons why this is not happening. One problem for not reusing the knowledge that some interviewees refer to is the fact that people do not think about it and do not see it as something necessary or as a responsibility, while the management also does not communicate the need for doing it. On the other hand, lack of time is also a reason why people do not act to reuse the knowledge, because all of their time is devoted to the actual PD. There are also people who believe that it is always better to come up with new solutions all

the time, so they do not need to utilize the knowledge acquired from previous projects. Apart from that, there is no structured or systematic method for this activity, so the LL for example, are according to many interviewees seen as just one more deliverable in the gates and no one really understands why they are useful and how they can be reused. The cross-functional communication can also be problematic sometimes, as an interviewee states. What is more, the knowledge is not traceable and it cannot be easily found, while product specific information are even harder to reach as stated before. An interviewee also states that there is no standardized documentation for the products or the projects and product or project documents can be very similar, but also very different. Some interviewees also refer to the lack of a structured database where someone can easily look for products by using keywords.

In addition, some interviewees believe that some people may underestimate the value of utilizing the knowledge or the whole concept of KM and organizational learning because they have a very technical background and they over focus on developing a product, so that there is no time to understand these concepts and how they can improve their performance. One employee clarifies that this is not the case for the majority of the engineers, but it really exists.

Furthermore, an interviewee says that knowledge utilization is part of a culture that does not exist at Emerson; a culture that promotes continuous learning and improvement as well as the value of understanding what has been done before. The same interviewee states that *"Making a mistake one time is super, making the same mistake for a second time is not good and making it for a third time is a catastrophe."* According to him, this is the culture that people in the organization should have in order to make mistakes, learn from them and not do them again.

Table 6 Hinders for knowledge reuse

Hinders for knowledge reuse
People not thinking about it
Not considered as necessary
Not seen as a responsibility
Insufficient communication of its importance by the management
Lack of time
Perception that inventing new solutions all the time is better
No structured or systematic method
Knowledge cannot be easily found
Lack of product specific information
Lack of a well-designed database
Underestimation of such activities
Lack of the appropriate culture that promotes it

5.4.2 Potential facilitators for knowledge reuse

When the interviewees were asked about how people can be motivated to utilize the knowledge, it was identified that a limited number of employees could easily answer this question since it has not really taken into consideration before. However, some of the interviewees said that it would probably be wise to explain the benefits such as speeding up the work, being more efficient, not having to heavily rely on other people and avoiding doing same mistakes due to ignorance. What most interviewees said, however, is that it is difficult to get results of a KM initiative like this if it is not integrated in the work and the duties. They stated that there is a need of making it a part of the employees' daily work to ensure that previous LL and documentation of project work are actually read through and reflected upon. One interviewee stated that since many projects are allocated to principal and senior engineers due to their high expertise, it may be more efficient to allocate less projects to them, or at least less projects that do not really need their expertise. In this way, the company would rely more on the engineers who also have high expertise in their respective fields, while allowing the principal and senior engineers to allocate more time for other responsibilities such as mentoring. In case engineers encounter problems along the way, they have the seniors to ask for guidance.

Apart from motivating the employees, the researchers' firm belief was that it is important to identify the best way to practically achieve knowledge utilization according to their personal opinion. Many interviewees state that it is important to communicate the existence of the LL more effectively through the whole organization and include it in the main responsibilities of the employees and the risk list. The knowledge must also be relevant, appreciated, available, adequately presented and introduced in the beginning of the project, for example in a presentation session. A systematic way of documenting the knowledge can also bring more effective utilization, according to some interviewees, while one interviewee suggests that no one in the company should work alone because the documentation that the person will produce is not going to be the best. The creation of a common forum for knowledge transfer and cross-functional discussions about problems, projects or products and having presentations of problems was also suggested by someone who added that people need to reflect after each stage in the projects and not only in the end. In addition, an employee mentioned that common engineering knowledge is easily found in the organization, but product specific knowledge needs to be documented, reviewed, pinpointed and stored in way that it can be easily found. Lastly, while there are employees in favor of creating a database to deal with the problem of knowledge transfer and utilization, others believe that it will not solve a big part of the problem because it cannot support the tacit dimension of knowledge, which needs communication and discussions.

5.5 Knowledge share

According to all interviewees, there are many opportunities for people to share opinions and knowledge with each other at RTR, but almost always in informal settings. Most of the interaction happens during the projects with team members talking to each other, asking for other opinions and discuss possible solutions for problems they encounter. Referring to the opportunities of sharing the knowledge, one interviewee stated, *"I think that people are very willing to share with each other, the problem is that sometimes you don't know what exact person has the knowledge you are looking for"*.

Some interviewees also talked about project meetings that are usually held a couple of times per week as good opportunities to discuss experiences and share knowledge. However, there is a common feeling that the lack of time makes even the meetings quite short and difficult to use for more detailed discussions. One interviewee said, *"In the meetings you always need quick decisions"*, which is the reason why many meetings are also quite short and used for status updates and not for detailed discussions. One interviewee stated that there have been discussions earlier in the company about having more formal settings for discussion and knowledge sharing, such as mentorship programs, but the lack of time and resources is the reason why it did not evolve into a standard procedure. Another issue mentioned by some interviewees was an initiative taken by the company called "Friday-educations" that is basically about optionally having a Friday afternoon to present anything being of significance or in some way share knowledge and have discussions with people interested in the subject. Some interviewees stated that it was a good initiative but it was basically the employee's' responsibility to schedule a session without any involvement of the top management. The attendance is also optional, which according to some interviewees is probably the reason why people decide that they need to finish other tasks and prioritize them instead of attending such an event. This opportunity of having a "Friday-education" is still available but very rarely taken. One interviewee also stated that since employees in general would prioritize other tasks, there might be a fear of scheduling an event, inviting employees, and then having nobody attending, which may also be a reason for why the motivation for scheduling something is lacking.

When managers were asked about their opportunities to share their personal opinion, they also got a follow up question whether or not they think that their authority might be a reason and most of them gave a positive answer. The engineers on the other hand said that, since they do not have authority, they still have good relationships with colleagues and managers, making it easy for them to talk and express their opinions. The interviewees generally stated that people are open to share with each other, while some suggested that the hierarchical system at RTR might be a hinder. For instance, one interviewee said that since the company has to heavily rely on the senior engineers, the latter may feel that there is no point in asking other less experienced engineers for their opinions since the seniors are the most skilled and experienced ones. One interviewee also mentioned that in order to solve problems, the seniors' ideas and solutions are

more easily accepted, basing it on the notion that they know better and have more experience and knowledge. On the contrary, it was mentioned by some interviewees that maybe there are employees feeling scared of asking questions to other people, especially those in higher positions, since they do not want to be considered as incapable. What is more, an employee stated that people rely on the senior engineers because they are afraid to take the risk and blame for a decision resulting in high levels of hesitation.

It was also mentioned by some interviewees that the interaction between disciplines and understanding for each other's field is not sufficient, resulting in discussions about how to combine each other's solutions and take decisions. These discussions usually lead to an agreement about what actions to take, but some interviewees think that it would be good to enhance mutual understanding and respect among different disciplines.

The main barrier to knowledge sharing, clearly identified by numerous employees is that people usually high workload and many responsibilities. An interviewee states that they have approximately 20% of their working time that is saved for additional activities, such as finding the right tools and do administrative work, while 80% is devoted to PD per se. While the employees try to decrease this percentage to 70-75%, they think that 20% of the time is not enough to include activities and time devoted to knowledge sharing. It is also said by an interviewee that the process of NPD does not really facilitate knowledge sharing and it becomes even more difficult when different business units are involved. Another interviewee refers to the culture of the company saying that it does not foster communication and knowledge transfer between individuals, compared to previous experiences in other companies. On the contrary, some other interviewees believe that the culture at RTR encourages communication and informal sharing between employees.

When the authors of this thesis tried to get the employees' perspective on the problem of knowledge transfer that the organization wished to approach through this thesis, many interviewees stated that while the organization has means to capture the knowledge, it is not well-equipped or effectively prepared to reuse this knowledge and direct it to the appropriate people via a good process. Much knowledge already exists in the company, but it is necessary to gather and structure it. Some interviewees believe that a main problem is that most of the knowledge is connected to specific individuals on which the organization heavily rely in order to proceed in the projects and this knowledge and experience cannot be easily written down; it stays only in people's minds.

Furthermore, some interviewees think that not having easily accessible information and knowledge about the products and previous projects is a big problem as it would be good to learn from what has been done before. People can become more interested in their job and see it as something fun if it is well handled, according to one interviewee. Another employee says that they lack a well-designed routine and education on how to use their good systems and store data.

Many systems or processes in the company are half-finished or never finished because there is no responsibility for them and, sometimes, the employees have to deal with a huge lack of information and processes. An employee exemplifies by saying that when the company initiated the SharePoint as new software, they just started using it without transferring all the necessary information from the previous software, resulting in having an empty SharePoint that no one uses and keep using the old one for reaching information.

Lastly, during the interviews, it was also identified that some employees are not really aware of the problem of knowledge transfer in the organization because they are not informed by the management about its importance, while others are not aware of the existence of the LL from previous experiences and the other documentation from past projects.

5.6 Problem solving at RTR

5.6.1 Common issues

In order to be able to get a deeper comprehension about the issues that may arise in the organization and the ways knowledge transfer and reuse can prevent them from recurring, the interviewees were asked about their personal view on the most significant issues they have to deal with in their work. These problems, as said by the employees, can be technical, such as water leakage, or organizational, such as communication issues. An issue mentioned by an interviewee is the fact that the engineers usually want to have the latest technology to work with and introducing it sometimes during the project work, which can create delays. Also, there are large reshuffles that are sometimes done late in the project and, according to an interviewee; those must be done in the beginning in order to leave the "small things" for the end. Generally, as the same the same employee states, "*Putting attention in the beginning of the project is vital as it is painful to have crucial realizations in the end.*"

Furthermore, one of the employees states that while the team is extremely good in technology and technological issues, they tend to miss out on other things. Explaining this, the same employee refers to some communication issues and states that there are no clearly defined responsibilities assigned to specific people and it is not widely known in the company who is in charge of what in other areas apart from technology. One more interviewee is focusing on other issues apart from technology, saying that the main problems that often recur have more an organizational character. In particular, the interviewee states that the NPD process is quite new to the company and it is constantly changing resulting in making it very difficult to understand what to produce in each stage, including documentation, and what deliverables to meet in each gate.

One last issue, mentioned by an interviewee, is the overreliance of the project members on the experience and knowledge of the senior engineers who usually have many duties and

responsibilities. These people cannot be replaced, according to the interviewees, and there is a big risk of losing their expertise and knowledge if they leave the company. Both during the whole project and in the reviews, they are necessary and the projects can in many cases not move forward without their approval.

5.6.2 Problem solving processes

Problem-solving processes were considered to be of great importance for this research because it is connected to knowledge creation and the choices of people whether they use knowledge from previous experiences or deal with the problem as it occurs every time from scratch. Many interviewees believe that it is natural to learn from history and this is mainly done by talking to experienced people as it is not so easy to reach these documents in the hard drives. At RTR, the engineers do not use problem-solving tools at the moment. Currently, when assistance is needed for solving a problem, the quality department to some extent uses the DMAIC cycle and some of the simplest tools that it provides. In order to increase awareness about the DMAIC cycle for problem solving, there have been optional seminars about it. While people are interested in starting using specific tools, but the main issue is to prevent various problems from recurring in many projects. One of the main actions when a problem arises though is to find the people with the knowledge necessary to solve it. Those people serve as a "database" and they also know how to direct others to find the appropriate documents. Some interviewees state that even if they had the appropriate documentation easily available to them, they would still seek the help of the experienced people in the company.

One interviewee states that *"we cannot reinvent the wheel again and again just because some people may want to sit in their room and investigate new solutions; we need to check previous experiences."* On the other hand, when a problem is completely new, the engineers need to make studies on the field to identify the causes of the problem. It is also suggested by an interviewee that brainstorming within the team and during the project will be very useful for problem solving and new solutions by including also people that work in the company for 20-30 years.

An interviewee says that when having to deal with a problem, it is preferred working alone in the beginning by using books or the internet to find information and then check the work by interacting with others. This was also something that was observed during the research, that often engineers were reading books such as handbooks and doing research on the Internet. The same interviewee states that even if there were knowledge available from previous projects, there would always be things to reinvent to some extent. However, the interviewee stated that having knowledge from previous solutions is always good and can ease the development.

Another interviewee says that having problem-solving integrated in the normal work is preferred because although going through a number of problems may be useful, it is better to try to solve

the problem directly in order to not spend time on trying to reuse old solutions that may not be suitable for the moment. According to another employee, when they construct a new component, they try to build it on the build-blocks from the best practices for one solution and then, they try to store this and put it together as a platform for the future to be able to build the component according to this platform. There is some variation that may appear, but at least there is a platform to begin with.

5.7 Workshop: Generating an engineering checksheet

In order to see in what ways an engineering checksheet may be applicable for capturing and transferring knowledge, there was a workshop held at the company. The attendees were both internal and external. For the internal employees, there were three mechanical engineers, the company's global quality director and process improvement manager. The external attendees were a KM Leader from Volvo GTT as well as two researchers from Chalmers University that has done research in KM practices in PD organizations. The Volvo GTT KM Leader was the one who was leading the workshop because of his extensive research on the checksheets.

As an introduction prior to the workshop, there was a presentation and discussion held by the authors of this thesis, which was aimed for the three engineers to have an overview of the field of KM as well as what an engineering checksheet is and why it may be applicable in the case of RTR. The presentation included a discussion about the findings of this research; especially those that led the authors consider the engineering checksheet as an appropriate tool for RTR. Identifying whether the three engineers, who were not part of the employees interviewed before, perceived the situation in a similar way compared to the interviewees and their thoughts about the checksheet as a tool were other important parts of this meeting. Overall, the comments were in accordance to what has been discovered from the interviews, that there is an issue with documentation, both in making it reusable for future projects, but also in finding what is needed, leading to the documentation not being so useful in many cases. There was a further discussion about other possible benefits of the checksheets, where one of them was triggering discussions among employees, especially at the stage of developing the checksheet when a lot of tacit knowledge needs to be written down. A potential benefit might therefore be to decrease the gap between the knowledge of juniors and seniors by capturing mainly the knowledge of the seniors, which may then help the juniors, or new people coming into the organization, to quickly get a good overview of the component/product. There were also questions raised about the necessity of excluding some forms of documentation if another tool like the checksheet is going to be useful.

The workshop itself started with a presentation held by the KM leader from Volvo GTT that described the background of the need for capturing actionable knowledge that can be reused. Furthermore, there was also a description of the checksheet, what has led to the development of

it and why it may be applicable as a tool for reuse. In order to provide the company with an idea of how a checksheet may look like, a component for an earlier product series was chosen prior to the meeting to be used for the testing of the checksheet. The KM leader, with some inputs from the external researchers from Chalmers, then asked questions to the internal attendees to capture valuable knowledge about the component. As there are some guidelines that Volvo GTT has created for what areas to focus on and what kind of questions to ask, there is not any guide or way of conducting the discussion that can be generalized for all companies. Consequently, the questions to ask and the areas to focus on were chosen throughout the meeting. It was detected quite early that even though there was a perception that the component chosen was fairly uncomplicated in developing, there are many crucial things to think about when designing it, as well as decisions to make earlier on. The input given by the engineers was then complemented by inputs from the quality director and process improvement manager who could give additional factors to include. These factors are based on quality issues that have risen and problems that have been detected foremost after product launch, but also during development, and that have the potential of being avoided in the future.

As completing a checksheet would require many more hours of discussions, it was decided that the information gained during the session would be adequate to show the overall goal with the tool. Due to confidentiality issues, the outcome of the workshop cannot be included, but the checksheet has the structure of the example given below in table 6.

Table 7 Part of the checksheet generated during the workshop

KNOW-WHAT	KNOW-WHY	KNOW-HOW	REFERENCES
……	……	……	……
Trade-off for the size of the ventilation holes.	There is a trade-off between the impact on the hole and the production aspect of making small holes.	Check standards/requirements. Talk to production and microwave department to determine the correct size. Make the holes invisible from a microwave perspective.	Standard.
……	……	……	……

In order to verify that parts of the information included in the checksheet were issues that have been identified by other departments as well, there was a meeting held after the workshop together with people from the Failure Analysis team, as well as the Product Manager. That

meeting was aimed for the researchers to get additional input that may be of importance for the checksheet. It was revealed that the issues that the team had faced before, were also the issues that were identified during the workshop, mainly built on the knowledge of the senior engineer.

6. Analysis and discussion

The purpose of this chapter is to use the theoretical framework in order to analyze the empirical findings of this research and provide the foundation for what improvement areas there are for knowledge share and reuse in the organization studied. The chapter also includes discussion points and the authors' view, while is structured according to the theory and the theoretical framework.

6.1 Managing knowledge in NPD

As was stated by Frost (2010), the essence of Knowledge Management (KM) is to make the right people reach and use the right knowledge and make sure that knowledge acquired is accessible and reusable. According to the empirical data, controlling the flow of knowledge is one of the improvement areas at RTR as no particular KM initiative has been taken. It is very important though for such a knowledge intensive organization to stay competitive and competent, as Goffin and Koners (2011) stated, by systematically managing the knowledge value streams. While the NPD model is according to the empirical data handled in a fairly good way, there seems to be an overall view among the interviewees that these kind of KM initiatives should be integrated into either the New Product Development (NPD) model or other processes in order to make sure that whatever initiative will be taken, it becomes an obligation and part of the job duties.

If the above is not done and the initiatives are left to be optional, there is a risk that they will not be done. The Friday educations that the company initiated can serve as a typical example for that. Due to the fact that they are optional, in combination with the lack of time the employees expressed, it is clear that there is a difficulty with retaining them and have them scheduled on a regular basis. This is in line with what McDermott (1999) stated about the challenge that companies face with making their employees take time to share and provide each other useful information and knowledge. It can therefore be argued that without the management controlling these kinds of activities and making sure that they really happen, it is possible that they will not lead to a knowledge transfer, despite these activities being good from a KM point of view and showing that the company is really concerned to improve knowledge-sharing activities.

As it was seen in the reference company Volvo GTT, there is strong focus on securing that all parts of the KM process are managed, mainly by delegating responsibilities that ensure that no process or activity lacks ownership and jeopardizes the knowledge flow and that it is integrated in the daily work of the PD department. The significance of this role as a knowledge owner is further stressed by Catic (2015a) as that person also ensures that the knowledge acquired is not only captured but also effectively and efficiently transferred and reused. Furthermore, it can be seen in the second reference company, Cosmos-net, that the allocation of responsibilities is crucial. Despite Cosmos-net focus on securing that documentation is updated, the interviewee clearly stated that without each document and template having an owner that maintains it and

makes sure that it is accessible, there is higher possibility of having excessive documentation that is not used.

Moreover, the company works with cross-functional teams where each individual brings diverse competence from different engineering units, which Parker (1992) argues is essential to achieve optimal outcome of the projects. It seems that this setup is working well for the company, but as the teams are resolved after the projects, it is may lead to a lot of knowledge not being shared between individuals and functions, especially as the time pressure makes the employees having to start with the next project as soon as possible. This is in accordance with what Clark and Wheelwright (1992) stated about this being a setting those PD organizations tend to have and that it makes learning from past problems less likely to occur. Moreover, since it is not always possible for the management to allocate resources for the projects including employees that have been working on similar areas before, it creates a need for making sure that the knowledge created is actually transferred and utilized in a systematic way.

6.2 Nature of knowledge

6.2.1 Tacit/Explicit knowledge and the SECI model

According to Polanyi (1966, p.4), tacit knowledge is strongly connected to the personal characteristics, emotions, values and experiences of an individual and it cannot be easily written down, symbolized or transferred. As it has been discovered, there is a high dependence on the senior engineers in the company, supporting the issues that Polanyi (1966) is mentioning of transferring, but also documenting the tacit dimension of knowledge. This indicates a need of enabling the transfer of tacit knowledge to the whole organization. The perception among the employees about the past documentation not being highly utilized also supports what Polanyi (1966) states about the difficulties with writing down, symbolizing and communicating the tacit knowledge. Taking this into consideration, it becomes clear that without enabling a knowledge transfer and documentation with the purpose of trying to reuse it in the future, there is a risk of losing valuable in-house knowledge that may be crucial for future PD. Furthermore, as was mentioned by Kingston (2012), there are different types of tacit knowledge. Based on the empirical data about documentation not containing actionable information and not being very useful, it can be argued that there in many cases has not been a capture of tacit knowledge, providing more in-depth information to the recipient. It can also be argued that in the case of RTR, a lot of symbolic experiential knowledge resides in the minds of the seniors after many years of experience, but since there has been a lack of ways capturing it, it has probably not been captured and reused other than anyone but the seniors themselves.

On the other hand, the explicit knowledge that, as Polanyi (1966, p. 4) states, can be easily written down and transferred in a systematic way is of great importance for RTR. The interviewees ask for design descriptions, process guidelines, possible restrictions or problematic

areas already known from previous experiences, which are more explicit in nature. However, in order to be able to write down all the above and then store them in a well-organized database, as some interviewees suggest, the organization needs a process of taking the tacit knowledge from the senior engineers and translate it into explicit documented knowledge in order to share it with the juniors or the newly recruited. This is a very challenging process that is called externalization, as Nonaka (1994) refers to it, while, according to Pitt and MacVaugh (2008), it can be done through articulating personal knowledge and creating the necessary documents or databases, for instance, that are derived from this knowledge. In addition, according to Nonaka and Takeuchi (1995), these documents can be analyzed and organized in order to offer easy access to the users and be diffused through the organization. This is the process of combination that is about explicit to explicit knowledge conversion, and it can be useful for RTR in order to improve the ease of access to the documents, the traceability of information and knowledge as well as the simplification and understanding of the a specific document.

Simultaneously, the tacit knowledge that senior engineers own can be transferred also through the process of socialization where the knowledge maintains its tacit nature as it is done through interactions and share of experiences without any systematic language (Nonaka, 1994). Pitt and MacVaugh (2008) state the importance of having competence databases, events or forums for "Know-How" and "Know-Who" in formal or informal settings. As far as events are concerned, the company's Friday education, as stated before, did not become so popular although it could be a good way to share tacit knowledge and identify the "Know-How" and "Know-Who". When it comes to competence databases, some employees state that all the documents include information about the people who created them, but it still needs time and effort to find the documents per se. Mapping the competence of the employees, as Alänge and Sjölander (1986) stated, can ease the process of finding who to talk to. Furthermore, it can lead to employees realizing that more people have specific competences that were not maybe known, leading to new interactions with these persons.

Saint-Onge and Wallace (2003) and Newell et al. (2002) also refer to the Community of Parties (CoP) as way for socialization. They argue that sharing is easier within the CoP as they share common experiences and expertise, which support them to develop knowledge and distribute it through the whole organization. While this is evident at Volvo GTT where they make use of CoP to remove communication barriers and support the knowledge owner who is in charge of the checksheet, it would be more beneficial for RTR to foster socialization in a more person-to-person way because CoPs require time and resources for the employees and the organization.

For the modes of knowledge conversion, Nonaka (1994) also refers to internalization, meaning explicit knowledge that needs to be transformed into tacit by, according to Pitt and MacVaugh (2008), enabling individuals to utilize documents, attend presentations and seminars and reflect upon them afterwards. At RTR the way internalization may exist at the moment is when people are reading product or project specific documents as well as design descriptions and try to absorb

this knowledge in order to make it part of their work, as Nonaka (1994) state. Hence, if the documentation is improved and more accessible in order for people to make better utilization of it, there will be even more knowledge produced through internalization.

According to the interviews and observations though, it would be prioritized and more efficient for the employees to have the knowledge that they need for the projects written down and stored while having easy access; meaning that externalization needs to be strongly considered. What is more, the senior engineers are not so many at RTR and some of them are located away from the rest of the team members in the projects, so it would not be efficient to rely on their presence all the time for the process of socialization. Furthermore, it is a fact that heavily relying on the seniors can create problems when they get retired or are absent for any reason, because the interviewees state that sometimes they cannot proceed to the next step in a project without having the seniors reviewing their work. In a "Just-In-Time" working environment, it is also required to make quick decisions and there is not always available time to wait for someone to talk, although this would be preferable, as an employee stated. However, externalization cannot stand alone at RTR because even having the knowledge written down and accessible to the engineers, the need for communication, explanations and additional advice from the seniors is unavoidable, and also desirable. As been stated before, this is due to the fact that there are limitations with codification, primarily with expressing and codifying tacit knowledge, which needs supporting actions. But, in this case, the time spent by the seniors will be much less and the reliance on them will be kept on a reasonable level.

6.2.2 Source and Recipient

According to Cumming and Teng (2003), in order to transfer the knowledge successfully the source of the knowledge must be aware of who the recipient is and both of them must be equally involved in the process of sharing. The same authors, as well as Davenport and Prusak (2000) also state the importance of the recipient feeling the ownership and absorption of the knowledge because without these the transfer cannot be successful. Furthermore, this is crucial when documentation is taken into consideration. Lindlöf (2014) identified the "documentation paradox", which occurs when the source is not aware of the recipient when documenting despite the importance of it, while simultaneously documenting for the purpose of making it reusable for a future recipient. This usually results in difficulties in reusing the captured knowledge, as a potential future recipient may not find what is documented useful.

For the Lessons Learnt (LL) as well as the rest of the documents produced during the project work at RTR, it was clearly identified during the interviews and observations that the roles of the source and the recipient of knowledge are not so clarified. When people are looking for information from previous projects, they stated that it is difficult to find out whom to talk to, meaning the source, because finding specific documents is also hard. This is especially difficult

when the one who is looking for information is fairly new at the company. The people that are usually asked for previous experiences are the seniors who are the main source of knowledge at RTR. But, as stated before, it is not always easy to find them because they are in many cases the only ones who have the knowledge of many projects resided in their minds and they have many responsibilities. The fact that many employees stated a desire of easily and quickly being able to find who to talk to supports Allen's (1984) idea of the law of least effort.

For the LL, it seems that while there is a clear role of the source, it is not equally clear who the recipient of the document is, as well as for the follow-up activities and the improvements that were discussed during the session. So, while the areas of improvement are identified during the session, the responsibilities are not clearly given to someone specific and it does not become clear who is in charge of what. This seems to be the main improvement area for utilizing the LL and not just store them in the project folder. In addition, during the LL session, the participants and the people who lead the session are not clearly stating the recipients, which may make the reuse of the document more difficult, as Lindlöf (2014) state in his theory about the "documentation paradox".

6.3 Factors influencing knowledge sharing

6.3.1 Organizational culture

According to Al-Alawi et al. (2007), there are five success factors connected to the organizational culture that are critical for knowledge sharing. The first one is trust, for example interpersonal or between co-workers. It seems that according to the observations and the overall statements from the employees, there is trust between them that does not hinder them from sharing their views, opinions and knowledge. However, as it can be seen in the empirical data, there is a culture of asking the senior engineers for guidance and more importantly for reviewing the work in order to pass the gates in the NPD model, which can lead to an assumption that the trust for the seniors is higher than among the employees on a more junior level as the seniors are expected to notice mistakes and give advice on improvements and changes. The second factor that Al-Alawi et al. (2007) discuss is communication between staff and according the to empirical data, it can be concluded that there seems to be an overall good and very frequent communication between employees. However, as been pointed out by some interviewees, there could be more communication between the engineering functions in order to get higher understanding for each other's work.

The third factor is information systems referring to the arrangement of people, data and processes. Overall, the integration between these three parts may need improvements as data existing in the company's hard drives is not easily accessible and there are no processes or guides for how to reach certain data that might be useful. The fourth factor discussed is reward systems but it can be stated that they do not exist in formal setting, although the company

appreciates good work and communication. These however, Al-Alawi et al. (2007) state are very important due to the fact that it is unrealistic to assume that all employees should share their knowledge without any incentives or gaining something from it, which is likely to be the case here as well. Lastly, the organizational structure is a factor that is stated being a possible constraint for information and knowledge flows. According to the empirical data, the organizational structure does not seem to be an issue for knowledge sharing between the employees. It is further stated by some interviewees that there is an overall good communication between employees and managers, which makes the organizational structure not being a hinder for the flow.

As was discussed by DeLong and Fahey (2000), the connection between culture and knowledge is affected by four factors. The first one was that culture influences the employees' perception of what type of knowledge is good and useful and that will lead them to what to focus on. As the interviewees in this research were all belonging to the engineering department, it can be seen from the empirical data that the type of knowledge they found most useful is only connected to the actual PD and the technical details of the components, such as design descriptions. Comparing it to the observations made which showed a high desire for product-specific knowledge for a more efficient PD and learning from mistakes, it is clear that the view on what knowledge is desirable is derived from the overall organizational view on why certain types of knowledge are more important than others. As the views on what types of knowledge are important expressed by the interviewees were also corresponding with the management point of view, it can be concluded that the influence the culture has is shown in both individual and organizational level.

The second knowledge-related behavior discussed is the relationship between levels of knowledge. DeLong and Fahey (2007) argued that it determines whether the ownership of the knowledge is individual or organizational. According to the empirical data, it seems that the main part of the knowledge is individual and considering the lack of processes for documenting knowledge in the past, it can be assumed that the knowledge today is still resided in the minds of the experienced individuals and is not documented and easily accessible for the organization.

The third aspect that culture affects is the creation of an environment that fosters social interaction and determines the time, places and ways people interact. It can be seen in the interviews that there are opportunities for people to interact, and it happens on a daily basis. It seems that there are not particular hinders regarding the spontaneous interaction, but there are no regulated informal occasions besides the coffee breaks for people to interact. However, it has been seen that during coffee breaks and lunches, the topics discussed were both work-related and not work-related leading to the conclusion that those occasions are also important for knowledge sharing.

Lastly, DeLong and Fahey (2007) argue that the culture influences the way a company creates and adopts new knowledge internally or from interactions with the external environment, how it is shared among the whole organization and in what ways it influences the business strategy. Firstly, RTR has collaborations with external organizations in order get input from the outside world and educational institutions such as the collaboration with Chalmers University. Secondly, according to the empirical data, it seems that the internal creation of the knowledge within the engineering department is rooted in the way the organization works with PD. The usage of the NPD model is a well-structured way of creating knowledge, but there are elements of it that can be adjusted. Currently, the cultural impact seems to be rooted in the way the employees develop the products and how they work. Many interviewees stated that while there is room for finding new ways of developing the products and finding new solutions, it is favored to go back and see what has been done before and try to reuse old solutions. This seems to be good not only for the sake of reusing knowledge, but also from a resource point of view as there is an overall view of a lack of time. However, considering that many interviewees expressed dissatisfaction with the documentation that has been done in the past, it can be assumed that it creates a need to find new solutions or go back and redevelop some components, which is positively affecting the knowledge creation but negatively regarding the time aspect. Furthermore, it is clear that the culture of the organization is encouraging to always be better and develop better products, which affects the way the knowledge is created. However, it could be argued that the desire of reusing as much as possible from past projects may be a hinder in the way the organization creates new knowledge.

6.3.2 Additional factors influencing knowledge sharing

As it has been already stated, in order to reuse knowledge, someone needs to initially share it. This does not necessarily mean that when knowledge is shared it is simultaneously reused; however ensuring that knowledge share really occurs in an organization is a precondition for knowledge reuse. This is the reason why identifying the factors influencing knowledge sharing in an organization is of great importance for this research. Table 7 includes the factors influencing knowledge sharing that found to be important to consider at RTR in order to improve knowledge sharing and have more possibilities to secure knowledge reuse.

Table 8 Factors influencing knowledge sharing at case company

Factors influencing knowledge sharing at RTR		
Individual	**Organizational**	**Technology**
Different levels of knowledge between people	Culture	Possible over reliance on technical solution
Possible underestimation of owned knowledge by the juniors	Trust	Database
Source and recipient thinking	One-way hierarchical knowledge flow	
Individual learning from past mistakes	Perception of what knowledge is important	
Lack of time	Motivation	
Allocation of time	Lack of time	
	Allocation of time	
	Guidelines and education	
	Interaction between different departments	
	Physical barriers/co-location	
	Faith in the initial KM investment/expectations	
	Communication of the objectives of KM	
	Organizational learning from mistakes	
	Expectations	
	Roles & responsibilities	
	Integration of sharing into the daily work	

6.3.2.1 Individual factors

Riege (2005) categorizes the factors to knowledge sharing into individual, organizational and technology and various authors have contributed to enrich these categories. Starting with the individual factors, one of them can be the communication and social skills that people may lack, but at RTR it seems that people have all the necessary skills and willingness to effectively share. On the other hand, the hierarchical system, that Probst et al. (2000) and Riege (2005) refer to, can be a potential hinder to knowledge transfer according to some interviewees at RTR. The fact that the company relies so heavily on the senior engineers may make them feel that there is no need for them to ask anyone else for something because they are the most experienced and skilled in the company. It was also said that sometimes the solution proposed by the seniors are more easily accepted and many employees may feel uncomfortable to ask questions to superiors in order not to feel or seem incapable. The underestimation of owned knowledge that Riege (2005) discusses can also be seen at RTR since there are employees who would not choose to take the risk and blame for a significant decision resulting in hesitation and more reliance on the seniors. Furthermore, Riege (2005) presents the lack of communication between source and recipient as well as the lack of awareness of who provides and who requires the knowledge as a significant individual obstacle, which also exist at RTR as discussed before. The creators of the LL document and the various project documents are not clearly aware of who is going to receive or need them in the future and there is a limited number of specific action plans for the captured knowledge in order to identify who will need to receive it.

Nonaka and Takeuchi (1995) also discuss the underestimation of tacit knowledge by various people as a factor to knowledge sharing. At RTR, it seems that there is not any underestimation, but probably limited awareness of its meaning because people may not distinguish the difference between tacit and explicit knowledge. On the other hand, the fact that all people talk about the value of the knowledge of the senior engineers that is not written down shows that they indirectly recognize the value of the tacit knowledge that they have as they always ask for it in order to solve problems or move to the next steps of the NPD. The insufficient management of experiences and past mistakes that Nonaka and Takeuchi (noted in Riege, 2005) as well as Delong and Fahey (2000) describe, is also evident at RTR as there is no systematic way of reaching information from previous projects and the LL are not always reused. However, apart from employees who believe that for solving a problem it is always good to look for a solution right away instead of looking for previous ones, there are many interviewees who appreciate the value of experiences and past mistakes in order to improve the current project work. What is more, the overall need that the employee's express for "not having to reinvent the wheel again and again" also shows willingness to learn from mistakes. However, the realization that in order to achieve that they need to effectively capture and systematically reuse the knowledge and, simultaneously, invest time and resources for that, needs to be clearly communicated throughout the entire organization.

One of the most important factor that were identified during this research at RTR is the lack of time that the interviewees, both junior and senior engineers as well as employees of other disciplines, are referring to. This is mentioned discussed by Riege (2005); when people do not have time to reflect and share. While it is presented as an individual factor, it is not always something that the individuals can control as it is connected to the general structure of their daily work and the requirements that the management set. It is the author's firm belief that prioritization is strongly affecting the allocation of time both by the employees per se but also by the management. Hence, when it is not massively believed that sharing and reusing the knowledge is important for the engineers, they will not perceive it as a main responsibility resulting in putting very limited time and energy for it. Many interviewees state that they are loaded with work and responsibilities and devoting 20% of their time for activities out of the actual PD is not enough to include systematic sharing and reusing activities. What is more, many interviewees refer to limited opportunities for discussion and sharing because of project meetings usually being very short focusing on status updates and quick decisions without leaving adequate time and space for detailed discussions and sharing. This may indicate that the management prioritizes the actual PD leaving very limited time for additional activities. While this fact is totally understandable, as the main strength of the company is the skilled engineers and the high-quality products they offer, it also implies that sharing and reusing should be more included in the long term aspect of continuous improvement. Sharing and reusing activities do require a lot of time and effort to be organized and become a part of the daily work, but in the long term, they can save time and resources by avoiding doing the same mistakes or the same work and spending less time for problem solving.

6.3.2.2 Organizational factors

The first and general organizational factor that Riege (2005) discusses concerns the adjustment of KM initiatives into the organizational culture of the company. As far as RTR is concerned, the interviews revealed that the main KM activity that is done, which is the LL, is integrated into the NPD model, which was added due to the organization realizing the importance of documenting what has been learnt. However, as the LL are mainly focusing on the organizational issues that may have raised, the technical details are left out, indicating that the documentation and discussion about them should probably also become integrated into the NPD. In an effort to deal with this issue, during this research some initiatives were found to be of great importance, but they were not chosen because they would not match the overall corporate culture.

The culture by itself can also affect knowledge share according to Riege (2005) as it determines how employees interact and whether the overall environment is open for sharing. Many employees state that at RTR there is a culture of “open doors”, meaning that people are not isolated in their offices. Most of the people feel that when they need something and they know where to find it, they do not hesitate to address to the specific person and, in general, people feel

free to share their opinion. One of the interviewees though, is referring to the culture of the company by saying that continuous learning as well as learning from mistakes is something that can be further fostered, which is stated by Nonaka and Takeuchi (noted in Riege, 2005) and Delong and Fahey (2000) as a crucial factor influencing knowledge sharing. This was included in the individual factors as well, but the authors wish to highlight here that it is not only the individuals who may not own this culture, but also the whole organization and how it promotes this culture. While the whole meaning of learning from mistakes was always important for the employees and the management at RTR, they recently started taking systematic initiatives for that. Additional aspects of the organizational culture at RTR that may serve as facilitators or barriers are already discussed in previous sections.

The hierarchical system can significantly affect knowledge sharing is discussed by Riege (2005) and Ives et al. (2000) as it can affect or restrict the flow of knowledge and the general communication. This issue is discussed in the individual factors concerning the way people of different hierarchical levels may feel. However, it is also an organizational issue because the heavy reliance on the seniors that makes their opinion strong and dominant and the possible hesitation of the juniors to take risks or blames affects the way the knowledge flows at RTR. So, when the direction of knowledge usually has the seniors as starting point and the juniors as end point there is a top-down approach that unwittingly occurs creating restrictions and a possible "one-way" communication.

Design of the working environment, as mentioned by Probst et al., (2000) and Allen (1977), is an organizational factor that also influences knowledge sharing. They state that avoiding designing the offices according to the hierarchy, removing physical barriers, such as walls, between employees and offering traffic patterns with physical contact when employees walk to a specific target, such as the coffee machine or the kitchen, are very important. At RTR, the engineering department works in offices that share the same space without any physical barriers, while most of the employees in other departments have their own offices. What is more, in some months, the company is going to move to a new location where people will not have their own offices, but work in the same open-office environment. There are various and controversial opinions on this issue, as most of the employees believe that this will definitely foster collaboration, communication and share, but it also generates a fear of losing privacy and comfort that supports concentration and productivity. However, the fact that the co-location of the Eagle team in order to be able to sit and work together has only positive outcomes according to the project members, may imply that working in a common space will be beneficial for the employees. In addition, as it was mentioned by the reference company Cosmos-net, the initiative of co-locating project members was highly successful as the interaction led to faster buy-in among the departments and supported the decrease in lead time, which is something that could be considered by RTR as well. When it comes to common spaces, coffee machines and the kitchen, during the presence of the authors at the facilities of the company it seems that it was very common to see people sitting together in the kitchen or having small talks while taking their coffee. However, informal

meetings between people in the actual office environment were not held very frequently according to the author's' observations, maybe because the environment of the engineering department is characterized by quietness and high concentration. Although the design of the working environment that Allen (1977) has analyzed in detail is important for knowledge sharing, it is not part of the scope of this thesis, so the authors are just presenting some main observations that may help the company be aware of its importance.

Riege (2005) further presents the communication of the objectives and reasons why a KM initiative is taken as an important factor to be considered. At RTR, many employees were not aware of the initiatives that the company has started in order to improve the flow of knowledge and foster organizational learning. The communication of the value of dealing with this topics was probably not so intense or well-targeted, which is something that should be kept in mind as communicating the purpose of these kind of KM initiatives is important for a faster buy-in from the employees in order to have a successful outcome. Furthermore, the employees do not always understand the overall value of managing the knowledge and what it needs. This can be understandable because most of them have technical background as engineers and KM is not part of their studies or daily work due to their strong focus on the actual PD. However, this fact indicates that for a successful outcome of this KM initiative, there should be more time spent on communicating the meaning and value of managing the knowledge. Making the employees feel that they are a part of the initiative and that their input is valuable could ease the integration of KM into the organization and the daily work of the employees.

Davenport (1997) refers to the importance of having faith in the initial investment of KM initiatives as the benefits may become visible in the long term. It is very understandable that the employees at RTR are focusing on developing products of the highest quality, have a high workload and many responsibilities, so there is no luxury of time for additional activities as only 20% of their time is devoted to these. It is very common for people to expect a radical recommendation or a tool that will support knowledge share and reuse, but while this may exist, the benefits will be visible in the long term and there is a need for loyalty into the initiative. Throughout this research, it was also found through researching the field of KM and especially through the reference companies that any KM initiative needs time and allocation of some new responsibilities, as Riege (2005) and Gold et al. (2001) state. At RTR, while people are focusing on doing a great job, many employees have said that there are some initiatives that are half-finished because of lack of allocated responsibilities and prioritization of other tasks. Typical examples are the detailed checklists that the electrical engineering department devoted time and effort to create or the transfer of data from Doctor to SharePoint in order to create a well-designed database.

When it comes to incentives and motivation of the employees to share, Ives et al., (2000) discussed the voluntary nature of sharing that require guidelines, motivation and education by the management. First of all, it seems that at RTR all the employees understand the benefits of

sharing and refer to some of them, sometimes without ease of specifying. This is the reason why some employees suggest that in order to motivate people to share, the management should specify and explain the benefits from it. It was also stated by some interviewees and also observed by the authors that the integration of KM into the daily work of the employees is something that will motivate them more because they will know when and how to capture, share or reuse. The LL or the rest of the documentation are not introduced at any time during the PD and the employees do not know specifically where and how to reuse them, which is natural and understandable if no guidance is provided. The only time that the LL and information from previous projects where introduced in the beginning of the project was in Eagle project and the employees perceived it as something very useful. Finally, the employees would be more motivated, as many of them state, if the KM activities are part of their responsibilities and not as optional as the Friday education, for instance.

6.3.2.3 Technology factors

In general, the engineers and the rest of the employees at RTR are working with highly developed technology and due to their technical background and personal motivation they are handling this technology and any technological issues in a very successful way. So, the issue of having a fear of new technology, using old one or not understanding the value and benefits of technological solutions that Riege (2005) discussed, is not evident at RTR. Furthermore, this knowledge and expertise on technology may make people over rely or overestimate the value and use of technology, as Riege (2005) state. During the research, it was evident that although many employees were aware of the necessity of having a technical way to share the knowledge or the value of a well-designed database, the tacit dimension of knowledge and the value of interaction were sometimes less considered. This is not interpreted though as an underestimation of the tacit dimension or the interactions, but more as an overestimation of technology and technical solutions to knowledge sharing.

Hendriks (1999) also discusses various IT solutions for the technological aspect of KM provided by many companies, but at RTR there was not any identification that an IT tool is needed at the moment as the company had to focus on other areas of KM to start with and starting using specific simple tools. Riege (2005) also suggests that using well-designed databases is something important for KM, but while there is the necessary infrastructure to build a database at RTR, the data transfer from Doctor to SharePoint is on the way and many employees ask for more advanced databases, especially for product specific information and knowledge.

6.4 KM lifecycle

6.4.1 Create

The phase of knowledge creation is about doing things in a way that leads to new knowledge as Gartner Group (1999) state. Undoubtedly, RTR is an organization that does things that lead to new knowledge in a daily basis as the engineers working in PD generate new products or make updates that lead to knowledge creation. Furthermore, the regular interactions between seniors and juniors during the projects also creates knowledge for both of them, but more likely for the juniors as they usually act as receivers who get new insights about issues, designs etc. In addition, Catic (2015a) refers to problem solving tools and processes such the A3 reports as well as the continuous reflections during each gate as the main ways that Volvo GTT uses in order to create knowledge. The general logic is that people tend to learn when they get deviations and problems that need to be captured in order to become available to the next employees that will develop a product to learn from them (Catic, 2015a). While the employees at RTR appreciate the perception of learning from mistakes, until now the company does not use a structured problem solving tool or a specific way to capture a problem and create knowledge. However, all the problems are either documented and stored in the project folders, where it takes time and effort for someone to find them or resided in the minds of the experienced engineers.

6.4.2 Capture

As was stated by Gartner Group (1999), the phase of capturing knowledge is about transformation of tacit knowledge into explicit, make sure to retain it and later distribute it to the ones who need it. According to the empirical data, there seem to be a number of different ways the knowledge is captured. The main way to capture product-specific knowledge are the design descriptions that are a part of the NPD model and are supposed to be documented by the engineers. As it was stated by some interviewees, there is no standardized way of how the design description should look like, which can lead to different levels of quality of the documentation. When there is no standardized way of documenting, it can be argued that there is a higher possibility that what is written down is more of the explicit type of knowledge instead of tacit, as trying to codify tacit knowledge into explicit usually can require some guidance for what is useful. Furthermore, there are general documentations done for each project, which also are part of the capturing, however the same thing applies here; there is a risk that what is documented is not always the most important from a specific project. When it comes to the LL, they are as well a good way of capturing knowledge that has been acquired, but they seem to be leaving out on the technical details and focus on the organizational issues that have arisen. The LL sessions are further analyzed and discussed in section 6.5.2.

6.4.3 Reuse

The reuse phase, according to Gartner Group (1999), is about applying or including the knowledge that is captured into the daily work, decision-making or development processes. This is the main improvement area for RTR concerning the KM life cycle in combination with the capture phase that is important in order to capture the knowledge in a way that makes it easy to reuse. The main ways that make it possible to reuse knowledge at the moment are the documentation from the previous projects, the LL and the senior engineers. Concerning the documentation, the extent to which it is reused is not that high, which is mainly due to difficulties with finding what is necessary and if found, it can be not so useful for some interviewees, indicating a lack of recipient thinking when documenting and very likely difficulties with writing down the tacit dimension of knowledge. The LL is at the moment not reused, but this is further discussed in section 6.5.2. Regarding the senior engineers, they are the ones that are usually asked for guidance, making their knowledge reused by others in their work. However, it can be assumed that as it is a mutual learning process, the seniors are most likely gaining some kind of new knowledge from juniors as well. Catic (2015b) refers to the engineering checksheet that Volvo GTT uses for knowledge reuse and is tested in order to assess the possibility of using it at RTR, but the details of it will be analyzed and discussed in the tools and mechanisms section.

6.5 Tools and Mechanisms

To start with, Pitt and MacVaugh (2008) suggest that standardized methods and practices are very important for organizations to store, assess, recombine and mobilize knowledge and information. This constitutes one of the main improvement areas for RTR and a motivation to identify specific tools and mechanisms to effectively share and reuse the knowledge. At the moment, while information and knowledge is captured in the ways mentioned before, it seems when they are stored in the databases of the company; they are not reused on regular basis or in an easy way. Consequently, both sharing and reusing knowledge needs to become more systematic and standardized.

What is more, Goffin et al. (2010) state that not every approach can be appropriate for every organization because even if there is evidence that a tool or mechanism has been successfully implemented in one company, it may not be the best approach for another one. So, when the authors were exposed to the KM practices that are used at Volvo GTT, it was crucial to identify what parts of these initiative can be tested or introduced for RTR. Volvo GTT uses the approach of Kennedy et al. (2008) meaning that the lifecycle of knowledge follows the phases of create, capture and reuse and the main tools that are used are the engineering checksheets for capture and reuse and the A3 reports for creating knowledge (Catic, 2015a). These tools are though

complemented by the white books that include all the detailed information and knowledge for developing a product and reflections during every gate of their PD model (Catic, 2015a).

6.5.1 Codification and Personalization

As was proposed by Hansen et al. (1999), there are two KM strategies namely codification and personalization. The first strategy is codification, which is referring to codifying and storing knowledge into databases for future utilization. According to the empirical data, there is a need for codifying knowledge and storing it as it is something that the organization needs for easy access. However, as was discussed by Rowley (2006), there is a distinction between data, information and knowledge that needs to be considered. Information is built on data that is made sense out of and for a specific purpose. But as the intention with KM is to make sure that knowledge is managed, there needs to be a distinction between information and knowledge. Jashapara (2005) in Rowley (2006) argues that knowledge per se is "actionable information". So, in the case of RTR where many interviewees state that documentation is lacking actionable information, it can be argued that the documentation at RTR is mainly containing information and in some cases probably just data. As was stated by Catic (2015a), in order for people to make use out of documentation, no matter what format it is, it has to be actionable. Consequently, when codifying explicit knowledge for documentation, it should always be considered in what ways the provided information could be useful. This can be done by having the receiver in mind when documenting, but also by securing that what is documented is actionable by discussing with potential receivers about the usefulness.

The second strategy that Hansen et al. (1999) discusses is personalization that is based on the assumption that knowledge is tied to the person. As this has been proved to be the case at RTR when it comes to knowledge about past products and projects, it clearly indicates a need for making sure that, what is presumed to be mainly tacit knowledge is shared between individuals. Despite codification sometimes being favored, Kreiner's (2002) concern about social processes being devalued should be considered, as they can be good ways for knowledge share and creation that should not be underestimated.

6.5.2 Lessons learnt

The LL which is the outcome of the post-project reviews is one of the lean tools used in Lean KM in PD serving as one of the main ways to learn from previous projects and include key learning that are good to know for future projects (Kennedy et al., 2008). Schindler and Martin (2003) state that PPRs is a way of capturing key experiences that can be used in future as well as current projects to avoid doing the same mistakes and sharing this evolved knowledge is the main outcome.

In the case of the LL done at RTR, it seems that they capture the general key learning's from the projects, but several interviewees' state that they do not usually go back to look for them and they are not introduced in any stage of the NPD model. It is not clear what happens with the document afterwards because it seems that the document is later stored in a folder, but as the responsibilities are not clearly delegated and the action plans are not clarified and written down, there are no specific recipients for the document and hence, no specific follow-up activities to make sure that people received and understood the information.

During the LL session that the authors attended, it was observed that many of the comments on the improvements that need to be done were addressed to everyone, referring to all the functions as a united team and by using a collective "we". The level of each employee's participation in the discussions was reasonable, however the extent to which some participated was very different as there were employees who were speaking and commenting upon most of the issues, while others did not express themselves at all.

What is more, throughout the entire meeting, all technical details of the project were not taken into consideration as this kind of issues are presumed to be discussed within each functional team. This is a possible reason why some employees think that the document of the LL does not include the information that they need sometimes. Furthermore, the document of the LL is not standardized, meaning that it can be found as Word or PowerPoint document in various forms, but most of the times including the same topics of "What worked well and why?" and "What did not work well, why and how can it be improved?"

Schindler and Martin (2003), as well as many other authors, find it crucial to reflect upon key experiences and lessons learned during a project after each milestone, such as gates in a stage-gate model, instead of having it only in the end of the project and have one single reflection. This may be another reason why the LL at RTR does not include everything that the employees need to know, while having the reflections only in the end may make people forget crucial things that need to be written down. The LL session that the authors observed, for example, was for a project that lasted for three years, meaning that the participants had to recall events that occurred during these years, which is a challenging task and the time given for that is limited. The main session lasts for two to three hours, while the complementary ones that the line managers run for their departments are quite short as well. This fact may imply an underestimation of the value of the session from the management or the actual participants because some of them believe that the time devoted to the LL must be kept in a very reasonable level to avoid a situation where people are overdoing it and spend more time than the necessary.

The issue that needs to be considered is that when people underestimate the time needed for the LL, the whole perception of it may be affected, creating a perception that this not something important and it is done only because it is included in the deliverables of a gate in the NPD model. The general feeling from the interviews and observations is that while everyone

understands that the LL and the whole meaning of reflecting upon the work is important, there are not many employees that believe that spending more time on that to make it reusable is feasible. There may be a general perception also that there is a way of reusing the LL and the knowledge from previous projects that will require very limited time and effort. The truth though is that while there are many ways to transfer and reuse the knowledge without putting as much effort as it requires now, there is always a need for devoting time to go through what happened in the past and learn what mistakes have been done to avoid repeating them. In addition, there is always a need to initially invest time and effort in order to effectively manage the knowledge and make it reusable in the long-term, as Davenport (1997) state.

6.5.3 Mentoring

Liker (2004) discussed mentorship at Toyota as a way for managers to act as mentors and not only functional managers, being responsible for the knowledge that exists within the function. While at RTR there are experienced senior engineers that own significant amounts of knowledge, a large part of their role is to support the project work, approve the work done and provide knowledge and expertise to the team. Although it could be argued that this is some form of mentorship that fosters knowledge transfer between individuals, especially seniors and juniors, there is no systematic or planned mentorship. This can be explained by the numerous tasks that the seniors have and the focus of the company on the actual PD, as said before, and not on the additional activities. As the empirical data showed, it is the senior engineers that are perceived to have the most knowledge and experience, which is why it can be argued that if any mentorship should exist, it should be the seniors mentoring juniors. This is therefore very much in accordance with what Shani et al., (2009) stated about mentoring being a great opportunity for any company to foster knowledge sharing between a senior and a junior. Not only would the junior learn many things from the senior and develop competence, but the mutual learning process could lead to the senior also developing his/her competence while simultaneously feel a satisfaction with the company appreciating the knowledge that person has and wants it to remain in-house. Moreover, as the lack of time is an issue, the intra team mentoring that Shani et al., (2009) discuss, could be a way of creating a standardized mentorship while simultaneously having the seniors and juniors working closely together in projects.

6.5.4 A3 reports

According to Shook (2009) the A3 reports are used to capture a problem and create new knowledge that can be reused, while Morgan and Liker (2006) state that it is a good way for the employees to summarize a problem-solving process on a piece of paper and for the management to get simple and short answers to what they need to know. At RTR, problem-solving procedures follows a more spontaneous path, by having the engineers looking for new solutions or searching through the documentation to find what was previously done. There is no problem-solving tool

that is used right now, although the Quality department has tried the DMAIC cycle and considers it as something very useful. In order to make solutions to past problems traceable and easily accessible to everyone, the A3 reports, or similar tools, can be a simple way for RTR to use in order to support learning from previous experiences.

6.5.5 Databases

Databases are important for RTR because, as Frost (2010) state, they organize the data in a way that it can produce information that will further lead to knowledge, according to the Data-Information-Knowledge-Wisdom (DIKW) hierarchy that Ackoff (1988) present. There is currently a need for RTR to create a database for products developed in the past that will enable users to search for products and not for projects. Also, there is a need for making data and information easily accessible without the presence of an expert to direct the user. The transportation of data and information to the SharePoint from Doctor is an on-going procedure that will solve most of the above. However, it should be kept in mind that whatever is being stored in databases should also have a purpose. The essence of documentation is that it codifies knowledge, experiences and understanding that resides in the heads of people into explicit characters, as Rowley (2006) state. So, when documents are stored in a database, it should be secured that what is written down is "actionable information" that can lead to knowledge. In case the documentation ends up being only data and information that is difficult to make use of, there will be a risk that people will not read it.

6.5.6 Checksheets

As was stated by Liker and Morgan (2006), the checksheet can serve as a reminder of what needs to be done, including knowledge acquired from past projects and design guidelines. Since the purpose of this thesis is to see in what ways knowledge acquired from projects can be reused, it is of importance to find tools that supports it. Catic (2015a) stated that there is not extensive research on tools for knowledge reuse and while finding ways of capturing the knowledge is important, it is useless if the captured knowledge cannot be reused. In combination with the empirical findings where many interviewees clarified a wish of being able to access product-specific knowledge and better documentation that is actually reusable, it was concluded that an engineering checksheet might fulfill these wishes. Many interviewees mentioned dissatisfaction with over-extensive documentation, which indicates that if something is going to be replaced by another tool or type of document, it has to be something easier, shorter and more useful in order for the change to be meaningful. Furthermore, the lack of actionable information in the documentation as was discussed before, can be improved by the checksheet as Catic (2015a) stated, because it serves as a tool for capturing actionable information that the recipient actually can make use of. As it has been discussed previously, it is concluded that in the case of RTR, there cannot be a too high reliance on reaching people, in many cases the senior engineers, that

have the knowledge needed, meaning that there has to be some sort of documentation that can enable a capture of tacit knowledge. However, it needs to be noted that tacit knowledge usually is difficult and in many cases impossible to capture, codify or transfer into explicit. But, by generating checksheets via workshops including employees with different levels of experience, as was mentioned by Kokkoniemi (2006), it is an indisputable fact that it will trigger discussions and questions, which may lead to tacit knowledge being articulated and thereby also written down.

Furthermore, as it was concluded in previous chapters, it seems that the interviewees in the organization are favoring externalization as a mean for knowledge sharing, strengthening the beliefs that an engineering checksheet can support it. This is especially the case for the high reliance on senior engineers as many of them cannot be reached at any point and some also are in different locations, which makes it difficult to argue for socialization as a prioritized mean for knowledge sharing. Furthermore, to cope with the issues any organization may have with the most experienced employees leaving the company for any reason, it is important to find ways of ensuring that despite the employees leaving, at least parts of knowledge remains in-house. Lastly, Morgan and Liker (2006) stated that by standardizing the checksheet by integration into the PD process, the usage of it can lead to not only a more effective capture of knowledge but also successful PD.

Based on the findings, the workshop that was held was for the purpose of trying to create a checksheet. It seems that by using the workshop-based approach as proposed by Kokkoniemi (2006), the interest and willingness among the employees to participate is high, most likely due to a feeling of being important for the outcome and that the knowledge resided within them is very valuable for the company. Due to the fact that a complete checksheet requires many hours of discussions to be generated, the outcome of the workshop was just a start for the specific component, however it was enough for the employees to have an overview of its usefulness. As the overall comments from the participating employees were good, it seems that there is a chance that implementing the checksheet as a tool for knowledge capture and reuse could be well received.

Moreover, it was observed and also validated by the participants that the whole process of generating a checksheet during the workshop was fostering knowledge sharing among the seniors and juniors as well as the rest of the participants. The juniors revealed that they learnt more about the component, the whole product and the issues that need to be considered while developing it. The participants that do not work directly with PD also argued that they learnt about details and functions of the component that they were not aware of. So, it can be argued that generating a checksheet can be a process of interaction and knowledge sharing among the participants and an additional opportunity for the juniors to get knowledge from the seniors.

However, as was mentioned by Catic (2015a), in order for the checksheet to be reusable for future projects, it needs to become a part of the PD process. This is in line with the overall perception the interviewees had about introducing KM initiatives, making sure that they become a part of the job duties. Furthermore, as Catic (2015a) stated, the checksheet needs to follow the rule of "less is more" in order for it to be easy to read and understand, which seems to be a precondition for making it work at RTR, as documentation that may be perceived as over-extensive as Catic (2015a) states usually leads to people not reading it. Further, Catic (2015a) stated the importance of having someone in charge of the checksheet. While Volvo GTT has the so called Knowledge Owners, consisting of experienced senior engineers or line managers, it should be noted that the essence of it is having someone in charge of updates and ensuring that it is used in the PD process. Hence, for an organization that experiences lack of resources, it could mean that ownerships and responsibilities are delegated, but to what extent and how much time is required depends on how many checksheets will be proved to be necessary, how much time is needed to create them and how much time is available for working on this. However, as Catic (2015a) mentioned, while in the beginning it may require some time to generate the checksheets, the process of creating new knowledge, and also creating knowledge that is useful to include in the checksheet, usually depends on future development projects. This means that the workload for the person in charge of the updates is usually not that high after the checksheet is created.

7. Conclusions

This chapter summarizes the findings that will support the ways that knowledge can be shared and reused. The conclusions are based on the analysis and discussion, while the research questions on which this thesis is based, are being answered. In the end of the chapter the authors are stating the contribution of this thesis to the research field of Knowledge Management (KM).

7.1 RQ1: In what ways can project acquired knowledge be reused in future projects?

It is initially necessary to ensure that knowledge reuse will have a more structured and standardized nature because standardization can support continuous learning and learning from mistakes. It is also evident that in order to foster an organizational learning, sharing knowledge between individuals and ensure knowledge dissemination across the organization and different functions is crucial. It can be concluded that when it comes to the current means of capturing knowledge, they are not adequate to ensure that the knowledge can be reused. A main reason for this is that the knowledge that needs to be captured and reused in the company is more tacit in nature, making the capture more difficult. In particular, the main knowledge of the organization resides in the minds of the senior engineers who have high expertise, experience and skills necessary to develop the products in a successful way. Consequently, capturing this knowledge as much as possible is vital, mainly with the mechanism of externalization to make it more explicit. However, it is also evident that focusing only on documentation is not sufficient. So, having socialization as a supporting mechanism is also necessary because interaction enhances communication and knowledge transfer. The distinction between what is data, information and knowledge at RTR is not so clear and it is evident that the documentation mainly provides information and not actionable information, i.e. knowledge that can be reused. However, as it is context dependent, it needs to be kept in mind that not everything can be turned into actionable information. The reusability of documents is highly dependent on what the content provides for a potential recipient, meaning that documenting according to what future recipients need is crucial. Even though it can be difficult to know who a future recipient could be and what that person needs to know, it should be elaborated upon the reusability of the information provided and how understandable it is for someone that maybe does not have the same understanding for the subject as the source has.

Furthermore, both knowledge capture and reuse need to be done in a structured and systematic way by reflections as deliverables that are integrated in New Product Development (NPD) model, preferably in earlier gates. For activities such as the Lessons Learnt (LL), that are usually done in the end as a gate deliverable, makes it difficult to recall what was happening in the whole project. The same applies to the design descriptions that should also be integrated in the NPD model. There is also a need to make sure that all the documents and knowledge have a clear

source and recipient to ease the reuse of them, because people do not usually know who to talk to when they need specific knowledge. By trying to make the process of finding knowledge sources, knowledge sharing can happen quicker and more efficiently.

What is more, roles and responsibilities for the activities that will support the KM initiative need to be identified and become part of the responsibilities and job duties of the employees involved. Moreover, the involvement of the management is vital in order to control these activities, identify their ownership and make sure that they actually occur.

In addition, activities such as mentoring may be an appropriate way to decrease the knowledge gap between seniors and juniors, and enhance a knowledge transfer. In this way, juniors can reuse knowledge from previous projects resided in the minds of seniors if knowledge is successfully transferred. Problem-solving tools such as the A3 reports could be useful for the engineers to use as a more systematic way of solving problems and simultaneously creating more knowledge to capture in a storytelling way that can ease a reuse by not having to rely on extensive documentation. Additional activities such as final presentations after projects are finished can also enhance knowledge transfer and reuse. Lastly, it is a fact that well-structured databases can ease the retrieval of documents and competence databases can ease social interaction by quickly finding out whom to talk to. However, for storing documents in databases, making sure that what is stored is actionable information, or at least can lead to the recipient developing knowledge based on it, is crucial in order to secure that the documentation and the database is well-functioning.

7.2 RQ2: What are the factors influencing knowledge sharing that the organization needs to consider in order to enable knowledge reuse?

In order to reuse knowledge, it is initially necessary to ensure that it is shared among the employees of the organization, so the factors influencing knowledge sharing are important to be considered. The hierarchy and heavy reliance on the senior engineers, that is also part of the organizational culture, constitute an individual factor influencing knowledge sharing, because the juniors demonstrate some hesitation in taking risks and a fear of taking the blame of actions; this is also connected to the underestimation of someone's own knowledge as the juniors over rely on the knowledge of the seniors. Another individual factor is the level of awareness and communication between the source and the recipient as the documentation, LL and the areas of improvement included there have no clear recipient. Lack of time is a further issue in the daily project work as most of the time of the engineers is devoted to the actual Product Development (PD) and the time left is not always enough for reflection, communication and sharing. The meetings do not provide time and space for reflection and sharing either due to a high focus on updates and quick decision making. An additional individual as well as organizational factor is the lack of sufficient management of past mistakes. The latter is necessary in order to foster

individual and organizational learning from mistakes as it is difficult to reach information from previous projects and the knowledge is not systematically reused.

As far as the organizational factors are concerned, the organizational culture has a crucial role to play as it can be both a facilitator but also a hinder. There is generally trust among the employees of the organization, but needs to be more encouraged for the juniors because of the high reliance on the seniors. Currently, this makes knowledge centralized in specific individuals and creates a one-way hierarchical knowledge flow. The perception of what type of knowledge is useful is at the moment restricted to the actual PD and technical issues, while other aspects, such as knowing how, when and why to reflect or how to learn, are sometimes less prioritized. The motivation for the employees is an important factor due to knowledge sharing being optional and people need to know its benefits and include it in their daily work and responsibilities. The same applies to the guidelines and education that the employees need in order to learn and understand their role in KM and organizational learning. Furthermore, the overall communication and interaction among staff is well fostered, but the interaction between different engineering departments is necessary to be more encouraged to ensure mutual understanding and increase efficiency.

The design of the working environment can affect teamwork when there are physical barriers among the employees as it is evident that co-location is more effective for the organization. In addition, having faith in the initial investment on KM creates several issues to deal with, as the expectations of the organization become very high for the short term, without the realization that KM focuses on the long term efficiency as well as continuous improvement and learning. Apart from this, the communication of the objectives and reasons why a KM initiative is an area of improvement as the employees need to become a part of it and the buy-in process will become faster.

For the technology, which is handled in an efficient way in the organization, an over reliance on it for knowledge sharing is the main factor affecting knowledge sharing. It jeopardizes the value of the tacit dimension of knowledge, which cannot be easily managed by using technology, while it is necessary to be one of the priorities in the perception of the employees.

7.3 RQ3: In what ways can an engineering checksheet be applicable for knowledge reuse at Rosemount Tank Radar?

The checksheet is a Lean tool for knowledge reuse that has been successfully used at Toyota and Volvo GTT as a reminder of things to do. It has been identified throughout this research that the checksheet is one of the appropriate tools that will support knowledge capture, share and reuse in this organization as well, if it is going to be used in a systematic and standardized way. Initially, the checksheet is a well-structured way to capture knowledge so that it can be reusable as it focuses on the actionable information that will serve as the foundation for the engineers in PD. It

is also a way to have product-specific knowledge available for the whole organization and to summarize this in order to avoid going through the extensive documentation. The overall project documentation and the checksheet are complement to each other, but following the rule of “less is more”, the checksheet is more suitable for knowledge reuse than other documentation. This is due to a probability of reaching a higher level of internalization, as the checksheet is easy to understand and read but also easy to grasp important aspects to consider. In addition, it contains actionable information that the recipient can make use of in the daily work.

The checksheet is also a good way to externalize, meaning transforming tacit to more explicit knowledge; hence, it can balance the heavy reliance on the senior engineers, as part of their knowledge will become organizational from individual. Furthermore, it can foster knowledge sharing and also lead to knowledge ownership by the recipient, as it is mostly based on the tacit knowledge of the seniors that needs to be transferred to juniors. If workshops are used for the generation of checksheets including many employees, the workshops per se can contribute to knowledge sharing and trigger discussion and interaction between employees. In an organization that needs to reuse what has been learnt in development projects, the checksheet can serve as a way of capturing and sharing the knowledge acquired between different project teams.

In order for it to be reusable, it should also be integrated into the NPD model. If it is integrated in the deliverables of the NPD model, it can serve as an assurance that learning from previous projects is being taken into consideration, avoiding making same mistakes as before. Lastly, using the checksheet for project planning can be possible due to easier estimations of time and resources required for developing a component or product when it is known what needs to be considered.

7.4 Contribution to the research field

This study has contributed to the research field of KM by identifying in what kind of ways project acquired knowledge can be reused in a NPD organization. Along with this, previous research has been confirmed in regards to barriers hindering knowledge flow as well as what factors are important to consider in order to have a successful KM implementation. Furthermore, as the research on engineering checksheets is not yet very extensive, the authors are inclined to believe that the conclusions about the ways a checksheet can be applicable in product development organizations have contributed to the field. As the research in practical tools for knowledge reuse and more specifically tools for capturing and reusing tacit knowledge, is not very extensive, the findings about the applicability of the checksheet as a tool can contribute to further research within the field.

8. Recommended actions

This chapter includes a more concrete and detailed presentation of the recommended actions for the organization based on the analysis, discussion and conclusions. The recommendations mainly consider actionable ways to ensure knowledge reuse as well as knowledge share. The section is divided into three parts. The first part is actions that can be taken immediately. The second part is actions that need some more investigation and activities to support them, and the last part includes actions that need to be taken to support the long-term success of the Knowledge Management initiative.

The recommended actions in this section include references to the theory, empirical findings and analysis/discussion to make the reader able to go back and bear in mind the reasons why specific actions are recommended. However, to get a full understanding of why these actions are recommended, it is suggested to read through the report as a whole because all the sections are connected to each other and complementarily contribute to the results of this study.

8.1 Actions possible to take directly

- Integrate reflections in various gates of the NPD model

It is advised for RTR to reflect more frequently during the New Product Development (NPD), because having the Lessons Learnt (LL) only in the end makes it hard for people to recall what was happening during the whole project, especially when it is a long-lasting one, and valuable knowledge may not be captured. These reflections will also support the generation of the checksheet as they include valuable information that can be added to it. It is advised to have reflections as a deliverable for each gate in the NPD model unless the project is very small in which case reflections can be done less frequently, but preferably not only in the end.

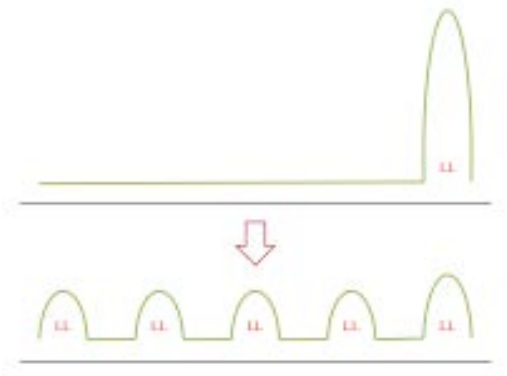

Figure 17 Illustration of Lessons Learnt transition

References: Theory p. 32, Empirical findings p. 52, Analysis/discussion p. 80

- Introduce Lessons Learnt review in the beginning of new projects

The organization should make sure that the LL are introduced in the beginning of every project to make sure that people go through them and get an understanding of what has been done before to have a guidance on how to avoid doing the same mistakes. Having the review of the LL as a

deliverable in one of the first gates or in a pre-study prior to a project is advised to make sure that this actually happens.

References: Theory p. 32, Empirical findings p. 52, Analysis/discussion p. 80

- Include the recipient of the document and the improvement areas in the Lessons Learnt.

It advised to include in every LL document the potential recipients when they are known in order to make sure that they will go through the document and reuse the knowledge included there. Furthermore, the areas of improvement that are identified during the LL session should be followed by activities and action plans to secure that they lead to concrete and actual improvements. Then, these activities and actions plans need to be assigned to specific people or groups of people that will be responsible for making them happen.

References: Theory p. 32, Empirical findings p. 52, Analysis/discussion p. 80

- Enable communication and social interaction through competence databases and co-location

Whatever tools and mechanisms the organization is implementing, knowledge share and reuse is difficult to happen without having communication, social interactions and an open environment for the employees to share their opinion. The organization should make sure it fosters communication and interaction among the employees and especially between senior and junior engineers. Having competence databases that will include all the employees of the organization, their experiences, the projects that they have participated in, the products they have developed and their general knowledge and expertise within the field can also foster interaction. This will make employees, especially juniors or newly hired, to be able to talk to the appropriate people when the need information and knowledge on a specific issue. Asking employees for their competences and having them rate their competence can be done in order to create the database. Having employees rate each other's competence could also be a way. Furthermore, co-locating the employees in order to have them working together in project teams is proven to be working for the communication and efficiency of Product Development, considering the Eagle project as an example, so the organization is advised to keep doing that for all the projects. This should be mainly considered when the company moves to the new facilities where they will have an environment with no physical barriers between the employees. It could be good to create project areas to ease the co-location.

References: Co-location Theory p. 27, Analysis/discussion p. 75
Competence database Theory p. 29, Empirical findings p. 53

8.2 Actions needing supporting activities

- Start using engineering checksheets for knowledge capture and reuse

As the engineering checksheet is applicable in the case of RTR, it is advised to try using checksheets in an upcoming project. In order to do it, the initiative should start with assigning someone to facilitate the overall Knowledge Management (KM) work at the company. This person should get some training in KM and creation of engineering checksheets, for example structured interviewing techniques, by some external KM coach. Also, assigning the role of Knowledge Owner is necessary, but it is up to the management to decide who should be the owner of what component/process/product/function. Moreover, choosing some specific components or products as checksheet pilots and use them immediately in an upcoming project in order to be able to evaluate the usability in the daily work of the engineers. Initially, developing the checksheets will require some time and effort, but the long-term benefits of having a structured way of capturing the knowledge will most likely outweigh it. Furthermore, there will be a need of maintenance, however, the fact that creation of new knowledge that is suitable to include in the checksheets is not developed in a very rapid pace, the workload of the knowledge owner will not be as high as it may be perceived. Lastly, in order to secure that the knowledge captured is reused, it is of importance that the usage of the checksheet is integrated in the NPD process.

References: Theory p. 34, Empirical findings p. 61, Analysis/discussion p. 83

- Start having mentors for the junior engineers

Mentoring is an appropriate way to decrease the knowledge gap between seniors and juniors, and enhance knowledge transfer. It is the authors' firm belief that there are ways of mentoring that do not require being in the form of a specific mentoring program, even though it would be advised. As the seniors are often assigned to different projects, they can at the same time be assigned as mentors for one or a few juniors within the particular project, making it an integrated duty in the project work. Having the senior acting as a teacher, setting goals and giving assignments to the juniors can be a general way of mentoring. Also, if there is co-location, this should not lead to a much higher workload for the seniors.

References: Theory p. 32, Analysis/discussion p. 82

- Create a community of expertise by using the senior engineers

Nowadays, the senior engineers are mostly assigned to specific projects for which they have the main responsibility. It is advised though to have the senior engineers as a community of expertise and not assign them to a particular project. In this way, they will be available for the junior or

less experienced engineers as mentors or people who provide advice and expertise. They can allocate their time in a way that they can be available for specific parts of the projects where their knowledge is really necessary, while devoting time to communication with the other engineers and share their knowledge.

- Consider to start using A3 reports

The A3 reports can be a useful tool for the engineers at the organization as a more systematic way of solving problems and simultaneously creating more knowledge to capture in a storytelling way. However, as the lack of time is an issue and the fact that no organization should start using many tools at the same time due to the time needed to adapt and ensure that they are used successfully, it is not advised to start using it right away. It could therefore be something to keep in mind for the future and something that could become an integrated part in the daily work, as the long-term benefits are probably high and worth the initial time and effort. What is more, the A3 reports can also be an additional source of information and knowledge to include in the checksheet for later reuse.

References: Theory p. 33, Analysis/discussion p. 82

8.3 Actions ensuring long-term success of the initiative

- Communicate the objective of the Knowledge Management initiative to the whole organization

It is advised to communicate to the employees the value, objectives and reasons why a KM initiative is necessary for the organization in order to make them feel a part of it, motivate them and make sure that they perceive it as something important that deserves some of their time. The same applies to the value of the reflections, LL, checksheets or any other tool that the company will use in the future, to secure that it is used in a successful way and all the users understand how to handle it. This can be done through presentations or seminars within the organization, led by an internal or external KM coach.

References: Theory p. 26, Analysis/discussion p. 74

- Obtain and maintain a source and recipient thinking

Being aware of the source and recipient of knowledge in every document is crucial. When the recipient is known, it should be clearly stated to make sure that the document will be reused by the appropriate people. The source of knowledge should always be stated to enable a future user to know who to talk to for additional information or guidance. Awareness of the source and the

recipient of knowledge will foster communication between them, which is important to enrich verbal explanations and discussions, as it is not always possible to get full understanding from a document.

References: Theory p. 20, Analysis/discussion p. 68

- Establish a well-managed database

The on-going transfer of project documentation from Doctor to SharePoint will solve some of the issues connected to need of having a well designed database and reach product-specific information. However, no matter what solution is chosen or even if additional databases are created, the organization needs to make sure that whatever is being stored has a purpose. Making sure that what is stored is actionable information, i.e. knowledge, or at least can lead to the recipient developing knowledge based on it, is crucial in order to secure that the documentation and the database is well-functioning. This could be done by having a sort of validation of documents and their content, maybe by senior engineers, but the essence is to ensure that what is documented can be reused.

References: Theory p. 34, Analysis/discussion p. 83

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10. Appendices

10.1 Appendix A: Interview Guidelines

Introduction

- Introducing the interviewers and the project
- Brief description of the interviewee about the position in the company and role in the projects
- Recording permission
- Anonymity

Current situation

1. How similar are the projects that you do?
2. Are you aware of the concept of Knowledge Management and what it means?
3. Do you have any guidelines when you are starting a project?
   - Design guidelines or process guidelines?
4. Are there any ways of reaching information from previous projects that you might need?
5. How does the process of capturing the knowledge look like right now?
   - Are there any tools used?
6. When are people reflecting upon the project?
   - Who is doing it and are there any defined roles for that?
7. How much time do they use for capturing the knowledge and create the lessons learnt? - How do you think it is working?
8. Do you have ways of utilizing the knowledge that has been created in any way?
   -Is it introduced sometime during a new project?
9. How would you act to solve a problem that arises?
   -Would you prefer dealing with the problem as it occurs or look for previous solutions and lessons learnt?
   -When a team comes across a problem, how do people usually solve it?
10. Are there any opportunities for employees to discuss and share knowledge acquired from the projects?
11. Do you have opportunities to share your opinion?
    -Are people interested and open to share?
    -In your opinion, what may be the reasons why people don't share their knowledge with others?
12. Do you feel that there are some obstacles for knowledge sharing?

Defining the problem

13. Do you know any problems that are often recurring in many projects?
14. How would you define the problem of knowledge transfer in the organization?
15. What do you think is the main problem for not utilizing the knowledge?
    -Are there any other problems or barriers that are in the way?

Preferred state

16. What do you think are the benefits of sharing the knowledge in the individual, team and organizational perspective?
17. What type of knowledge do you want to transfer?
    - Can it be written or does it stay in peoples mind?
18. What can be a motivation for the employee to try to utilize the knowledge?
19. If you are the source of knowledge, how would you prefer to distribute and share it?
20. If you are the recipient of knowledge, how would you like to receive it?
21. What is required for you in order to make a good job?
    -What do you need to know?
22. In what way do you think that the knowledge created can be utilized?