Learning Lessons within Risk Management in Construction Projects

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This thesis was written in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

in Construction Management & Engineering

at the Delft University of Technology

Commissioned by

Ingenieursbureau Amsterdam

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"Those who cannot remember the past are condemned to repeat it"

George Santayana, 1905

Acknowledgements

In the context of my Master of Science in Construction Management and Engineering (CME) at the Faculty of Civil Engineering and Geosciences, at the Delft University of Technology, I conducted this research as my final graduation project. In January 2019, I started orienting on a research topic and everything went in a rapid pace from thereon. During the last nine months of being a student I can genuinely say that I have enjoyed the journey and that I am happy with the results of my research.

The end result of my thesis would not have been achieved without the contribution of my graduation committee and I would like to take the opportunity to thank everybody that has contributed to the process of conducting this research. Firstly, I would like extend my deepest gratitude to my daily supervisors Erfan Hoseini and Joyce van Tellingen for sharing their knowledge on risk management and their guidance from the beginning to the end of my research. Secondly, I would like to sincerely thank Marcel Hertogh and Jan Anne Annema for their valuable insights, criticism and sharing their own experiences during the meetings. I have experienced the meetings as very valuable to make my research more understandable and for me to be able to take a step back, so that I could consider what direction I should be heading in. Thirdly, I would like to thank Sjoerd Blokpoel for the opportunity to conduct my research within the Municipality of Amsterdam and all of the interviewees that have gone out of their way to share their experiences and knowledge with me. I enjoyed conducting all interviews and I was surprised by the interest and enthusiasm that was shown for this research.

I would like to thank my close friends and my girlfriend for their support during the last few months as well as providing happy distraction to rest my mind outside of my research. Most importantly, I would like to thank my parents for providing me with this opportunity and everything they have done for me over the years. This one was for you!

Alexander Janetzky
Amsterdam, October 2019

Summary

Introduction, objective and research questions

Every construction project has risks (Beltrão & Carvalho, 2019) and ineffective risk management can lead to a project's failure (Eaton, Dikmen, & Akbiyikli, 2016). The construction sector has rather poorly developed organisational learning capabilities (Styhre, Josephson, & Knauseder, 2004) and this results in lessons not being learned and applied in future projects. Lessons learned form the intellectual assets of an organisation and can help to reduce project risks (Carrillo, Ruikar, & Fuller, 2013). However, no lessons learned process has yet been developed for risk management. Furthermore, lessons learned processes can be ineffective because other variables can facilitate or hinder an organisation's ability to learn lessons (Duffield & Whitty, 2012). Facilitators positively influence organisational learning and barriers influence it negatively. The objective of the research is *to study how the facilitators and barriers can influence learning lessons in an organisation and to develop a lessons learned process for risk management.* The Ingenieursbureau is a public organisation that executes construction projects for the municipality of Amsterdam and has addressed their interest in learning lessons within risk management. Therefore, this research will be conducted within the Ingenieursbureau. The research question that has to be answered to reach the research objective is:

How can the lessons learned of risk management be collected and applied in future construction projects?

To be able to reach the objective and answer the research question, the following sub-questions have been derived:

Sub-question 1:	What are facilitators and barriers of an organisation to learn lessons within projects?
Sub-question 2:	What are the facilitators and barriers of the Ingenieursbureau to learn lessons within projects?
Sub-question 3:	How can lessons be learned in projects?
Sub-question 4:	How can lessons be learned in risk management?

Methodology

The research that is presented has been divided into two main parts. The first part focuses on *studying how the facilitators and barriers can influence learning lessons in an organisation.* A literature study will be conducted to identify variables and these will be validated by discussing them with risk managers. These will be used to create a questionnaire and the answers will be discussed during interviews. Thereafter, the results can be used to determine the facilitators and the barriers of the Ingenieursbureau. The second part of this research focuses on *developing a lessons learned process for risk management* A literature study will be conducted to identify the lessons learned process for projects and this will be used to develop a process for risk management. This will be done by discussing it in two expert sessions and nine interviews, and by testing it during three project reviews. After each step, the process will be reviewed and improved before validating it in the next step.

Facilitators and barriers

Sub-question 1 is *what are facilitators and barriers of an organisation to learn lessons within projects?* To answer this question, a literature study has been conducted to identify variables and the Systemic lessons learned knowledge (Syllk) model has been used to categorise them. The Syllk-model has been used because no other models conceptualise how facilitators and barriers influence organisational learning. The first Syllk-category is *people* and focuses on the employees of an organisation. It is divided into the layers *learning*, *culture* and *social*. The second Syllk-category is *Systems* and focuses on the systems that are required to support employees in learning. The layers are *technology*, *process* and *infrastructure*.

Sub-question 2 is *what are the facilitators and barriers of the Ingenieursbureau to learn lessons within projects?* The results of this research show that of the 30 variables that have been identified in the literature study, 19 of these have been identified as possible barriers for the Ingenieursbureau. An overview of the results is shown in Table 1. According to the studied literature, the Syllk-category *people* is considered to have a greater influence on an organisation learning lessons than the systems category. Therefore, the results are positive for the Ingenieursbureau because this category contained 8 facilitators. The Syllk-category *systems* only contains 3 facilitators and the other 12 variables were considered as barriers. The layer *process* only has barriers because the Ingenieursbureau does not have a lessons learned process. The layer *technology* has four barriers but it is not expected that these will severely hinder organisational learning.

Table 1: Facilitators and barriers within the Ingenieursbureau (own table)

Layer	**Facilitators and barriers within the Ingenieursbureau**
Learning (People)	Insufficient workshops and training provided (B) Employees are willing to learn (F) Insufficient stimulation to share information (B) Employees are willing to share information (F) Unstressed working environment (F)
Culture (People)	Lack of support from higher management (B) Lack of positive feedback from colleagues (B) Colleagues accept each other (F) Lack of accepting mistakes from colleagues (B) Employees feel comfortable to speak freely (F)
Social (People)	Insufficient collaboration within teams (B) Reliable colleagues (F) Approachable colleagues (F) Social contact during work (F) Lack of social contact outside of work (B)
Technology (Systems)	Slow and inefficient systems (B) Unreliable systems (B) Systems are difficult to use (B) Clear overview of systems (F) Insufficient interconnection between systems (B)
Process (Systems)	Unclear process and not well understood (B) Guidelines of process are not well documented (B) Insufficient training how to execute process (B) Outcome of process is unclear (B) Inflexible process (B)
Infrastructure (Systems)	Unpleasant physical working space (B) Open door policy (F) Short geographical distances (F) Insufficient availability of training facilities and meeting rooms (B) Unclean facilities (B)

Lessons learned process for projects

Sub-question 3 is *how can lessons be learned in projects?* The steps of existing lessons learned processes are not consistent and therefore the steps of 18 different processes have been reviewed and compared. The results have been used to design a framework (Figure 1) and to answer the sub-question. The framework shows that the lessons learned can be applied in *the project start-up (1)* of future projects. Once the *project has been executed (2)*, *new lessons learned can be collected (3)* by executing five sub-steps. Thereafter, the lessons learned need to be *documented (4)* and *verified (5)*. From thereon, the lessons learned can be *validated (6)* and *implemented (7)* within the organisation. The last steps are to *store (8)* the lessons learned in databases and *disseminate (9)* the lessons learned to employees. Thereafter, the existing lessons learned can be applied in future projects during the *start-up of a project (1)*.

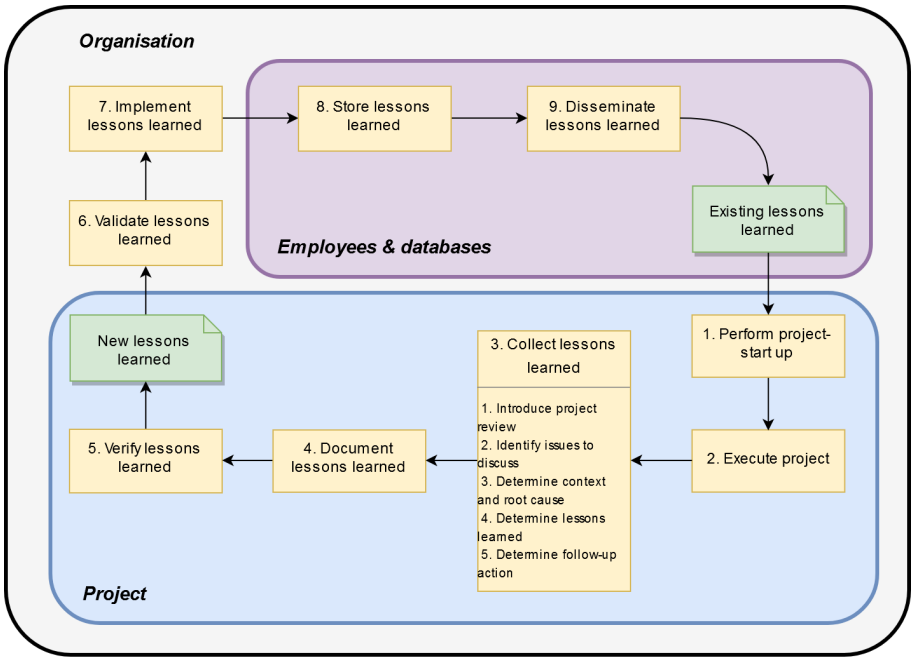

Figure 1: Lessons learned framework for projects (own illustration)

Lessons learned process for risk management

Sub-question 4 is *how can lessons be learned in risk management?* To answer this question, the lessons learned process for projects (Figure 1) has been used as input to develop a lessons learned process for risk management. The results of sub-question 4 show that four steps should be taken and this has been combined with the risk management method RISMAN to design a framework (Figure 2). RISMAN is a common risk management method that is applied within construction projects in the Netherlands (Augustijn, 2006; Kuipers, 2016) and it the method that is applied by the Ingenieursbureau. The first step is *to hold the start-up or follow-up (1)*, the second *to execute risk management (2)*, the third *to review the project (3)*, the fourth *to document and verify the lessons learned (4)*, and lastly *to store and disseminated the lessons learned (5)*. Thereafter, existing lessons learned can be applied in new projects by discussing them during the first step in *the project start or follow-up (1)*. More elaboration on the steps is given in the next section where the main research question is answered.

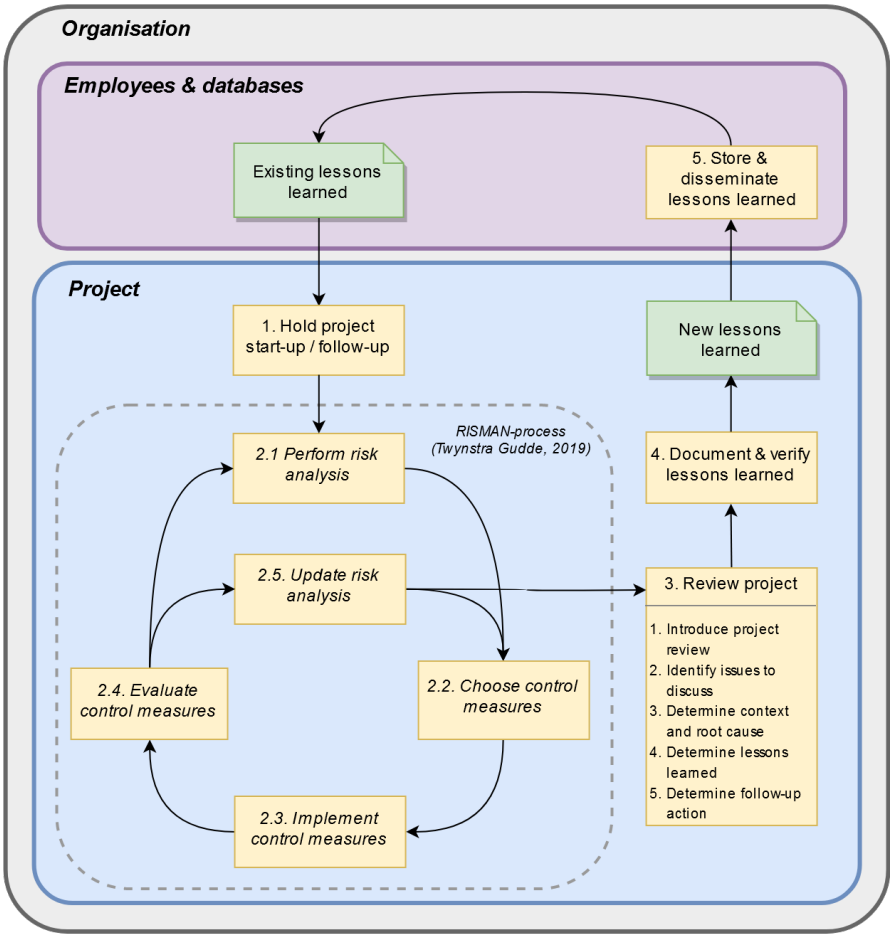

Figure 2: Lessons learned framework for risk management (own illustration)

Answer to main research question

This research is the first to develop a lessons learned process for risk management and is also the first to study and determine the interaction of facilitators and barriers with the lessons learned processes. This research focused on filling these gaps in the known scientific literature. This has been done by combining these separate theories into a framework (Figure 3) to address the practical problems that organisations in the construction sector encounter and to answer the main research question: *how can the lessons learned of risk management be collected and applied in future construction projects?*

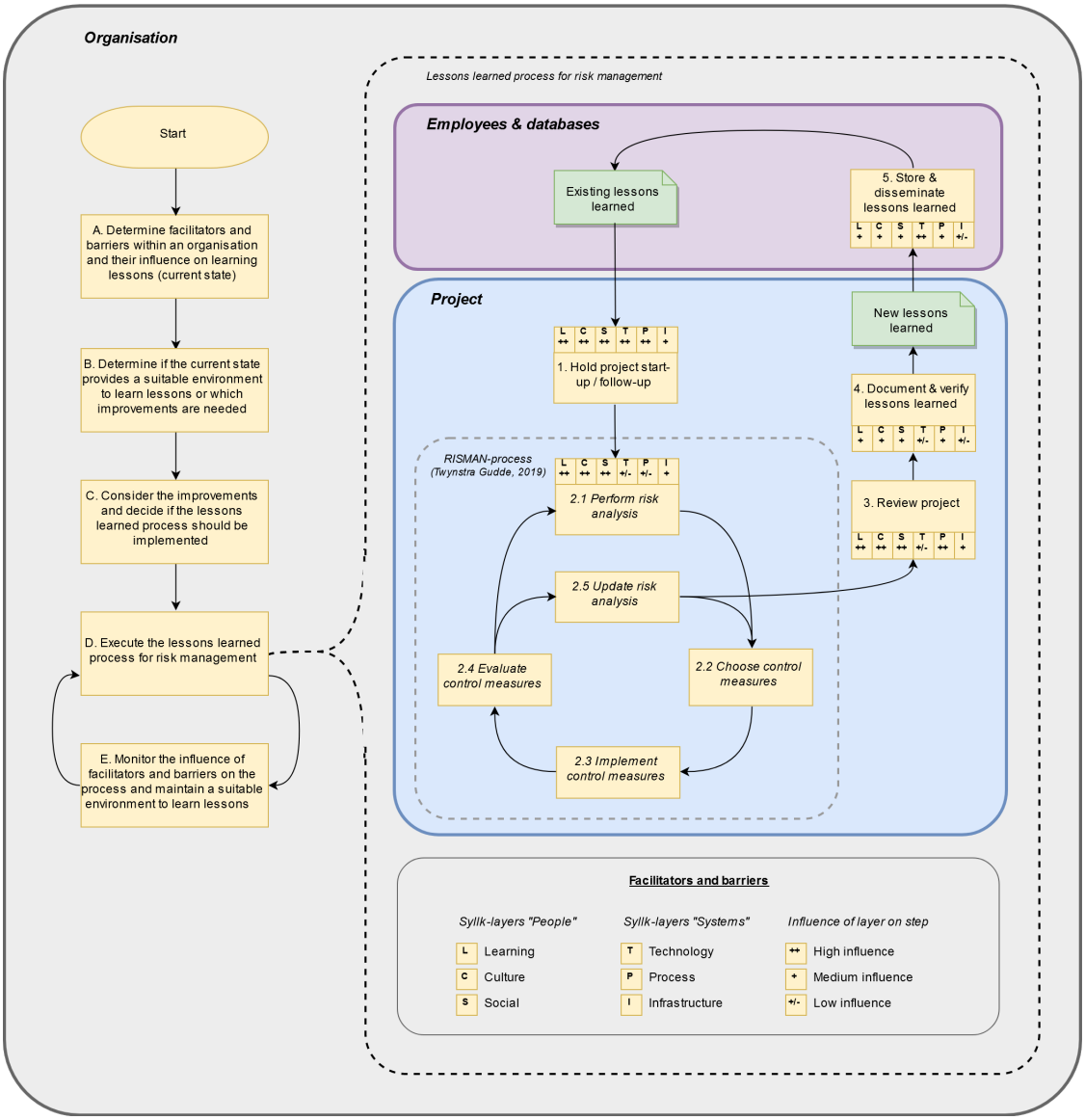

Figure 3: Final lessons learned framework for risk management (own illustration)

The framework (Figure 3) shows the starting position followed by five steps (A-E) on the left that represent the steps that need to be taken within the organisation before and after implementation of the lessons learned process. The lessons learned process itself is shown in Step D and further detail on the process is shown within the dotted lines. A legend for the interaction of facilitators and barriers within the process is shown at the bottom. Step A shows that the first step is to determine what the facilitators and barriers are within an organisation. Thereafter, it should be determined how they influence learning within the organisation. Step B shows that these insights should be used to determine if the current state of the organisation is suitable and provides sufficient support to learn lessons. If this is not the case, it should be determined which improvements are needed to create this.

Thereafter, in Step C the consideration can be made to determine if the improvements are achievable to ensure the suitable environment and the decision can be made to implement the lessons learned process. If the process is implemented, the process can be executed (Step D). The results of this research showed that the process is capable of collecting lessons learned and the risk managers of the Ingenieursbureau perceived it as valuable. This continuous interaction between the process the facilitators should continuously be monitored (Step E) to ensure a suitable environment.

Recommendations for the Ingenieursbureau

Based on the results of this research it is recommended to implement the process. However, to implement to process successfully it is highly recommended to make the following two improvements.

1. The higher management should monitor if the process is executed uniformly and according to the guidelines.
2. A user-friendly database should be developed to store and retrieve lessons learned on.

Based on the results of this research it is recommended take the following five improvements into account.

1. Employees should attend more workshops to increase the sharing of tacit knowledge.
2. The stimulation to share information within the organisation should be increased.
3. The focus within projects should not only lie on achievements but also on the mistakes.
4. The impact of the computer systems on the learning should be determined so that improving them can be considered.
5. The availability of meeting rooms should be improved.

Contribution of the research

- This research was the first to develop a method to determine the facilitators and barriers within an organisation by applying the Syllk-model.
- This research was the first to develop a lessons learned process for risk management.
- This research was the first to study the interaction between the facilitators and barriers with the lessons learned process.

Limitations of the research

- The lessons process has only been tested in three project reviews, the projects were all executed within the city of Amsterdam, and the projects were all executed by the Ingenieursbureau.
- To determine the facilitators and barriers of another organisation the research will have to be conducted again.
- The facilitators and barriers have been validated with the risk managers but it was unclear if the risk managers had full understanding of the Syllk-model, the group was limited and not diverse because the group consisted of four risk managers.
- To determine the score of the facilitators and barriers an assumption has been made but making another assumption would have influenced the results.
- The interviews have only been conducted with nine employees of the Ingenieursbureau
- The impact of variables cannot be easily compared because the influence of some variables is greater than others.

Recommendations for further research

- Validate and monitor the process further within the Ingenieursbureau.
- Validated the further in other organisations, a (large) contractor for instance.
- Develop a method to determine the effect of a control measure on a risk.
- Further study the influence of the facilitators and barriers on the steps in the lessons learned process.
- Improve the method to determine facilitators and barriers within an organisation.
- Improve the process by developing extra steps to compare multiple projects to each other to learn additional lessons.

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Research strategy

1 Introduction

1.1 Context

Every construction project has risks due to the complex environment, such as the involvement of various public and private stakeholders, technological demands and large investments (Eaton et al., 2016; Beltrão & Carvalho, 2019). According to Mustafa and Al-Bahar (1991), typical risks that are present in every construction project are uncertain weather conditions, subcontractor failure and different site conditions. Risks in projects cannot be eliminated (Burchett, Tummala, & Leung, 1999) and therefore risk management is essential to ensure that the numerous risks have minimal negative effect on the project's objectives (Rahman, 2018). Effective risk management can help to reduce, absorb and transfer risk, and exploit potential opportunities (Liu, Flanagan, & Li, 2003). Risk management is crucial for a project's success and in contrast, poor and ineffective risk management can lead to a project's failure (Eaton et al., 2016). The risk management process has been divided into risk identification, risk analysis and risk response (Berkeley, Humphreys, & Thomas, 1991; Flanagan & Norman, 1993; Govan & Damnjanovic, 2016) and according to Ghaffari (2013), additional steps are reviewing and learning. However, no process has been defined within risk management to review and learn from projects.

Lessons learned can be defined as knowledge gained from successful, or unsuccessful experiences that can be used for improving future performance (Paranagamage, Carrillo, Ruikar, & Fuller, 2012; Fong & Yip, 2013). Lessons learned can help to reduce project risks because they form the intellectual assets of an organisation (Carrillo et al., 2013) and can be applied in future projects (Schindler & Eppler, 2003; Howard & Smith, 2016). According to Berke (2001), "lessons learned are the building blocks of organisational learning and organisational knowledge". With a long term perspective, effective knowledge transfer after the completion of projects might lead to the development of a sustainable competitive advantage if applied properly (Nonaka, Toyama, & Konno, 2000; Von Zedtwitz, 2002; Schindler & Eppler, 2003; Carrillo et al., 2013). In contrast, the failure to learn lessons and manage knowledge efficiently means that crucial insights that have been gained during the project are likely to disperse after completion of the project and therefore cannot be applied within future projects (Aerts, Dooms, & Haezendonck, 2017). This can cause unnecessary reinventions, errors and time wastage which may result into rework. Rework is one of the primary factors that contributes towards the poor performance and productivity in the construction industry (Wiewiora, Trigunarsyah, Murphy, & Liang, 2009) and according to Li and Taylor (2014), rework could increase construction costs by 10% to 15% of the contract price if it occurs in the construction phase. The construction sector has rather poorly developed organisational learning capabilities (Styhre et al., 2004) and the construction sector can benefit from a clear lessons learned process for risk management.

1.2 Problem

Reviewing and learning lessons from previous projects is uncommon in project-based organisations (Newell, Bresnen, Edelman, Scarbrough, & Swan, 2006) despite that projects create a suitable environment to gain valuable experiences that can be applied in future projects (Wiewiora et al., 2009; Pemsel,

Wiewiora, Müller, Aubry, & Brown, 2014). Furthermore, the unique characteristics of projects, such as the temporary and inter-disciplinary nature (Packendorff, 1995), the limited time and resources, the pressure, the complexity and new team composition (Schindler & Eppler, 2003), seem to prevent the transfer of knowledge. This is because the project team moves on after the project has been complete and the knowledge is likely to disperse (Bakker, Cambré, Korlaar, & Raab, 2011; Lindner & Wald, 2011; Pemsel et al., 2014; Almeida & Soares, 2014; Howard & Smith, 2016). After a project is completed and a new project starts, the process is rather reinvented instead of using the lessons learned from previous projects (Nelson & Winter, 1983; Wiewiora et al., 2009). According to Hertogh, Baker, Staal-Ong, and Westerveld (2008), a reason is "project teams relish the challenge in tackling problems which are new to their experience, rather than researching solutions from elsewhere." Furthermore, it is hard to identify, adopt and implement lessons learned into project-based organisations (Williams, 2004; Darfeuille, 2017) and if lessons are learned, it is uncommon for employees to use them because the organisation often lacks structure to learn lessons (Hobday, 2002).

Learning will not occur unless a clear process has been defined within an organisation and attention is paid to collecting, storing and disseminating lessons learned (Williams, 2008). Pettiway and Lyytinen (2017) studied the application of lessons learned processes in organisations and concluded that it occurred that employees saw it as an obligatory part of project management and was conducted with limited energy. The information was not seen as valuable and recorded with no intention of future use. Lessons learned processes have failed to deliver and are ineffective because other variables can either facilitate or hinder an organisation's ability to learn lessons (Duffield & Whitty, 2012). An example of such a variable is *an employees willingness to learn.* If the employee is willing to learn, this variable will positively influence organisational learning and it can be seen as a facilitator. If the employee is not willing to learn this variable will negatively influence organisational learning and it can be seen as a barrier. There are several facilitators and barriers that can influence an organisation's ability to learn lessons and it is important to study these before recommending a process. This is because these insights are needed before the process can be implemented effectively and with support from the organisation.

1.3 Objective and research questions

The objective of the research in this report is *to study how the facilitators and barriers can influence learning lessons in an organisation and to develop a lessons learned process for risk management.* The Ingenieursbureau is a public organisation that executes construction projects in the city of Amsterdam for the municipality and has addressed their interest in learning lessons within risk management. This research will be conducted by studying the facilitators and the barriers within the Ingenieursbureau and the process will be developed in collaboration with the employees of the organisation. The research question that has to be answered to reach the research objective is:

How can the lessons learned of risk management be collected and applied in future construction projects?

To be able to reach the objective and answer the research question, the following sub-questions have been derived:

- Sub-question 1: What are facilitators and barriers of an organisation to learn lessons within projects?
- Sub-question 2: What are the facilitators and barriers of the Ingenieursbureau to learn lessons within projects?
- Sub-question 3: How can lessons be learned in projects?
- Sub-question 4: How can lessons be learned in risk management?

1.4 Scope

According to the International Organization for Standardization (ISO) 31000:2009, a risk can be defined as "the effect of uncertainty on objectives" (Olechowski, Oehmen, Seering, & Ben-Daya, 2016). A risk is a situation which occurs in the enterprise that can negatively (hazard) or positively (opportunity) affect business objectives (Ivascu & Cioca, 2014). Therefore, the main objectives of risk management are to increase the probability and impact of opportunities and decrease the probability and impact of hazards (Bowen, 2010). However, opportunities should be treated separately and differently than hazards because identifying and analysing opportunities requires a different approach (Staal-Ong, Kremers, Karlsson, & Baker, 2016). This is because hazard management focuses on treating and/or isolating the negative effects of risks that can negatively influence an organisation's objectives, while opportunity management focuses on searching for opportunities and/or possibilities that can contribute to generating new ways of development and revenue growth (Ivascu & Cioca, 2014). Therefore, this research will focus on risks as hazards and not on risks as opportunities.

In this research a lessons learned process will be developed for risk management, while analysing the facilitators and barriers of the organisation that can influence the ability of learning lessons in projects. The organisation creates the environment (the projects) and the abilities (facilitators and barriers) in which an organisation can learn lessons.

1.5 Outline

This report consists of 9 chapters including the introduction and an overview of this is shown in Figure 4. Chapter 2 is dedicated to the research method and it will be explained how the sub-questions will be answered and how they will contribute towards answering the main research question. In Chapter 3, sub-question 1 will be answered by discussing the theory on facilitators and barriers that can influence an organisations ability to learn and re-use lessons. Thereafter, sub-question 2 will be answered in Chapter 4 by applying the theory from Chapter 3 in practice and determining what facilitators and barriers of the Ingenieursbureau are. In Chapter 5, sub-question 3 will be answered by reviewing processes to learn lessons in projects and explaining the different steps. Chapter 6 is dedicated to the lessons learned process steps from Chapter 5 and will be discussed and tested in expert sessions, interviews and project reviews. In this chapter sub-questions 4 and 5 will be answered. Next, in Chapter 7 the conclusions for the research questions and recommendations will be made for the Ingenieursbureau and further research. Lastly, in Chapter 8 the discussion is provided by explaining the contribution and the limitations of the research.

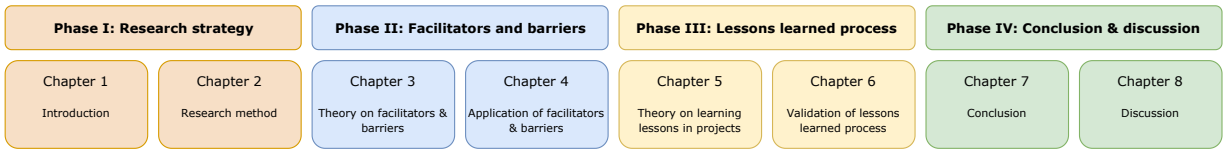


Figure 4: Research outline (own illustration)

2 Research method

In this chapter the research method is discussed and the steps that need to be executed. The research that is presented has been divided into two main parts and throughout this thesis they are addressed as Phase II and Phase III. Phase II focuses on the facilitators and barriers and Phase III focuses on the lessons learned process. The facilitators and barriers will be studied before the process will be developed because the process itself facilitates or hinders learning in an organisation. Therefore, the insights gained from how the process can facilitate and hinder learning can be used during the development of the process in Phase III. In Figure 5 an overview of the research method is shown and how both phases are divided into sub-phases and steps. In section 2.1 further elaboration is provided on Phase II and in section 2.2 on Phase III.

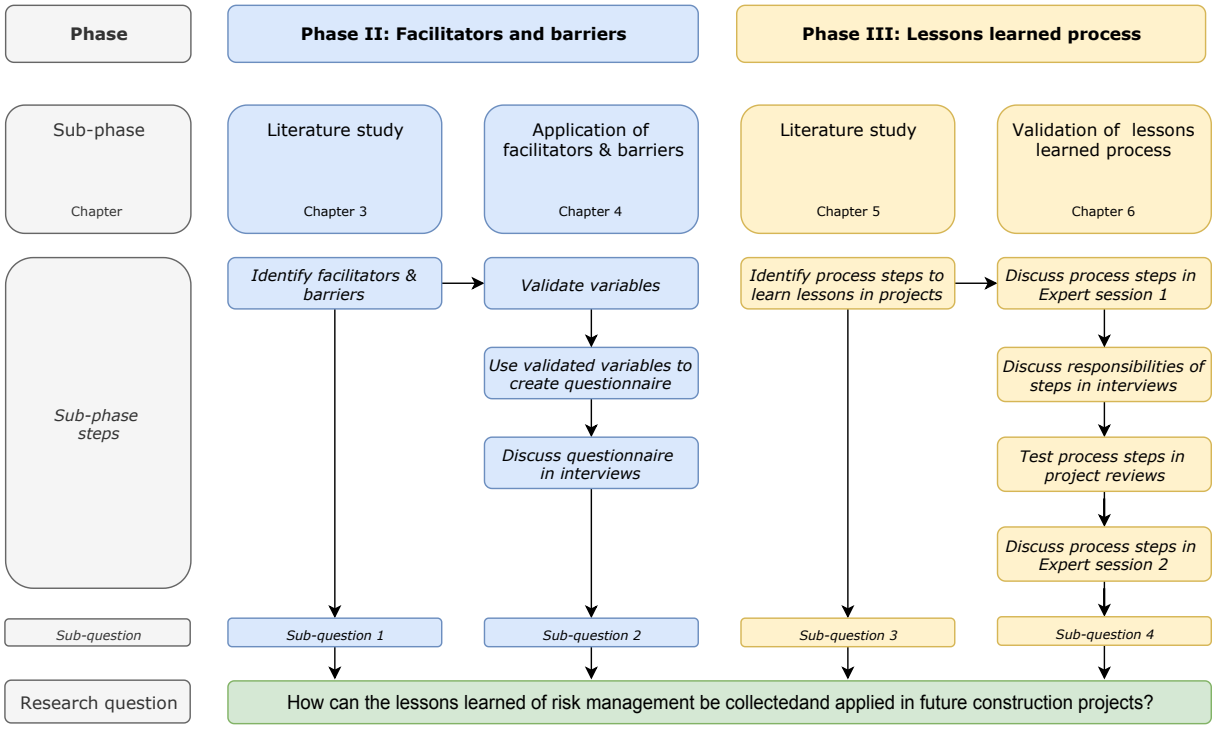


Figure 5: Research framework (own illustration)

2.1 Phase II: Facilitators and barriers

This phase focuses on the first part of the research objective and that is *to study how the facilitators and barriers can influence learning lessons in an organisation.* The phase has been divided into two sub-phases and the first will focus on the literature about the facilitators and barriers. The second sub-phase will focus on applying the literature to determine what the facilitators and barriers are within the Ingenieursbureau. The steps that will be executed in this phase are shown in Figure 6.

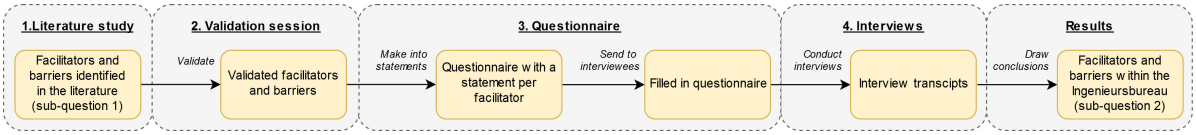


Figure 6: Methodology: application of the facilitators and barriers (own illustration)

2.1.1 Literature study

The objective of a literature study is to explore and discuss key published research. In this section the focus will lie on answering sub-question 1: *what are facilitators and barriers of an organisation to learn lessons within projects?* By gaining insights in these variables it may become clear how they affect learning and reusing lessons learned.

2.1.2 Application of facilitators and barriers

The objective of this section is to answer sub-question 2: *what are the facilitators and barriers of the Ingenieursbureau to learn lessons within projects?* To answer this question three main steps need to be executed and this is shown in Figure 6. The results of the literature study will be used as input for the first step and that is to validate the identified variables. Secondly, the validated variables will be used to create and send a questionnaire. Thirdly, the results of the questionnaire will be discussed in the interviews. The results of the three steps will be used to draw conclusions and determine the facilitators and barriers within the Ingenieursbureau.

Validate the facilitators and barriers
The first step is to validate the variables that have been identified in the literature study. According to Brace (2004), this should be done because they may not have been clearly been defined or are ambiguous and can therefore be interpreted wrongly. Furthermore, it is important to determine if the variables are applicable within the Ingenieursbureau. Therefore, a validation session will be organised with risk managers. During the session a presentation will be given on how facilitators and barriers can influence learning within an organisation. This will be done so that all the risk managers have a clear understanding of the theory. Thereafter, the variables that have been identified in the literature study will be presented and discussed. The risk managers can provide feedback and if wanted they can suggest other facilitators and barriers. The results of the session will be a list of validated facilitators and barriers that will be used in the next step.

Use the facilitators and barriers to create a questionnaire
The second step is to use the validated variables and create a questionnaire. Per variable a statement is made and this is explained with an example. For instance, the lessons learned process can facilitate or hinder learning within an organisation and multiple variables will be identified for the process. To determine if a variable facilitates or hinders learning in the Ingenieursbureau, the structure that is shown in Figure 7 on the following page can be used to create the statements. If the facilitator *understandable* is used, the statement could be: *The lessons learned process that is applied within the Ingenieursbureau is understandable.* Statements will be made for all the variables and thereafter the statements will be combined to create a questionnaire. The interviewees will be asked to fill in the questionnaire prior to the interviews so that the interviewees had time to review each statement prior to the interview.

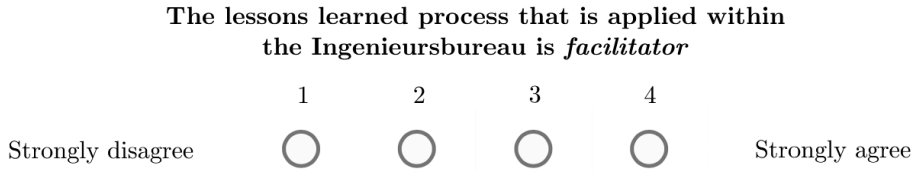


Figure 7: Example of structure used in statements for interviews (own illustration)

Each statement can be answered with strongly disagree (1), disagree (2), agree (3) and strongly agree (4). By using a 4-point Likert scale and not including an undecided option, this forces the interviewees to choose if they experience the variable as a facilitator or a barrier. An interviewee will score a statement with a 3 or a 4 if the interviewee experiences the variable as a facilitator. Therefore, the assumption is made that a variable can be seen as a facilitator if the average score is equal to a 3 or higher. If the average score is lower that a 3 the assumption is made that interviewees do not experience the variable as a facilitator and can therefore be seen as a barrier.

Discuss the facilitators and barriers in interviews
The third step is to conduct the interviews and this will be done with the project managers, project controllers and risk managers that work on the projects that will be reviewed in Phase III. Three projects will be reviewed and therefore a total of 9 interviews will be conducted. The interviews will be conducted with the same interviewees as in Phase III. During the interview the answers to the questionnaire will be discussed and the interviewee will be asked to elaborate on the answer per statement. Furthermore, if the interviewee experiences a variable as a barrier it can be asked what improvements are needed before this may be experienced as a facilitator. The results of the interviews will be used to answer sub-question 2: *what are the facilitators and barriers of the Ingenieursbureau to learn lessons within projects?*

2.2 Phase III: Lessons learned process

This phase focuses on the second part of the research objective and that is *to develop a lessons learned process for risk management*. The phase has been divided into two sub-phases and the first will focus on the literature about lessons learned processes for projects. The second sub-phase will focus on validating the literature to develop a lessons learned process for risk management. The steps that will be executed in this phase are shown in Figure 8.

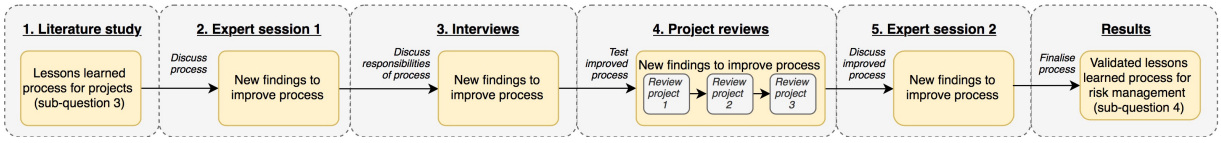


Figure 8: Methodology: validation of the lessons learned process (own illustration)

2.2.1 Literature study

The objective of a literature study is to explore and discuss key published research. In this section the literature study will focus on answering sub-question 3: *how can lessons be learned in projects?* By gaining insights in the different steps of the process to learn lessons in projects it may become clear what the essential process steps are for an organisation to learn and reuse lessons.

2.2.2 Validation of the lessons learned process

The objective of this section is to answer sub-question 4: *how can lessons be learned in risk management?* The question will be answered by validating the literature from sub-question 3 and the four main steps that need to be executed are shown in Figure 8. During each step, findings may be found and these will be used to improve the process before applying it in the next validation step. The first

step is to discuss the process with risk managers in Expert session 1 and the second is to discuss the responsibilities within the process during interviews with project managers, project controllers and risk managers. The third is to test the process in project reviews. The fourth step is to discuss the process in the Expert session 2 with risk managers. After the four validation steps, all the findings will be used to answer sub-question 4.

Discuss process in Expert session 1
The first step of validating the lessons learned process is to discuss the process during the first expert session with risk managers. Prior to the expert session, own adjustments will be made to the process to specify it towards risk management and this will be the input for the expert session. During the expert session a presentation will be given and firstly, the objective of the research will be explained, how the four validation steps will be executed, and what the goal of the expert session is. Secondly, an overview of the process steps will be shown each step explained briefly. Thirdly, each step will be explained in more depth by discussing the objective of the step, how the step should be executed, and what the possible risks are if the step is not executed correctly. After each step has been presented the risk managers will be asked for feedback on their general impression and on how they expect it will perform in practice. It is important that the risk managers look at each step with a critical eye because they have experience in facilitating risk sessions in practice. Therefore, their insights and judgement can result in valuable feedback. For instance, it is possible that the risk managers recognise certain problems within the suggested steps and can explain as to how and why this should be improved.

Discuss responsibilities in interviews
The second step of validating the lessons learned process is to discuss which project team member(s) should be responsible for which step. The interviews will be conducted with the project managers, project controllers and risks managers that work on the projects that will be reviewed in the next validation step. A total of three projects will be reviewed meaning that a total of 9 interviews will be conducted. The reason these roles have been chosen will be explained by elaborating on the five roles that are defined in the Ingenieursbureau's Integrated Project Management teams (Gemeente Amsterdam, 2013):

1. Project manager: The project manager is overall in charge during the project and responsible for the final result. The focus of the project manager lies on the quality of the project, schedule, and budget.
2. Project controller: The project controller has a central role within the project team and connects the project manager with the rest of the project team. Furthermore, the project controller is responsible for directing the risk management process. The risk manager supports the project controller in the risk management process by facilitating risk management sessions and is responsible for keeping the risk register up to date. If desired, the project controller can transfer responsibilities to a risk manager. Furthermore, the project controller is supported by the financial advisor and the planning advisor.
3. Environment manager: The environment manager is responsible for the contact with the stakeholders involved in the project. The environment manager keeps in contact with the inhabitants and companies when information is needed and to keep the stakeholders satisfied, and responsible for permits for instance.
4. Contract manager: The contract manager is responsible for setting up and monitoring the the contracts between the parties that are involved in the project.
5. Technical manager: The technical manager is responsible for the technical aspects of the project.

All five roles within the integrated project management team are responsible for risks within their role but due to the scope of this research, interviews cannot be conducted with all roles. Therefore, the interviews will be conducted with the project managers, project controllers and risk managers of the projects that will be reviewed. The project manager has been chosen because the project manager is responsible for the overall project result and will most likely have a broader view on the project. The

project controller has been chosen because the project controller is responsible for the risk management in the team, and has the meetings with the environment, contract and technical manager. The risk manager has been chosen because the risk manager works closely with the project controller and is responsible for keeping the risk register up to date.

Test process in project reviews
The third step of validating the lessons learned process is to test the process in project reviews with project team members. Prior to each project review, the available documents on the project will be analysed to create a global idea of the project and identify important events if possible. Furthermore, the risk registers are required to determine the identified risks and they often contain other risk related information such as the cause, event, consequence and control measure. According to Beyers, Braun, Marshall, and De Bruycker (2014), archival resources such as risk registers and other documents will not be sufficient to study because crucial information can be absent as to how and why certain issues are prioritised, and why or how individual interests have influenced these issues. Such insights can be essential to determine which lessons can be learned from the projects and therefore these will be retrieved during the project reviews.

The process will be tested in three project reviews and the findings of each review will be used to improve the process before applying it in the next project review. The focus of the project review is not only to improve the process but to test if the process is capable of collecting lessons learned. Table 2 shows that each project will be in a different project phase and each review will have a different project team composition present. The choice for the diversity has been made to increase the validity of the final process.

Table 2: Overview of the project team roles present per project review (own table)

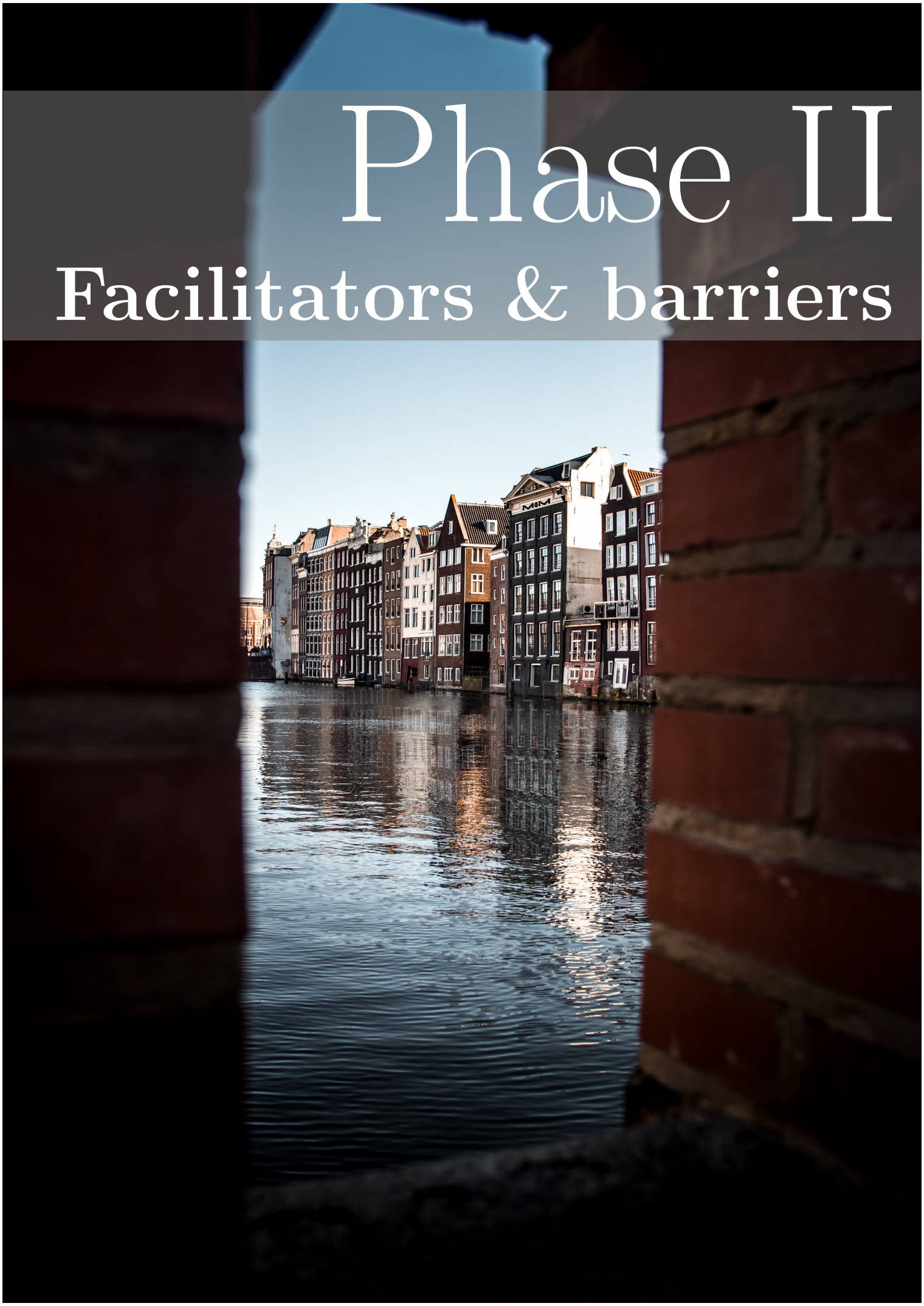
Project	**Project phase**	**Roles present**
Project A	Project completed	Project controller Risk manager
Project B	Construction completed	Project manager Technical manager Contract manager Assistant environment manager Financial advisor Supervisor (contractor) Foreman (contractor) Foreman (contractor)
Project C	Preparation completed	Project manager Project controller Technical manager Environment manager Contract manager Risk manager

Discuss process steps in Expert session 2
The fourth and final step of validating the lessons learned process is the second expert session with risk managers. Prior to the expert session, a concept version of the final process will be made and this will be the input for the expert session. During the expert session a presentation will be given and firstly the research objective and the goal of the expert session will be explained. It is important to explain that the findings of this validation step will result in the final process that will be recommended to the Ingenieursbureau. Secondly, an overview of the process steps will be shown and step will be briefly explained. Thirdly, each step will be explained in more depth by discussing the objective of the step, how the step should be executed, who should be responsible, and what the possible risks are if the

step is not executed correctly. After each step has been presented the risk managers will be asked for feedback on their general impression and on how they expect it will perform in practice. It is important that the risk managers look at each step with a critical eye because they have experience in facilitating risk sessions in practice. Therefore, their insights and judgement can result in valuable feedback. For instance, it is possible that the risk managers recognise certain problems within the suggested steps and can explain as to how and why this should be improved. The findings of the expert session will be used to develop a final process and answer sub-question 4: *how can lessons be learned in risk management?*

Phase II

Facilitators & barriers



3

Theory on facilitators & barriers

In this chapter the theory on facilitators and barriers that can influence organisational learning will be discussed. The facilitators and barriers need to be studied before a lessons learned process can be implemented (Duffield & Whitty, 2012) and in this research the Systemic lessons learned knowledge (Syllk) model developed by Duffield and Whitty (2012) will be used to study them. In section 3.1 the motivation why this model has been chosen and in section 3.2 an introduction to the model will be given. The two categories of the Syllk-model are *people* and *systems* and these will be discussed in in sections 3.3 and 3.4. Lastly, in section 3.5 sub-question 1 will be answered: *what are facilitators and barriers of an organisation to learn lessons within projects?*

3.1 Motivation for the Systemic lessons learned knowledge model

There is considerable amount of literature on learning lessons within organisations and addresses how it can be facilitated. However, the literature on *how* organisational learning impacts project management is limited (Duffield, 2017) and there are limited models that conceptualise what organisational learning is and how to implement it (Duffield & Whitty, 2014; Lambe, 2014). Therefore, the Systemic lessons learned knowledge[1] (Syllk) model was developed by Duffield and Whitty (2012). The model is shown in Figure 9 and it clearly shows how facilitators and barriers influence disseminating lessons learned from a project to the organisation and thereafter applying them again in future projects. The focus of the model lies on improving organisational project knowledge sharing to ensure that organisations apply lessons learned. Since the Syllk-model has been developed, no other models have been developed that show how facilitators and barriers influence learning lessons within organisations and no improvements to the Syllk-model have been made other than by the developers. Therefore, the choice has been made to use the Syllk-model in this research.

3.2 Introduction to the Systemic lessons learned knowledge model

The Syllk-model is based on "the Swiss cheese model" developed by Reason (1997). The Swiss cheese model shows that an error can occur if all the holes are lined up and a barrier did not prevent the error from occurring. Duffield and Whitty (2012) have broadened the Swiss cheese model beyond safety to meet the learning needs of project organisations. The relationship between the Syllk-model and the Swiss cheese model is that all the holes (facilitators) of the layers need to be aligned to effectively learn and apply lessons in an organisation, and impediments (barriers) can impact this negatively (Duffield & Whitty, 2012). This means that each layer has to facilitate learning, lessons in an organisation before the lesson learned in a project can be stored, and before the stored lesson can be applied in a

[1]Since Duffield and Whitty (2012) published their model, it has been adopted by the Norwegian Public Roads Administration and it has been used to support a digital lessons learned programme in Austria, Switzerland and Germany (Paver & Duffield, 2019).

future project. The layers represent "the various organisational systems or functions that collectively drive the overall behaviour of the organisation and hinder the dissemination and application of lessons learned between the project team and the organisation" (Duffield, 2017). As can be seen in Figure 9, Duffield and Whitty have defined two main categories that are both divided into three "layers", and furthermore each layer consists of several facilitators and barriers. The first Syllk-category is *people* and the layers are *learning*, *culture* and *social*. This is supported by the second Syllk-category *systems* and the layers are *technology*, *process* and *infrastructure* (Duffield, 2017).

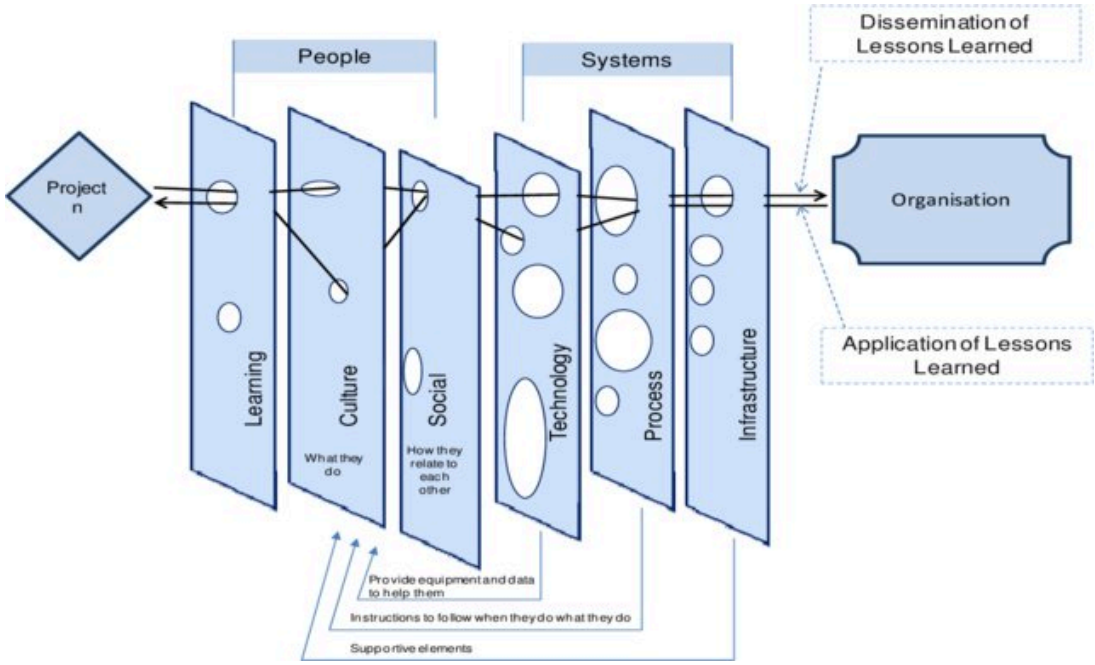


Figure 9: Systemic lessons learned knowledge model (Source: Duffield & Whitty, 2012)

Duffield and Whitty (2012) have applied the Syllk-model within different types organisations, including a public project-based organisation that executes infrastructure projects just as the Ingenieursbureau, to identify the possible facilitators and barriers by organising a brainstorming session with employees. However, the choice was made not to copy these identified variables because the validity of them is questioned. The first reason is the outcome of such a session can be very dependent on the group composition. The second reason is the variables may be specific for the organisation that it has been identified for. The third reason is multiple variables are not understandable or there is overlap between the variables. Therefore, an additional literature study towards facilitators and barriers has been conducted in this research to identify variables and the Syllk-model has been used to categorise them.

3.3 Facilitator and barrier category I: People

The first Syllk-category focuses on the people within the organisation. This category is seen as the most important category because it is most likely to have a greater influence on an organisation learning lessons in comparison to the systems category (Von Zedtwitz, 2002; Duffield & Whitty, 2012; Paranagamage et al., 2012). According to Maqsood (2006), the human contribution can be between 67 and 80% while the contribution of the systems can be between 20 and 33%. To elaborate on this, Lank (1997) states that "the organisations that are best at knowledge sharing are not necessarily those with the best technology infrastructure. But they do have a culture of teamwork and trust. If you have that culture and put in tools to help knowledge flow quickly around the organisation you have a hugely powerful combination." According to Hanisch, Lindner, Mueller, and Wald (2009) "even the best IT systems and methodologies for supporting the storage and dispersion of knowledge gained in

projects are useless if the employees resist using them." The three layers of the category are *learning*, *culture* and *social*, and the facilitators and barriers of each layer will discussed in this section[2].

3.3.1 Learning

The first layer represents employees learning in an organisation and Duhon and Elias (2007) define learning as "any increase in knowledge or skills that enable the learner to be more effective." Increasing this can be facilitated by the organisation and by employees. Firstly, the organisation can increase an employee's knowledge by providing *sufficient training and workshops*$_1$ (Duffield, 2016). Secondly, it is important that employees have commitment and are *willing to learn*$_2$ (Dressler & Palen, 2007). Employees should not only be committed to learn but should be committed to exchange knowledge within an organisation (Davenport, Long, & Beers, 1997; Ajmal & Koskinen, 2008). Again, this can be facilitated by the organisation and by employees. Firstly, the organisation should *stimulate sharing information*$_3$ (Paranagamage et al., 2012) because this positively effects the performance of knowledge transfer and the creation of knowledge (Syed-Ikhsan & Rowland, 2004; Duffield & Whitty, 2014). Secondly, employees are not always *willing to share information*$_4$ because they do not directly see the personal benefits of sharing knowledge (Schindler & Eppler, 2003; Ajmal & Koskinen, 2008). Project managers can influence this if they show and express their willingness to share information and solve an organisation's problems. Such an attitude can create an environment of trust, and influences the attitude throughout an organisation about knowledge sharing, collaboration, and employee participation (Goh, 2002).

In project-based organisations, project teams work under pressure and a *stressed working environment*$_5$ is considered an important barrier because time is limited (Schindler & Eppler, 2003; Williams, 2007; Julian, 2008; Wiewiora et al., 2009; Gerling, 2014; Shokri-Ghasabeh & Chileshe, 2014; A. Hartmann & Dorée, 2015; Howard & Smith, 2016). After a project is completed, project teams are often recruited as soon as possible for new projects (Ajmal & Koskinen, 2008) and this reduces the time and opportunities to review the completed project (Styhre et al., 2004). Another reason is that project team members often work on several projects and this reduces the time and opportunity to review the project (Bakker et al., 2011).

3.3.2 Culture

The second layer represents the culture within an organisation and Anantatmula (2010) defines this as "shared beliefs, values, and practices of a group or groups within the organisation." An organisational culture can strongly hinder or facilitate knowledge creation and transfer (Fairclough, 2002; Von Zedtwitz, 2002; Schindler & Eppler, 2003; Ajmal & Koskinen, 2008; Moud & Abbasnejad, 2009; Hanisch et al., 2009; Johansson, Moehler, & Vahidi, 2013). For example, according to Moud and Abbasnejad (2009) "a creative environment encourages employees to look for problems and solve them in order to help organization in its long term objectives." A reason is it empowers employees to reflect on their actions, consider how these actions can contribute to problems, recognise the necessity for change, and perceive their own roles in the change process (Senge, 1991). However, developing a learning culture within an organisation can be seen as a long-term process (Caldas, Gibson, Weerasooriya, & Yohe, 2009). The employees should have passion for the organisation's mission, know what needs to be improved and developed, and feel *supported by higher management*$_6$ (Duffield, 2016). Management can support this by creating a culture in which *colleagues accept each other*$_8$ (Duffield & Whitty, 2016b) so they feel safe and motivated to share their ideas with management and other colleagues (Nonaka et al., 2000). In other words, employees should feel *comfortable to speak freely*$_{10}$ and openly. It is important that successes are acknowledged and employees receive recognition for their work by *colleagues giving each other positive feedback*$_7$ (Duffield & Whitty, 2014). However, it is maybe even more important that employees feel comfortable enough to admit their own mistakes. This is because the fear of being criticised may result in employees not wanting to openly share

[2]A number is written after each facilitator and barrier that is discussed in the section and this corresponds to the numbers of the facilitators and barriers in Table 3. For example, $Facilitator_1$ in the section corresponds to Facilitator 1 in the table.

(Duffield, 2016; Julian, 2008). An open culture in which mistakes are openly discussed and accepted is important because others can learn from this (Hanisch et al., 2009) and this could lead to creating better knowledge and innovative design alternatives (Moud & Abbasnejad, 2009; Lindner & Wald, 2011; Paver & Duffield, 2019). This can be facilitated by *colleagues accepting* the $mistakes_9$ of others (Lo & Fong, 2010; Duffield & Whitty, 2016a) and to create such a culture, management should treat their employees fairly and in such a way that they are not afraid of being punished for failures (Moud & Abbasnejad, 2009).

3.3.3 Social

The third layer represents the social interaction within an organisation and Goffman (2003) defines this as the behaviour by which we act and react to those around us. Social interaction forms the basis of the relationships amongst employees within an organisation (Duffield, 2016). Learning in an organisation is a social phenomenon (A. Hartmann & Dorée, 2015). Therefore, social interaction can facilitate learning and is very important for the transfer of tacit knowledge (Nonaka et al., 2000). According to the results of Zhao, Zuo, and Deng (2015), "when the relationship was friendly and co-operative, members of two project teams were more willing to transfer information and knowledge for each other." Therefore, *colleagues have to collaborate well together*$_{11}$ within project teams (Duffield & Whitty, 2014). Furthermore, social interaction is facilitated if colleagues are $reliable_{12}$, and are *honest and have integrity*$_{13}$ (Bakri & Amaratunga D, 2018). Barriers of social interaction prevent employees getting to know each other on a personal level and developing a relationship with each other. This can be the case when a strong friendship culture is absent within an organisation, there is little informal communication or there is little social activity (Duffield, 2016). Due to the nature of project-based organisations, team members are often new to each other (Adenfelt & Lagerström, 2006), and shallow relationships can be caused by a lack of $trust_{14}$ (Politis, 2003; Al-Alawi, Al-Marzooqi, & Mohammed, 2007). Bakri and Amaratunga D (2018) state that "for a construction project to be completed on time every member of a construction project must feel confident that they can trust the other team members and can make real contribution." Enhancing *social contact*$_{15}$ by arranging social events could play an important role in reinforcing trust between co-workers and building informal friendships (Al-Alawi et al., 2007).

3.4 Facilitator and barrier category II: Systems

The second Syllk-category focuses on the systems that are required to support the employees to be able to learn lessons within an organisation. This category is important because the knowledge and experience that is gained from projects is often not Systemically integrated into the knowledge base of the organisation (Schindler & Eppler, 2003; Wiewiora et al., 2009). Therefore, these layers mostly facilitate making knowledge explicit. The three layers are *technology*, *process* and *infrastructure*, and the facilitators and barriers of each layer will discussed in this section.

3.4.1 Technology

The fourth layer represents the information technology systems that employees use to store, record and access information (Duffield & Whitty, 2014). Technology provides an organisation with ease of communication, and collection and re-use of knowledge (Shurrab, 2013) and amplifies human expertise (Moffett, Mcadam, & Parkinson, 2003). According to Moffett et al. (2003), "technology enables employees to capture data, information and knowledge that surpasses human capacity in absorbing and analysing these in a focused manner." Technology supports the conversion of tacit to explicit knowledge, helping to capture, encode, and distribute organisational knowledge (Duffield, 2017). The technology systems that employees work with can facilitate learning in an organisation by being *fast and efficient*$_{16}$ so limited time of employees is consumed on waiting. It is important that the systems are consistently good in quality or performance and can therefore be seen as $reliable_{17}$. Systems that are not *easy to use*$_{18}$ can be seen as a barrier because employees will less likely want to (learn how to) work with them (Duffield, 2016). Technological barriers can be created if an organisation uses multiple systems without a *clear overview*$_{19}$ which systems should be used because this can cause

confusion and the systems are inconsistent, do not *interconnect*$_{20}$ or do not interface with each other (Duffield & Whitty, 2012).

3.4.2 Process

The fifth layer represents the lessons process that can be applied within an organisation to actively collect, store and reuse lessons learned. Inconsistent, misguided and confusing processes will make it hard for an organisation and project team members to learn lessons (Duffield & Whitty, 2012). Therefore, the process needs to be *clear and well understood*$_{21}$ so employees can execute it (Duffield & Whitty, 2016a). Furthermore, *the guidelines of the process should be well understood*$_{22}$ (Duffield, 2016). To facilitate learning, team members may need basic *training how to execute the process*$_{23}$ and how to capture lessons effectively. Training could be about storing and retrieving information effectively and facilitate the use and understanding of the process (Duffield & Whitty, 2016a). The better a team member understands the process, the better the team member will be at creating and transferring knowledge (Syed-Ikhsan & Rowland, 2004). It is important that the lessons captured contain specific details, because otherwise the lessons may contain vague information and unclear recommendations (Dressler & Palen, 2007). Therefore, it is important that *the outcome and the desired results of the process are clear*$_{24}$. Furthermore, it is important that the process is *flexible*$_{25}$ and supports innovation. However, a challenge can be that if the process is too flexible, there is no way of executing the process right.

3.4.3 Infrastructure

The sixth layer represents the work spaces, buildings and facilities within an organisation that contribute to the realisation of products or services (International Organization for Standardization, 2015). According to International Organization for Standardization (2015), "infrastructures should provide the suitable conditions and accessories to perform the appropriate business tasks and activities and assist in achieving the desired conformity of product and service requirements." In the definition three important aspects can be determined. The first is the suitable conditions, such as a pleasant climate, and therefore it is important that the employees have a *pleasant physical working space*$_{26}$ to work in. The second is accessories to perform appropriate business tasks and activities, and therefore it is important that facilities such as *training facilities and meeting rooms are available*$_{29}$. This can be for meetings, presentations and other consultations. The third is assist in achieving the desired conformity, and therefore the facilities within the organisation should not only be available but should be *clean*$_{30}$ as well (Duffield & Whitty, 2012; Duffield, 2016). Furthermore, *open door policies*$_{27}$ can encourage openness and transparency between employees. Lastly, conformity can be hindered if *excessive geographic distances*$_{28}$ have to be travelled if employees work on projects that are located outside of the main building they work.

3.5 Conclusion

In an organisation it is not sufficient to implement a lessons learned process without considering other variables that can facilitate and hinder an organisation's ability to learn and reuse lessons. A literature study has been conducted to identify the variables and the Systemic lessons learned knowledge (Syllk) model has been be used to categorise them. Together, this has been combined to answer the first sub-question: *what are facilitators and barriers of an organisation to learn lessons within projects?*

An overview of the identified facilitators and barriers per layer are shown in Table 3 and more information on each can be found in the text of this chapter. The identified facilitators and barriers in the table will form the input for determining the facilitators and barriers of the Ingenieursbureau in Chapter 4.

Table 3: Facilitators and barriers: results literature study (own table)

Layer		**Facilitator**	**Barrier**
Learning (People)	1	Sufficient workshops and training	Insufficient workshops and training
	2	Willingness to learn	Lack of willingness to learn
	3	Stimulated to share information	Not stimulated to share information
	4	Willingness to share information	Lack of willingness to share information
	5	Unstressed working environment	Stressed working environment
Culture (People)	6	Support from higher management	Lack of support from higher management
	7	Positive feedback from colleagues	Lack of positive feedback from colleagues
	8	Colleagues accept each other	Colleagues do not accept each other
	9	Colleagues accept mistakes	Colleagues do not accept mistakes
	10	Comfortable to speak freely	Uncomfortable to speak freely
Social (People)	11	Sufficient collaboration within teams	Insufficient collaboration within teams
	12	Reliable colleagues	Unreliable colleagues
	13	Honesty and integrity	Lack of honesty and integrity
	14	Trust	Lack of trust
	15	Social contact	Lack of social contact
Technology (Systems)	16	Fast and efficient	Slow and inefficient
	17	Reliable	Unreliable
	18	Easy to use	Difficult to use
	19	Clear overview of systems	Unclear overview of systems
	20	Interconnection	Insufficient interconnection
Process (Systems)	21	Clear and well understood	Unclear or not well understood
	22	Guidelines of the process are well documented	Guidelines are not well documented
	23	Training is provided how to execute the process	Insufficient training on the process
	24	Clear outcome and desired results	Unclear outcome and undesired results
	25	Flexible	Inflexible
Infrastructure (Systems)	26	Pleasant physical working space	Physical working space is unpleasant
	27	Open door policy	No open door policy
	28	Short geographical distances	Excessive geographical distances
	29	Training facilities and meeting rooms available	Lack of training facilities or meeting rooms
	30	Clean facilities	Unclean facilities

4

Application of the facilitators & barriers

In this chapter the facilitators and barriers of learning lessons in the Ingenieursbureau will be discussed. The variables that have been identified in Chapter 3 will be used to determine if they facilitate or hinder learning within the Ingenieursbureau. Firstly, the variables will be validated by discussing them with the risk managers and this is discussed in section 4.1. Thereafter, the validated variables will be used to create questionnaires and these will be discussed during the interviews. The results of the interviews for the Syllk-category *people* can be found in section 4.2, and the answers for the Syllk-category *systems* can be found in section 4.3. An overview of the interview transcripts can be found in Appendix A. Thereafter, sub-question 3 is answered in section 4.4: *what are the facilitators and barriers of the Ingenieursbureau to learn lessons within projects?*

4.1 Validation of the facilitators and barriers

The facilitators and barriers that have been identified in Chapter 3 need to be validated to ensure that they are clearly defined, not ambiguous and applicable within the Ingenieursbureau. The validation will take place during the expert session with the risk managers. Firstly, the Systemic lessons learned knowledge model (Figure 9) will be presented to the risk managers and explained how the different layers can influence learning and reusing lessons in an organisation. Thereafter, the identified facilitators and barriers from Table 3 will be explained per layer and discussed with the risk managers. The risk managers can give their opinion about each facilitator and barrier and their feedback will be used to make adjustments if needed.

During the expert session it turned out that the risk managers agreed with and understood the majority of the facilitators and the barriers. However, feedback was given that variables that were defined in the layer *social* were not clearly defined and had overlap. Firstly, the feedback was given that it was not clear what the exact difference was between the facilitators *reliable colleagues*$_{12}$, *honesty and integrity*$_{13}$ and *trust*$_{14}$. This was because these three facilitators have many overlap with each other and therefore the choice has been made to combine the three facilitators into the facilitator *reliable colleagues*$_{12}$. Secondly, a risk manager identified a social facilitator that was thought to be missing and finds it important in her work. The other risk managers agreed with the importance of the facilitator and that it should be added to the list. The facilitator has been defined as *approachable colleagues*$_{13*}$[3] and it refers to how approachable colleagues are at work. This was seen as important because unapproachable colleagues are seen as a important barrier at work. Thirdly, the feedback was given that it was not clear how the facilitator *social contact*$_{15}$ should be interpreted because social

[3]Before the validation step Facilitator 13 was *honesty and integrity* and after the validation step Facilitator 13 has become *approachable colleagues*. To indicate if changes have been made to a certain facilitator during the validation step, a * will be added to the notation of the facilitator. For example, Facilitator 13 will become *approachable colleagues*$_{13*}$. This will be done for Facilitator 14 and Facilitator 15 as well.

contact can take place during work and outside of work. In section 5.1 it has been explained that social contact is of great importance for the transfer of tacit knowledge because not all lessons learned may be written down. Therefore, the choice has been made to divide the facilitator into *social contact during work*$_{14*}$ and *social contact outside of work*$_{15*}$.

The feedback that was given by the risk managers has been used to make adjustments to the facilitators and barriers. An overview of the validated and adjusted variables are presented in Table 5 and these will be used in the interviews to determine the facilitators and the barriers within the Ingenieursbureau.

Table 5: Facilitators and barriers: results validation session (own table)

Layer		**Facilitators before validation**	**Facilitators after validation**
Learning (People)	1	Sufficient workshops and training	Sufficient workshops and training
	2	Willingness to learn	Willingness to learn
	3	Stimulated to share information	Stimulated to share information
	4	Willingness to share information	Willingness to share information
	5	Unstressed work working environment	Unstressed work working environment
Culture (People)	6	Support from higher management	Support from higher management
	7	Positive feedback from colleagues	Positive feedback from colleagues
	8	Colleagues accept each other	Colleagues accept each other
	9	Colleagues accept mistakes	Colleagues accept mistakes
	10	Comfortable to speak freely	Comfortable to speak freely
Social (People)	11	Sufficient collaboration within teams	Sufficient collaboration within teams
	12	Reliable colleagues	Reliable colleagues
	13*	~~Honesty and integrity~~	Approachable colleagues
	14*	~~Trust~~	Social contact during work
	15*	~~Social contact~~	Social contact outside of work
Technology (Systems)	16	Fast and efficient	Fast and efficient
	17	Reliable systems	Reliable systems
	18	Easy to use	Easy to use
	19	Clear overview of systems	Clear overview of systems
	20	Interconnection	Interconnection
Process (Systems)	21	Clear and well understood	Clear and well understood
	22	Guidelines of the process are well documented	Guidelines of the process are well documented
	23	Training is provided how to execute the process	Training is provided how to execute the process
	24	Clear outcome and desired results	Clear outcome and desired results
	25	Flexible	Flexible
Infrastructure (Systems)	26	Pleasant physical working space	Pleasant physical working space
	27	Open door policy	Open door policy
	28	Short geographical distances	Short geographical distances
	29	Training facilities and meeting rooms available	Training facilities and meeting rooms available
	30	Clean facilities	Clean facilities

4.2 Facilitator and barrier category I: People

In this section the results of the interviews are discussed for the Syllk-category *people*. The statements that have been made from the validated variables have been sent to the interviewees prior to the interviews. The average score (1-4) per statement and the motivation behind the scores will be discussed for the layer *learning* in section 4.2.1, followed by the layer *culture* in section 4.2.2 and lastly, the layer *social* in section 4.2.3.

4.2.1 Learning

Table 7: Facilitators and barriers: results of the Ingenieursbureau for "learning" (own table)

	Variable	**Score**	**Conclusion**	**Improvement**
2	Willingness to learn	3.1	Facilitator	Not recommended
4	Willingness to share information	3.1	Facilitator	Not recommended
5	Unstressed working environment	1.6	Facilitator	Not recommended
1	Workshops and training	2.9	Barrier	Recommended
3	Stimulation to share information	2.8	Barrier	Recommended

The statement *within the Ingenieursbureau you receive sufficient workshops and training*$_1$ scored a 2.9. The score and the conclusion of the interviews show that the variable can be considered a barrier. During the interviews all interviewees indicated that there are many opportunities to follow training and workshops. For example, risk managers follow a three day RISMAN-course and a project manager told that he just completed a two year project management study. However, the majority of the interviewees experience a lack of stimulation from the Ingenieursbureau to follow training and workshops. If you do not apply for anything, nothing will happen. An interviewee indicated that it is difficult to create time for training with the current workload and because the team manager does not actively promote training, she does not make use of the opportunity to follow training or workshops. The example was given that a project manager followed a two year project management study, however he had to complete his assignments in his own time after work, at night and during the weekends. The expectations are that it is relatively easy for the Ingenieursbureau to stimulate and ensures more employees attend workshops. Furthermore, it is expected that this will have a high impact on learning within the Ingenieursbureau and therefore this is recommended.

The statement *my colleagues are willing to learn*$_2$ scored a 3.1. The score and the conclusion of the interviews show that the variable can be considered a facilitator. Interviewees indicated that new ideas are received openly and positive feedback is given rather than criticism. Furthermore, a project manager explained that she organises an event twice a year to review the collaboration between the project team members. She knows that not all project managers organise such project reviews and therefore not all of the project team members are used to doing this. When she does this she indicated that her project team members fully cooperate and she gets positive feedback and that the project review is experienced as positive.

The statement *within the Ingenieursbureau you are stimulated to share information*$_3$ scored a 2.8. The score and the conclusion of the interviews show that the variable can be considered a barrier. It was mentioned that meetings are organised that focus on sharing information and experiences. Such meetings are organised for departments (such as for the project controllers) and within projects. However, interviewees explained that they could be organised in a more structured way and it is a pity that it is not documented for future use. There are colleagues who have a lot of knowledge to share but do not do this and knowledge sharing should become some kind of a compulsory element. Therefore, the recommendation is to improve the *stimulation of sharing information*$_3$ by taking the

arguments of the interviewees into consideration. The expectations are that this will have a positive impact on learning within the Ingenieursbureau.

The statement *my colleagues are willing to share information*$_4$ scored a 3.1. The score and the conclusion of the interviews show that the variable can be considered a facilitator. Interviewees indicated information is shared easily during work due to the flexible working spaces and during the integrated project management team meetings for instance, and outside of work through tools such as e-mail and WhatsApp. A project controller explained that when she came back from holiday recently, she was updated straight away by colleagues about an important process that had been changed in the time she was absent. A project manager indicated that she actively stimulates this during the integrated project management team meetings and by organising events to improve the collaboration within the team. She stated that "you could say that as a project manager I actively manage this and when I speak to individuals I notice that information has actively been shared. For instance, if I have a meeting with the technical manager I can notice that outside of these organised meetings the technical manager has been updated by the contract manager. For me as a project manager, I experience this as positive and this gives me confidence in my team." Therefore, the conclusion of the interviews is that the variable is a facilitator. However, a risk manager experienced the willingness to share information less positive since risk managers are not present during the integrated project management team meetings. In larger projects risk managers have meetings with the project controller and it is up to the project controller to give an update on the project. This does not always happen, and in smaller projects these meetings do not always take place and the risk manager indicated that he can notice that he misses information about the project. Therefore, it is recommended to take this into consideration because this may have effect on learning within the Ingenieursbureau.
The statement *I work in an unstressed working environment*$_5$ scored a 1.6. This indicates that it may be a barrier but the conclusion of the interviews is that it is considered a facilitator. All interviewees indicated that they experience stress and a high work pressure but 8 of the 9 interviewees experience it as positive. A first example was given by a risk manager who explained that her agenda is always full and there are moments that work needs to be done in the evening or weekends. She does not experience such work pressure as negative but as positive and does not enjoy work as much if she does not have much to do. A second example was given by a project manager who explained that within projects there is stress and a high work pressure but experiences this as positive. It gives adrenaline and this is what a project team need to make projects a success. An example was given that in a previous project she would not have been able to achieve the successes without stress and a high work pressure, and that is something that gives her satisfaction in her work.

4.2.2 Culture

Table 8: Facilitators and barriers: results of the Ingenieursbureau for "culture" (own table)

	Variable	**Score**	**Conclusion**	**Improvement**
8	Colleagues accept each other	3.2	Facilitator	Not recommended
10	Comfortable to speak freely	3.0	Facilitator	To consider
6	Support from higher management	2.8	Barrier	Highly recommended
7	Positive feedback from colleagues	2.7	Barrier	To consider
9	Colleagues accept mistakes	2.7	Barrier	Recommended

The statement *within the Ingenieursbureau you receive sufficient support from higher management*$_6$ scored a 2.8. The score and the conclusion of the interviews show that the variable can be considered a barrier. The majority of interviewees feel supported by higher management but have to do a lot themselves to get the support. In some cases not enough support is given by higher management

when this is needed and this results in new initiatives not succeeding within the organisation. This is because higher management does not make the changes and initiatives compulsory. Therefore, employees feel less motivated to learn something new. This could be improved with a more controlled way of working with clear steering, goals and guidelines from the higher management. An interviewee explained that at the moment the management style is "let's do [...] because we want to achieve something together" but there is no form of control. She would prefer a controlled way of working with management setting clear goals and guidelines, and saying "okay, from now on we are going to do it like this" and thereafter having a more controlling working style to ensure employees do adhere to the changes and new initiatives. The expectations are that improving this variable will have a high impact on learning within the Ingenieursbureau and therefore it is Highly recommended to improve this.

The statement *my colleagues give each other positive* $feedback_7$ scored a 2.7. The score and the conclusion of the interviews show that the variable can be considered a barrier. A project manager explained that during the project reviews that she organises, she noticed that both positive and negative feedback is provided. However, multiple interviewees explained that within the project teams it is not common to give positive feedback and it should be improved. Positive feedback is given in a more hidden way such as recommending someone because he or she is good at her job. A project controller explained that a reason could be because as engineers, "we just presume things to go correctly and see that as the norm." A project manager explained that giving feedback is seen as more difficult, and it is something that she thinks needs to be improved because it is of great importance for successful collaboration within project teams. Improving this variable may improve learning within the Ingenieursbureau and therefore it is recommended to consider improving this.

The statement *my colleagues accept each other*$_8$ scored a 3.2. The score and the conclusion of the interviews show that the variable can be considered a facilitator. The interviewees acknowledged that this happens and that it is important to take a colleague's personality into consideration when approaching them because everybody is different. However, a project manager did explain that he notices project members need to get to know and trust each other before they accept each other.

The statement *my colleagues accept when another colleagues make a mistake*$_9$ scored a 2.7. The score and the conclusion of the interviews show that the variable can be considered a barrier. The importance of making and accepting mistakes was acknowledged by interviewees. A project manager explained that she supports her project team members when they makes mistakes because this is what she learned the most from herself. Furthermore, an interviewee explained that "when discussing the mistakes, there is a chance that others have experienced the same problem but have dealt with it differently. By discussing these mistakes, a lot can be learned from each other." A project manager stated that "for me as a project manager it is more important how you deal with your mistakes instead of making them. If someone makes a mistake and is not transparent about this but tries to cover it up and it goes wrong, the result of this can be that there is not have enough time to correct it. I as a project manager do not accept this because I cannot control the problem anymore. So, making mistakes is okay but it is important to deal with them correctly, be transparent and communicate them accordingly." However, interviewees explained that the focus within projects lies mainly on achievements and positive aspects, and not on the negative. Therefore, it is recommended to improve this and focus on the negative as well.

The statement *I feel comfortable to speak freely to my colleagues*$_{10}$ scored a 3.0. The score and the conclusion of the interviews show that the variable can be considered a facilitator. Interviewees explained that the culture within the Ingenieursbureau is seen as very open and that they find it easy to speak freely because they have a direct approach towards colleagues. An interviewee stated that "if someone is not happy about something I have done that person can always discuss this with me, and I will do the same. However, I do experience that not everybody finds this easy." This was acknowledged by other interviewees as well, and another project manager explained that "I did not strongly agree because I notice that not everyone finds it easy to speak freely and give negative

feedback for instance. This is difficult though, and something that we are learning and improving, but it is important to mention it to improve the collaboration. If a project team has been working together for a longer time this is easier for project team members, but when I look at the Ingenieursbureau as a whole my opinion is that this can be improved." Therefore, the Ingenieursbureau should consider to improve this.

4.2.3 Social

Table 9: Facilitators and barriers: results of the Ingenieursbureau for "social" (own table)

	Variable	**Score**	**Conclusion**	**Improvement**
13*	Approachable colleagues	3.3	Facilitator	Not recommended
14*	Social contact during work	3.2	Facilitator	Not recommended
12	Reliable colleagues	3.1	Facilitator	Not recommended
11	Collaboration within teams	2.9	Barrier	To consider
15*	Social contact outside of work	2.6	Barrier	To consider

The statement *my colleagues collaborate well together within project teams*$_{11}$ scored a 2.9. The score and the conclusion of the interviews show that the variable can be considered a barrier. A project controller explained that "within the team we collaborate well together because there is one common goal in the project and all project team members work towards the common goal." However, interviewees explained that collaboration in project teams will always be difficult as all project team members have a different vision on the problem and what needs to be done. The differences are caused for instance by the expertise, role in project team, experience and educational background. Therefore, it can be difficult if a consensus needs to be reached within a project because the differences can cause project team members to find different things important in a solution. The conclusion of the interviews is that the variable is a barrier but it is expected that improving it have a low effect.

The variable *my colleagues are reliable*$_{12}$ scored a 3.1. The score and the conclusion of the interviews show that the variable can be considered a facilitator. All interviewees agreed that they their colleagues are reliable and this is important when working in project teams. However, a risk manager explained that "colleagues do not always keep to their promises and agree to things too quickly in my opinion. An example is when I facilitate risk sessions I ask the participants to prepare something because efficiency can be important in some sessions. This is often not done resulting in an inefficient risk session, and I have to interview people outside of the sessions for instance." This could be something for the Ingenieursbureau to consider improving and the expectations are that this may improve learning within the Ingenieursbureau.

The statement *my colleagues are approachable*$_{13*}$ scored a 3.3. The score and the conclusion of the interviews show that the variable can be considered a facilitator. All interviewees experience this as positive and indicated that they find this important for their work, and they try to present themselves in this way too. A project manager explained that he does not have to hesitate with asking questions to project team members in the weekend for instance, and despite him not expecting an answer during the weekend he explained that he does normally get them. Furthermore, a project manager explains that she sees approachable colleagues as crucial for the collaboration in her project team. She explained that "if this is not the case, I would rather not work with that person in my team and therefore as a project manager, I select my project team members with this in the back of my head."

The statement *there is sufficient social contact during work*$_{14*}$ scored a 3.2. The score and the conclusion of the interviews show that the variable can be considered a facilitator. A project manager who strongly agreed with this explained that within her project team everybody is always interested in

others. She explained that "I find it important that my team is open and indicate if private situations may influence their performance at work so we as a team can support them. If this is the case, I can take this into consideration by reducing the work hours and getting a substitute for instance." However, interviewees explained that social contact has decreased since the reorganisation and the growth of the Ingenieursbureau because not everybody knows each at work, works with earphones or works from home. This results in less social contact during working hours.

The statement *there is sufficient social contact outside of work*$_{15*}$ scored a 2.6. The score and the conclusion of the interviews show that the variable can be considered a barrier. Many social activities are organised outside of work and mostly in project teams. A project manager told that she organises an event with the whole project team at her house at least once a year. During this event, the first part has a more serious part that focuses on improving the collaboration in the team, and the second part focuses on having fun. "For instance, last year I asked everybody to bring a dish, and with such a large project team this resulted in us having 30 different kind of food, which was a lot of fun." However, the social events are mostly organised within project teams and too few social activities are organised by the Ingenieursbureau itself. There are approximately two events a year and if they cannot join the limited activities, they miss out. Therefore, the recommendation is to improve this because the expectations are that this will have positive effect on learning within the Ingenieursbureau.

4.3 Facilitator and barrier category II: Systems

In this section the results of the interviews are discussed for the Syllk-category *systems*. The average score (1-4) and the motivation behind the scores will be discussed for the layer *technology* can be found in section 4.3.1, following by the layer *process* in section 4.3.2 and lastly, the layer *infrastructure* in section 4.3.3.

4.3.1 Technology

Table 10: Facilitators and barriers: results of the Ingenieursbureau for "technology" (own table)

	Variable	**Score**	**Conclusion**	**Improvement**
19	Clear overview of systems	3.1	Facilitator	Not recommended
17	Reliable systems	2.7	Barrier	To consider
18	Easy to use	2.7	Barrier	To consider
16	Fast and efficient	2.2	Barrier	To consider
20	Interconnection	2.0	Barrier	To consider

The statement *the computer systems are fast and efficient*$_{16}$ scored a 2.2. The score and the conclusion of the interviews show that the variable can be considered a barrier. This is because the programmes are not always fast, many different passwords are needed for different programmes and a problem that was mentioned multiple times was that the operating system on the computers that the Ingenieursbureau uses is slow. The impact of improving the systems may have effect on learning within the Ingenieursbureau and the recommendation is to consider this.

The statement *the computer systems are reliable*$_{17}$ scored a 2.7. The score and the conclusion of the interviews show that the variable can be considered a barrier. Interviewees mentioned that there was a large system crash twice in one week last year that resulted in an official investigation. However, despite the fact that interviewees rely on the systems an interviewee said "the programmes do what they should and I have never lost work for instance." The impact of improving the systems may have effect on learning within the Ingenieursbureau and the recommendation is to consider this.

The statement *the computer systems are easy to use*$_{18}$ scored a 2.7. The score and the conclusion of the interviews show that the variable can be considered a barrier. Multiple interviewees explained that they find it difficult to have to work with so many programmes and passwords, and another interviewee explained that she cannot use her phone for work because it is too old. The impact of improving the systems may have effect on learning within the Ingenieursbureau and the recommendation is to consider this.

The statements *the overview of computer systems that I have to use is clear*$_{19}$ scored a 3.1. The score and the conclusion of the interviews show that the variable can be considered a facilitator. The majority of interviewees find the overview of the programmes they have to use for their work clear and therefore the conclusion of the interviews is that this variable is a facilitator.

The statement *the computer systems interconnect*$_{20}$ scored a 2.0. The score and the conclusion of the interviews show that the variable can be considered a barrier. Multiple interviewees explained that they use different programmes for work and there is no interconnection. For instance, risk management, finance and planning are three different programmes and everything has to be filled in manually in each programme. Interviewees indicated that it would be much more efficient if there was one programme everything could be done in at once, or that there was interconnection between the programmes. The impact of improving the systems may have positive effect on learning within the Ingenieursbureau and there it is recommended to improve this.

4.3.2 Process

Table 11: Facilitators and barriers: results of the Ingenieursbureau for "process" (own table)

	Variable	**Score**	**Conclusion**	**Improvement**
24	Flexible	2.0	Barrier	Highly recommended
21	Clear and well understood	1.7	Barrier	Highly recommended
22	Well documented guidelines	1.4	Barrier	Highly recommended
25	Clear outcome	1.4	Barrier	Highly recommended
23	Training how to execute process	1.2	Barrier	Highly recommended

In the layer *process*, there were no facilitators and the average score of the layer is 1.5. The statement *the lessons learned process is clear and well understood*$_{21}$ scored a 1.7, the statement *the lessons learned process well documented guidelines*$_{22}$ scored a 1.4, the statement *I receive sufficient training how to execute the lessons learned process*$_{23}$ scored a 1.2, the statement *the lessons learned process is flexible*$_{24}$ scored a 2.0 and the statement *the outcomes of the lessons learned process are clear*$_{25}$ scored a 1.4. The variables scored low because all interviewees indicated that there is no process to learn lessons or they were not sure if there was a process. All interviewees did acknowledge that more should be done to learn lessons within the Ingenieursbureau and that the Ingenieursbureau could benefit from a lessons learned process. The focus within projects currently is on completing the project and achieving results and not on knowledge sharing and learning lessons. Therefore, project team members are looking ahead and not reviewing what they are doing, despite this being of great importance. Therefore, the conclusion of the interviews is that this variable is a barrier. The expectations are that improving these variables will have a high effect on learning within the Ingenieursbureau. Therefore, it is Highly recommended to improve this.

However, project reviews are organised but this is done on own initiative. A project manager explained that her team and her experience them as valuable but added that "I have never been questioned by higher management if I have reviewed my project, so I can only draw the conclusion that it does not matter if I review my project or not." A project manager who has attended project reviews explained

that the project reviews are sometimes inefficient because it is not determined what the outcome of the review should be or what exactly is going to be reviewed. In complex projects this can result in different aspects trying to be reviewed and not focusing on one main aspect. An interviewee's experience can add to this, he explained that there are often no clear guidelines or structures for project reviews. Therefore, a complex project with a duration of a few years is tried to be reviewed within a morning or afternoon and this is ineffective because only a few aspects of the project can be discussed.

Despite the Ingenieursbureau not having a process, interviewees were asked what they do at the start of a project to use lessons learned from previous projects in a new project. An interviewee explained that before the start of a project and/or project phase, she actively searches through documents of completed project for information and/or lessons learned that she could apply. The other interviewees do not actively search for information and/or lessons learned. However, the three project managers explained that they have experience and apply their own personal experience in new projects. Furthermore, a project manager indicated that before the project start-up, she has meetings with the important stakeholders such as the asset manager, and has meetings with colleagues that may have worked on similar projects. She does this because she indicated that they may have information and insights that can be used in her project, and by doing this she may prevent reinventing the wheel. Another project manager indicated that after the scope and other important aspects of the project have been determined, he and his project team have meetings with other project teams who have executed similar projects to determine what their difficulties were and how they can learn from them.

Interviewees were asked if they did anything to collect lessons learned during a project. One example was by a risk manager who has created his own generic risk register for a large programme that consists of several similar projects. This idea was initiated because problems occurred as there were multiple technical and environment managers working in different projects within the same programme. There was no information sharing between the technical managers and no information sharing between the environment managers. The risk manager explained that because the projects are similar, the risks are similar too. Therefore, to prevent risks occurring without being identified, the risk manager initiated the generic risk register. In the preparation phase and the execution phase, he scans the generic document twice to determine if risks apply to the new project.

4.3.3 Infrastructure

Table 12: Facilitators and barriers: results of the Ingenieursbureau for "infrastructure" (own table)

	Variable	**Score**	**Conclusion**	**Improvement**
27	Open door policy	3.2	Facilitator	Not recommended
28	Short geographical distances	3.1	Facilitator	Not recommended
30	Clean facilities	2.8	Barrier	To consider
26	Physical working space	2.7	Barrier	To consider
29	Availability of facilities and meeting rooms	2.0	Barrier	Recommended

The statement *the physical working space is pleasant*$_{26}$ scored a 2.7. The score and the conclusion of the interviews show that the variable can be considered a barrier. In the interviews it was mentioned that the climate inside of the Ingenieursbureau that is is too warm, although it has improved a lot this year. Furthermore, the flexible working spaces are experienced positive by some interviewees, and negative by others because it can be very noisy. The expectations are that improving these aspects may have effect on improving learning within the Ingenieursbureau. Therefore, the recommendation is to consider this.

The statement *there is an open door policy*$_{27}$ scored a 3.2. The score and the conclusion of the interviews show that the variable can be considered a facilitator. This is because all interviews agreed with this statement and therefore it is not recommended to improve this variable.

The statement *the geographical distances between buildings/projects that have to be covered are short*$_{28}$ scored a 3.1. The score and the conclusion of the interviews show that the variable can be considered a facilitator. The distances that the employees have to cover are not large and all interviewees agreed with this and therefore the conclusion of the interviews is that the variable is a facilitator. The municipality buildings are within the city centre and most projects are too. Some employees have to go outside of the city centre, to Amsterdam North for instance, but indicated that they do not experience this as something negative and actually quite enjoy it.

The statement *there are sufficient facilities and meeting rooms available*$_{29}$ scored a 2.0. The score and the conclusion of the interviews show that the variable can be considered a barrier. All interviewees indicated that there are problems within the Ingenieursbureau to reserve meeting rooms. For large groups, it is the norm that this has to be reserved 2-3 months in advance, or an external meeting room has to be hired. Furthermore, interviewees explained that the meeting rooms are not occupied despite that the meeting rooms have been reserved. Therefore, the recommendation is that this should be improved because the expectations are that this will have positive effect on learning.

The statement *the facilities within the Ingenieursbureau are clean*$_{30}$ scored a 2.8. The score and the conclusion of the interviews show that the variable can be considered a barrier. The reason is because some of the interviewees were happy with the cleanness while others were not. However, none of the interviewees had example of severe unclear situations and therefore the Ingenieursbureau is recommended to consider improving this.

4.4 Conclusion

In an organisation it is not sufficient to implement a lessons learned process without considering other variables that can facilitate and hinder an organisation's ability to learn and reuse lessons. To determine the facilitators and barriers for the Ingenieursbureau, the variables that have been identified in Chapter 3 have been used as input. Firstly, the variables have been validated and secondly, statements were made of the variables to create a questionnaire. Thirdly, interviews were conducted and for each layer, the answers to the statements were discussed to determine if the variable could facilitate or hinder learning lessons within the Ingenieursbureau. The results are shown in Table 13 on the following page and have been used to answer the third sub-question: *what are facilitators and barriers of the Ingenieursbureau to learn lessons within projects?*

The Syllk-category *people* is considered to have a greater influence on an organisation learning lessons in comparison to the systems category. Therefore, the results are positive for the Ingenieursbureau because this category contained 8 facilitators. The results show for example that the employees are willing to learn and share information, accept each other, are comfortable to speak freely, are approachable and are reliable. These facilitators are of great importance for organisational learning and difficult to influence. The category contained 7 barriers that should be considered or are recommended to be improved, but it is highly recommended to improve one of the barriers. The results show that employees do not feel supported by higher management and this results in initiatives not succeeding. It is highly recommended to improve this because this will have high impact on organisational learning.

The Syllk-category *systems* only contained 3 facilitators and the other twelve variables were considered as barriers. The Ingenieursbureau is highly recommended to improve 5 of these barriers and these are related to the layer *process*. This layer only contains barriers and the reason is because there is no process within the Ingenieursbureau for employees to apply to learn lessons. It is expected that improving this will improve organisational learning a lot and therefore it is highly recommended. The focus of the Chapter 5 and Chapter 6 will lie on developing a process that can be applied within the Ingenieursbureau. Furthermore, the layer *technology* contains 4 barriers but this is mainly caused by minor

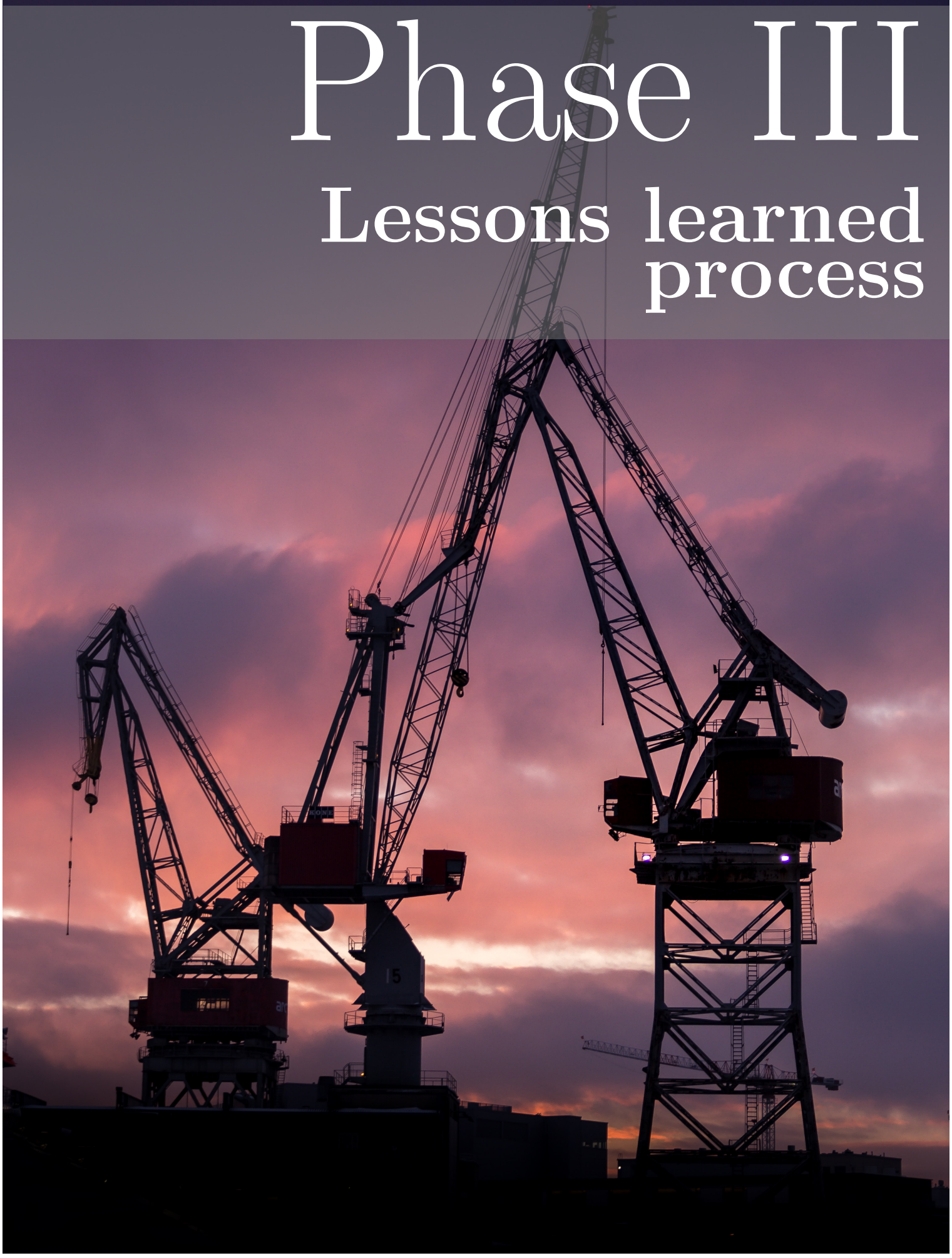
irritations by employees. Examples are using multiple passwords for different computer programmes and the computers are not always considered fast. Therefore, it is not expected that these variables have a great influence on organisational learning. It is expected that improving this may improve organisational learning but not much, and therefore it is recommended that the Ingenieursbureau considers this but does not have such a priority as the process.

Table 13: Facilitators and barriers within the Ingenieursbureau (own table)

Layer		**Facilitators and barriers within the Ingenieursbureau**
Learning (People)	1	Insufficient workshops and training provided (B)
	2	Employees are willing to learn (F)
	3	Insufficient stimulation to share information (B)
	4	Employees are willing to share information (F)
	5	Unstressed working environment (F)
Culture (People)	1	Lack of support from higher management (B)
	2	Lack of positive feedback from colleagues (B)
	3	Colleagues accept each other (F)
	4	Lack of accepting mistakes from colleagues (B)
	5	Employees feel comfortable to speak freely (F)
Social (People)	1	Insufficient collaboration within teams (B)
	2	Reliable colleagues (F)
	3	Approachable colleagues (F)
	4	Social contact during work (F)
	5	Lack of social contact outside of work (B)
Technology (Systems)	1	Slow and inefficient systems (B)
	2	Unreliable systems (B)
	3	Systems are difficult to use (B)
	4	Clear overview of systems (F)
	5	Insufficient interconnection between systems (B)
Process (Systems)	1	Unclear process and not well understood (B)
	2	Guidelines of process are not well documented (B)
	3	Insufficient training how to execute process (B)
	4	Outcome of process is unclear (B)
	5	Inflexible process (B)
Infrastructure (Systems)	1	Unpleasant physical working space (B)
	2	Open door policy (F)
	3	Short geographical distances (F)
	4	Insufficient availability of training facilities and meeting rooms (B)
	5	Unclean facilities (B)

Phase III

Lessons learned process



5

Theory on lessons learned processes

The lessons learned processes for projects that are suggested in the literature will be discussed in this chapter. Firstly, in section 5.1 the difference and importance of tacit and explicit knowledge is explained. Secondly, 18 different lessons learned processes have been reviewed and compared to gain insight in which steps should be taken to learn lessons in projects. In section 5.2, an overview of the steps that are used in the 18 processes is shown. Thereafter, sections 5.3 to 5.10 are dedicated to elaborate on the steps to learn lessons in projects that have been identified in section 5.2. Lastly, in section 5.11 the conclusion of the chapter is given by answering the sub-question *how can lessons be learned in projects?*

5.1 Explicit and tacit knowledge

The steps to learn lessons in projects (see section 5.2) focus on making knowledge explicit by recording and documenting it (codification) and there is less focus on sharing tacit knowledge amongst employees (personalisation). According to Fernie, Green, Weller, and Newcombe (2003), "explicit knowledge represents only the tip of the iceberg of the entire body of knowledge and therefore the focus should not lie on codifying knowledge." Therefore, to gain more insight in this, the difference between explicit knowledge and tacit knowledge, and the importance of both will be explained in this section.

Explicit knowledge has a fixed content that can be documented, structured and externalised in various information technology systems (Adenfelt & Lagerström, 2006; Ajmal & Koskinen, 2008). Explicit knowledge is easy to document and therefore the information can be included in the historical database of the specific project and organisation (Project Management Institute, 2004). Organisations focus on explicit knowledge to ensure that knowledge does not disperse (Hertogh, Bakker, De Man, & Scholten, 2015). Such databases are typically computerised because the assumption is made that knowledge and learning can be shared across projects so that reinvention can be avoided (Newell et al., 2006). However, if an organisation only focuses on codification, the danger lies in the databases and manuals containing valuable information but not being used by employees (Hertogh, De Haas, Bellinga, & Blok, 2016).

Tacit knowledge represents the perceptions, experiences and behaviour of humans, and it refers to feelings, intuitions and insights (Ajmal & Koskinen, 2008). Tacit knowledge is difficult to grasp, evaluate or trade (Nonaka et al., 2000). Therefore, tacit knowledge is hard to codify, and convert into explicit knowledge and that creates difficulties when transferring the knowledge because only explicit knowledge can be integrated in the organizational knowledge base (Adenfelt & Lagerström, 2006; Lindner & Wald, 2011). Means to transfer tacit knowledge are informal meetings, coffee breaks and workshops (Wiewiora et al., 2009). Social interaction to transfer tacit knowledge should improve because many lessons may not be written down and therefore may not be included into the explicit

knowledge leaning process. According to Milton (2012), "organisations should put in place structures and mechanisms that allow people to seek lessons beyond those which they know they will already find in the lessons database, and which allow people to discuss lessons that may never have been collected and recorded." This is in line with Paver and Duffield (2019), who state that the focus should not be directly on codifying tacit knowledge into explicit knowledge but on "linking people with knowledge to one another, to forming and supporting communities and, in general, providing an environment in which knowledge might be shared, enhanced and, sometimes, created." However, an organisation should not only focus on personalisation. Project team members gain and create tacit knowledge during the project by learning certain skills, individual and daily operational know-hows, or learn about the organisational culture and routines. An important character of tacit knowledge is that employees are not aware of the value of the knowledge they posses for themselves or for others (Hertogh et al., 2016). The disadvantage is if project team member leaves a project and the information has not been made explicit and documented, this means that the knowledge will disperse and will not be available to the project team and the organisation (Hertogh et al., 2015).

There is a relationship between codification and personalisation because if an employees codifies knowledge, the employee develops himself by understanding the (tacit) knowledge better and therefore the employee will be better to be able to make things explicit (Hertogh et al., 2015). However, it is important that an organisation focuses on both codification and personalisation of information. During the construction of the Gaasperdammertunnel (2014-2016), the focus laid on sharing explicit and tacit knowledge and this was experienced as positive. It resulted in employees becoming aware of their own actions and thoughts (Hertogh et al., 2016). To improve personalisation, organisations should focus on improving social interaction between organisational members to improve the transfer of tacit knowledge (Arenius, Artto, Lahti, & Meklin, 2002; Moud & Abbasnejad, 2009).

There is a correlation between the size of the company and the preference for codification or personalisation. The results of a research conducted by Penn, Ang'wa, Forster, Heydon, and Richardson (1998) clearly show that the smaller the organisation is, the more important informal word of mouth is valued by employees. On the other hand, the larger the organisation is, the more important written memos are valued by employees. A reason why word of mouth communication is easier in smaller organisations is because there is less diversity between employees in terms of functions and activities. Therefore, social interaction occurs more when an informal management style is applied (Brady, Marshall, Prencipe, & Tell, 2009). In large project-based organisations, the transfer of knowledge is less effective through social communication because the chances for direct interaction are limited, and therefore knowledge transfer occurs better through documented lessons learned (Wiewiora et al., 2009). Therefore, the preference for formalisation and therefore the codification of knowledge increases in larger organisations (Hanisch et al., 2009). However, it is difficult for large organisations to know what is known, and therefore it can be important to have personnel who knows where they can find the knowledge (Nonaka et al., 2000).

5.2 Comparison of lessons learned processes

A clear process should be defined within an organisation to enhance learning from projects that pays attention to collecting, storing and disseminating lessons learned (Williams, 2008). According to Marlin (2008), "a lessons learned process is one that crosses functional boundaries and allows an organisation to learn from both its mistakes and its successes. An effective lessons learned process should prevent us from repeating our mistakes and allow us to repeat our successes. It should be an instrumental part of any organisation's overall 'continuous improvement' process." This is in line with Paranagamage et al. (2012), who furthermore conclude that it contributes to creating a competitive edge over other companies and encourages innovation. However, the steps of lessons learned processes vary from each other and therefore a literature study has been conducted. The steps of 18 different processes have been reviewed and compared to gain insight in which steps should be taken to learn lessons in projects, and the results of the comparison are shown in Table 14 on the following page.

Table 14: Results of comparing lessons learned processes (own table)

		Steps of lessons learned processes[a]							
References	**Framework**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Collier et al., 1996			*	*	*				*
Weber et al., 2001	Figure 18		*	*	*			*	*
Baird et al., 2004	Figure 19		*				*		*
Roth & Kleiner, 2004		*	*	*	*				*
Mendoza & Johnson, 2006			*	*	*			*	
Goodrum et al., 2007	Figure 20		*		*		*		
Rowe, 2007	Figure 21		*	*	*			*	
Caldas et al., 2009			*	*			*		
Jalili et al., 2011	Figure 22		*	*	*			*	
Walden, 2011			*	*	*		*	*	
Milton, 2012		*	*	*	*	*	*	*	*
Benevento & Magoula, 2013	Figure 23		*	*				*	*
McIntyre, 2014		*	*	*	*	*		*	*
Lopes et al., 2015	Figure 24		*	*	*	*	*	*	
Oberhettinger, 2015			*	*	*	*	*	*	
Chaves et al., 2016	Figure 25		*		*			*	
White & Cohan, 2016	Figure 26	*	*	*	*			*	*
Friesen et al., 2017			*	*		*	*	*	*

[a] 1 = Project start-up; 2 = Collect; 3 = Document; 4 = Verify; 5 = Validate; 6 = Implement; 7 = Store; 8 = Disseminate;

A total of eight different steps have been used in the different processes (see Table 14). The second column of the table refers to the frameworks and these can be found in Appendix B. The The insights from the processes and frameworks will be used to design a framework in the conclusion of this chapter in section 5.11. All 8 steps will be discussed in the following sections because the steps will be validated in Chapter 4, and if a certain step is not needed it can be eliminated from the framework. The steps are:

1. Hold project start-up. This step was used in 3 out of the 18 processes (17%). This step will be discussed in section 5.3.
2. Collect lessons learned. This step was used in 18 out of the 18 processes (100%). This step consists of five sub-steps and these will be discussed in section 5.4.
3. Document lessons learned. This step was used in 15 out of the 18 processes (83%). This step will be discussed in section 5.5.
4. Verify lessons learned. This step was used in 14 out of the 18 processes (78%). This step will be discussed in section 5.6.
5. Validate lessons learned. This step was used in 5 out of the 18 processes (28%). This step will be discussed in section 5.7.
6. Implement lessons learned. This step was used in 8 out of the 18 processes (44%). This step will be discussed in section 5.8.
7. Store lessons learned. This step was used in 14 out of the 18 processes (78%). This step will be discussed in section 5.9.
8. Disseminate lessons learned. This step was used in 8 out of the 18 processes (44%). This step will be discussed in section 5.10.

5.3 Hold project start-up

Before the start of the project it is important to discuss certain aspects with all the project members (White & Cohan, 2016). Firstly, the purpose and need for lessons learned during the project should be discussed to get the minds of the project team members focused on learning lessons. Secondly, the process and strategy that will be used to collect, analyse and disseminate the lessons learned should be discussed. Different aspects can be discussed, for instance the audience of the lessons learned, the roles that project team members will have within the project team and who will contribute in which way, and on a product format (length, style, and presentation). Thirdly, it is very important to discuss lessons from previous projects, preventing that the same mistakes from previous project will occur again and discussing this will highlight the importance of learning lessons (Boehringer, 2009; Goffin, Koners, Baxter, & Van der Hoven, 2010). This step is considered to be of great importance since the majority of cost overruns in the Netherlands occur in the pre-construction phase (Cantarelli, Molin, Van Wee, & Flyvbjerg, 2012). Therefore, it is important to address the lessons learned from previous projects in future projects as early as possible.

5.4 Collect lessons learned

The second step is to collect lessons learned and this can be done by organising a project reviews with the project team (White & Cohan, 2016). It is one of the most structured and applicable approaches to pass on experience from one team to the next (Von Zedtwitz, 2002). A reason is that the knowledge that has been gained during a project is usually dispersed among different project team members and therefore reviewing the project together can beneficial (Busby, 1999). Project team members get the opportunity to thoroughly review a project to determine the successes, near misses and/or failures that can be used as lessons for future projects (Birk, Dingsor, & Stalhane, 2002; Dingsøyr, 2005; Rowe, 2007; Anbari, Carayannis, & Voetsch, 2008; Fong & Yip, 2013). It is important to focus on the near misses and failures because Swan, Scarbrough, and Newell (2010) explain that "the nature of a review usually is what has gone well, and what we have achieved. It tends not to focus on where the problems have been and the things that have not worked well and where things could be changed or done better or altered." According to Carrillo, Choudary, Harding, and Oluikpe (2010), project reviews "provide an opportunity for project teams to share and even explicate their tacit knowledge through the face-to-face interactions facilitated before the team is dissolved." The team discussions may lead to innovation and better ideas in comparison to an individual reviewing the project (Carrillo et al., 2010). It is important that the focus of the review is on processes and other aspects of the project itself, and not on a specific persons actions. Different project team members may have experienced the same action differently, and both persons observation should be honoured (Boehringer, 2009). Furthermore, team members may need basic training as how to capture lessons effectively and provide specific details, because otherwise the lessons may contain vague information and unclear recommendations (Dressler & Palen, 2007).

Project reviews can be organised at the end of a project, project phase or sub-project (Dingsøyr, 2005; Howard & Smith, 2016). It is insufficient to only identify lessons at the end of the project because they need to be considered during the project to effectively facilitate the learning process (Williams, 2003; Julian, 2008; Maluleke & Marnewick, 2012; Lopes et al., 2015). The first reason not to leave this until the end is because memories fade and this can result in lessons learned being lost as time passes (Marlin, 2008; Julian, 2008; Pettiway & Lyytinen, 2017). The second reason not to leave this until the end is because the lessons learned can be biased because the focus may lie on recent occurrences, and not occurrences over the whole project life cycle (Maluleke & Marnewick, 2012). The third reason not to leave this until the end is because the temporary nature of project teams and time pressure can be why critical members not being able to participate in the project reviews (Pettiway & Lyytinen, 2017). Therefore, it is important to implement project reviews at various phases of the project life-cycle (Anbari et al., 2008), especially when considering the time it takes to execute construction projects.

If a session is organised, not all project team members should take part and ideally the group should be

limited to six or eight people (Collier et al., 1996). Only project team members that were involved in the projects most challenging problems, that have a thorough understanding of the project's important issues and decisions, and the reason behind the decisions should participate (Collier et al., 1996). Furthermore, if a session is organised, someone who was not part of the team should facilitate the review (Collier et al., 1996; Schindler & Eppler, 2003; Julian, 2008). This is because an internal project team member may not ask the right questions and discuss sensitive topics (Milton, 2012). An external facilitator has a larger chance of avoiding a blaming and defensive atmosphere, so that the focus can lie more on the processes that achieved success or failures (Julian, 2008). Furthermore, an external facilitator is more likely to take criticism gently, and is less likely to be biased, show favoritism to individual project members or have a hidden agenda (Desouza, Dingsøyr, & Awazu, 2005). After the right facilitator has been chosen there are four steps that have to be taken.

To collect lessons learned, 5 sub-steps have been identified in the literature that should be taken and the steps are *introduce project review*, *identify issues*, *determine context and root cause of issues*, *determine lessons learned* and *determine follow-up action*. These five sub-steps will be discussed in sections 5.4.1 to 5.4.5.

5.4.1 1: Introduce project review

The first step is to introduce the project review by discussing the purpose, process and ground rules. It has to become clear to the attendees that the purpose is to identify lessons learned that future project teams can benefit from. Thereafter, the project manager should review the project objectives and this can be done by reviewing the original terms of reference and whether there were any changes to them. The final step of the introduction is to discuss the project's achievements by determining what actually happened in the project and what was achieved at the end. In large and complex projects it can be useful to do this by using a flowchart for the analysis.

5.4.2 2: Identify issues

The second step is to identify the issues and issues can be defined as important topics or problems that should be discussed. The issues that are identified can be seen as the success factors and challenges that need further analysis. When identifying the issues, criteria such as time, budget, and technical and legal specifications can be considered (Anbari et al., 2008). Von Zedtwitz (2002) concludes that project reviews focus mostly on technical output and bureaucratic measurements, and process-related factors such as project management are rarely discussed.

In project reviews there are different ways to identify issues. Examples are (Milton, 2012):

- Ask project team members to come up with successes and challenges before the meeting and bring an own list. However, this is not always given much thought but it can be a way to collect issues from project team members who cannot attend.
- Ask attendees to brainstorm their positive and negative successes and challenges and write them down on post-it notes. Thereafter, the post-its can be collected and discussed in the group, and grouped into themes for analysis. If needed, possible connections between groups can be marked with arrows (Collier et al., 1996; Bjørnson, Wang, & Arisholm, 2009).
- Map the project in a flowchart that includes the major tasks, activities and steps. This can make it easier for project team members to identify activities that they found successful or challenging. The results of the discussion can be used for further analyses.
- Ask attendees to identify their successes and prioritise them. However, this can result in attendees discussing items instead of identifying them.
- Ask attendees to identify their successes and discuss them in groups.

5.4.3 3: Determine context and root cause of issues

The third step is to discuss the issues to determine the context and the root causes of the issues. Collecting data within projects on what happened is not the main problem but it is understanding what exactly went wrong and why (Williams, 2003). Firstly, the context has to be determined but problems are not simple issues but "a complicated web of interdependent matters" (Williams, 2004).

Secondly, the root cause needs to be determined and this is very important because the issue may repeat if the cause of problem is not eliminated (Rosenfeld, 2013; Myszewski, 2013). According to Williams (2003) "the outcome of large projects is generally messy and the history is unclear, and structuring is needed to establish the chains of causality." It is important to capture facts while analysing relevant project documents, and during interviews the explanations for various circumstances in projects can be combined into causal maps and possibly identify feedback loops (Williams, 2003). According to the results of Newell et al. (2006), databases that contained lessons learned were not used because the focus of the knowledge lied on what was done, rather than how it was done and why it was done that way. This is in line with Hertogh et al. (2016) who concluded that for a contractor it is not only important to determine the "what" and "how" but the "why" as well. Two methods are discussed how to determine the root cause of the issue. The first is the traditional 5-whys and the second is the method suggested by Milton (2012).

Firstly, the 5-whys method can be applied to identify the root causes of the issues. The first question to ask is "why is this issues happening?" Thereafter, the question "why is that?" and the answer should be written down. This step should be repeated and the root cause has been identified when asking "why is that?" yields no further useful information. A good rule of thumb is to ask the question five times but for different issues this may be asked fewer or more times (Serrat & Serrat, 2017).

Secondly, Milton (2012) states that "what?", "how?" and "why?" questions should be asked in order to identify the root causes of issues. These questions can be asked in individual interviews and in group meetings and will take between 10 and 20 minutes per individual. Examples are:

- Why do you think you were successful?
- What did you put in place to ensure success?
- What was missing that caused that to happen?
- What makes you say that?
- Can you explain how you achieved that?
- Can you tell me about that?

5.4.4 4: Determine lessons learned

The fourth step is to determine the lessons learned by asking further questions once the root causes behind the lessons have been identified. To require the interviewee to analyse the learning point and make recommendations, future tense "what?" questions should be asked. In group sessions, asking future tense questions is a way to avoid blaming and conflicts during the meeting. Examples are:

- What would be your advise for someone doing this in the future?
- If you were to do this again, what would you do next time?
- If you could go back in time and give yourself a message, what would you tell yourself?

Future tense questions make it possible for the interviewees to think past the history of the project, and forces them to think about what should be repeated or avoided. It is important to ensure that the lessons learned are specific and actionable because they will otherwise not be of use after the interview. Therefore, it is important to ask further questions about what an interviewee actually means when using words such as "lots" and "enough".

5.4.5 5: Determine follow-up action

The fifth step is to determine if follow-up actions are needed for the lessons that have been identified. According to Milton (2012), there are five types of actions that can arise from a lesson learned and the first is *fixing a problem* and this can be seen as the simplest and most obvious actions. The conclusion of a certain lesson during a group meeting could be that the process would have gone better if a certain problem did not occur. If the organisation has the power and capabilities to fix this problem, this is the action that needs to be taken. Examples can be buying or replacing a piece of equipment, training staff or hiring new staff. The second is *further investigation* because it was not possible to (fully) determine the root cause. This can happen because people with certain expertise were not present, certain data was not available due to the complexity of the identified lesson. Examples can be setting up an investigation or laboratory study, collecting more data or involving an expert. The third is *documenting a procedure or process* when a project team has done something for the first time. Due to the new experience, many lessons may be identified but all the actions that are identified come down to the same one. In that case, examples of actions can be to set up an operational procedure, guidelines, checklists, training materials or FAQs. The fourth is *updating a documented procedure or process* and this can result when an improvement or pitfall is identified in an existing procedure or process. Procedures or processes cannot simply be modified because the modification is more than likely to affect others within an organisation as well. Furthermore, modifications need to be verified and validated to ensure that it does not cause more problems. Thereafter, training course, other training or e-learning material may need updating. The fifth is *circulating the lesson for others to decide on action.* This might be needed for complex lessons and/or actions when different departments of an organisation, or multiple stakeholders are involved. For instance, identifying a safety hazard on site can be removed but the lesson needs to be circulated on all sites with similar operations to determine if it does (not) occur there too.

5.5 Document lessons learned

The third step is to document the lessons learned after they have been collected. The importance and the different crucial steps in documenting lessons learned has not been emphasised enough in the literature and therefore the suggestion has been made to make this a separate step in the lessons learned process. According to Milton (2012), "recording the lesson is a step where value is often lost. A lesson that is not documented well, through ambiguity, lack of clarity, lack of context or lack of detail might not be reapplied and is therefore a wasted opportunity for performance improvement." In a study conducted by Goffin et al. (2010), the results showed that post project review reports contained on average three lessons learned but during additional post project reviews 56 lessons learned were discussed. One project team member said "there is no use writing this down — no one on the distribution list apart from us will know what we are talking about." A reason that makes documentation difficult for project team members is because tacit knowledge has to be translated into explicit knowledge (Goffin et al., 2010). Further elaboration about what makes it difficult to translate tacit knowledge into explicit knowledge can be found in section 5.1.

Documentation often focuses on a project's results and how project specific solutions have been created or how certain special issues have been solved are often omitted. The focus often lies on *what*, *where* and *how many*, and not on the crucial aspects *why* and *how* (Schindler & Eppler, 2003). Furthermore, documentation is crucial because each lesson needs to contain sufficient context so it can be understood by a reader who has not read up on the project (Desouza et al., 2005; Milton, 2012).

According to Rose (2013), the documentation of lessons learned "includes the causes of issues, reasoning behind the corrective action chosen, and other types of lessons learned about communications management." However, Rowe (2007) and Milton (2012) both state that it is important to add the category of the lessons learned to the documentation. Furthermore, Milton (2012) suggests that adding the event in which the lesson learned occurred is important, and the use of context. To summarise, documented lessons learned should at least contain contain the following six elements:

1. *The category to which the lesson refers.* Existing taxonomy can be used to categorise the lessons learned and the choice can be made to add additional keywords. Examples of categories according to Rowe (2007) are project management, resources, technical, communication, business processes, requirements, design and build, testing, implementation and external areas. If desired, keywords and the category can be split into two separate columns to make it easier to search for the lessons learned.
2. *The context in which the learning happened.* It is important that the documented lessons learned contain as much context and detail as it needs to be understood in isolation, without the reader having to have read other documents on the project. Simple lessons need less context and can be documented easily by writing, process flow, template or diagram. More complex lessons are harder to write down in a few lines because they are difficult to explain. Complex lessons need more context and in some situations they can be documented in the form of a story. Another aspect that can influence the amount of context that is needed is the audience the lesson is written for. If the lesson is documented for fellow project team members, less context is needed than if it is documented for a different team, project or country (Milton, 2012).
3. *The event itself from which the learning occurred.* For example, the lesson learned occurred during an accident, a mistake, a certain part of process, etc.
4. *The root cause of the lesson.* It is important for people who validate the lessons and for future users of the lessons to understand the root cause of the lesson. How to determine the root cause of lessons learned is discussed in section 5.4.2 on page 39.
5. *The lesson learned.* It is important to express the lesson as a "specific actionable recommendation". This means that the lesson learned has been defined clear and it is clear what should be done in the future. Aspects such as the context support the lesson, resulting in the reader being able to understand the lesson in isolation and understanding how the lesson can be applied in the future (Milton, 2012).
6. *The action arising from the lesson.* This is a crucial step in documenting lessons learned so that the lesson learned can be applied in the future. How to determine the action that is needed that can make improvements in future projects has been discussed in *Step 2 - Collect lessons learned*.

5.6 Verify lessons learned

The fourth step is to verify the accuracy of the lessons learned (White & Cohan, 2016). Project team members should have the opportunity to analyse and respond to the document before it is finalised (Rowe, 2007). Furthermore, the lessons learned should be verified according to redundancy, consistency and relevance (Chaves et al., 2016). The project team member responsible for the verification should determine if the captured lesson learned is relevant for other future projects, is unique to a particular type of project, or is relevant for the whole organisation (White & Cohan, 2016). Finally, it is important to verify that the lessons are clear, the recommendations are specific and actionable, and that there is a sufficient amount of context (Milton, 2012). According to Lopes et al. (2015), the following three actions can be taken by the project team member responsible for the verification:

1. Approve and publish the item in the knowledge database for consultation by the project teams
2. Request a review, by returning the item to the author for additional information, revision, or changing of the category
3. Reject, by returning the item to the author, always with the appropriate explanations when it does not have significant relevance to justify its publication for dissemination or implementation at a later date.

5.7 Validate lessons learned

The fifth step is to validate the applicability of the lessons learned because it is important that the actions that have been assigned to a lesson are validated (White & Cohan, 2016). This is because to

confirm that the suggested processes require change that leads to overall improvement. During the validation three aspects have to be determined.

1. Determine if the suggested lesson is really a new lesson. It can occur that lessons are identified because project team members are not aware, or did not execute the process properly, and not because there is a malfunction within the process. In this case the process does not need to be modified but other actions should be identified to make sure this lesson is learned.
2. Determine if it is necessary that the process needs updating because of the identified lesson. To determine this, it is very important that the lesson learned has been documented particularly well. For the person who does the validation, it has to be clear what the circumstances were because these might never happen again, and therefore no process modification is needed. Furthermore, the documented lesson learned could be more of an opinion or an idea.
3. Determine if the process can be updated as an effect of the identified lesson, without causing new problems and/or risks. This has been addressed in documentation steps and due to its importance, it needs to be validated. Updating or changing a process may result in certain improvement but may create risk as well. Therefore, before implementing the lesson, the whole process has to be reviewed and validated with the suggested change (Milton, 2012).

5.8 Implement lessons learned

In step 5 the lesson learned has been validated, and it has become clear if the action that derived from the lesson (Step 2) is correct and/or sufficient. The fifth step is to implement the lesson learned. According to Marlin (2008), "the learning part only comes when the lesson has been institutionalised, for example changing a policy, writing a procedure, revising a standard, issuing a new specification, improving a work process, etc."

5.9 Store lessons learned

The seventh step is to store the documented lessons learned into the repository. This can be done in the form of a template, a detailed report or a one paged summary of the findings and recommendations. Normally this is done on a shared electronic drive or a project library with other project documents, and/or in shared lessons learned folder (Rowe, 2007).

According to Hillson (2002), structuring information can be seen as one of the most difficult tasks in reviewing post-projects. Reasons can be because knowledge transfer is more than just a copy-paste undertaking (Szulanski, 2000) and many organisations do not store this information in an accessible format (Hillson, 2002). Therefore, it is important to invest time and money to prevent knowledge from dispersing after the completion of a project (Szulanski, 2000). For example, this can be done with an administrator who is responsible to make sure that each lesson is verified and can be applied in future projects, that the lessons do not contain any negativity towards other colleagues, that the database is kept easily accessible, and that the lessons can be searched for easily by using effective keywords (Marlin, 2008).

It is important that the lessons learned are stored in an easy accessible location (Dressler & Palen, 2007). According to Dressler and Palen (2007), this is because "lessons are also quite often bundled together into a large post-project-report format or stored in a repository without an index. A single bundled report format makes it difficult to find the specific individual lessons that have value for subsequent activities. Not having an index for a lesson repository hinders users from locating useful lessons. The technology and user interface for the lesson repository quite often is confusing and difficult to navigate, making lesson capture, searches, and application difficult." Therefore, it can result in "a dumping ground of trivial and confusing lessons that offer little or no value to others" (Dressler & Palen, 2007). Holm (2016) researched how to improve lessons learned in organisations, and one of the conclusions was that it is important for employees to be able to find information fast and easily. To make it easy for future project team members to retrieve and reuse lessons learned, it can be helpful

to use capabilities to search for key words when storing them (Rowe, 2007; White & Cohan, 2016), and to remove duplicated lessons (Milton, 2012).

5.10 Disseminate lessons learned

The eighth step is to distribute the lessons learned amongst the project team members and other employees who could benefit from it (Rowe, 2007). In an organisation, lessons can be "pushed" by distributing them, or "pulled" by manually searching for them (White & Cohan, 2016). Within project-based organisations, lessons learned can be distributed by three methods (Weber et al., 2001). The first is *passive dissemination* and this is the most traditional form in which users "pull" the information by manually searching for lessons learned in an internal database/intranet after they are stored. The second is *active casting* in which lessons learned are "pushed" by broadcasting them to project team members through a dedicated list server. The third is a "push" method too, by *sending* the lessons learned to project team members in the form of bulletins. Fong and Yip (2013) identified in their research that e-mails and written documents are the most suitable channels to disseminate lessons, and internal databases/intranet are the least suitable.

5.11 Conclusion

A clear process should be defined within an organisation to enhance learning lessons from projects that pays attention to collecting, storing and disseminating lessons learned (Williams, 2008). However, the steps of lessons learned processes vary from each other and therefore a literature study has been conducted. The steps of 18 different processes have been reviewed and compared to gain insight in which steps should be taken to learn lessons in projects. The results have been used to design a framework (Figure 10) to answer sub-question 3: *how can lessons be learned in projects?*

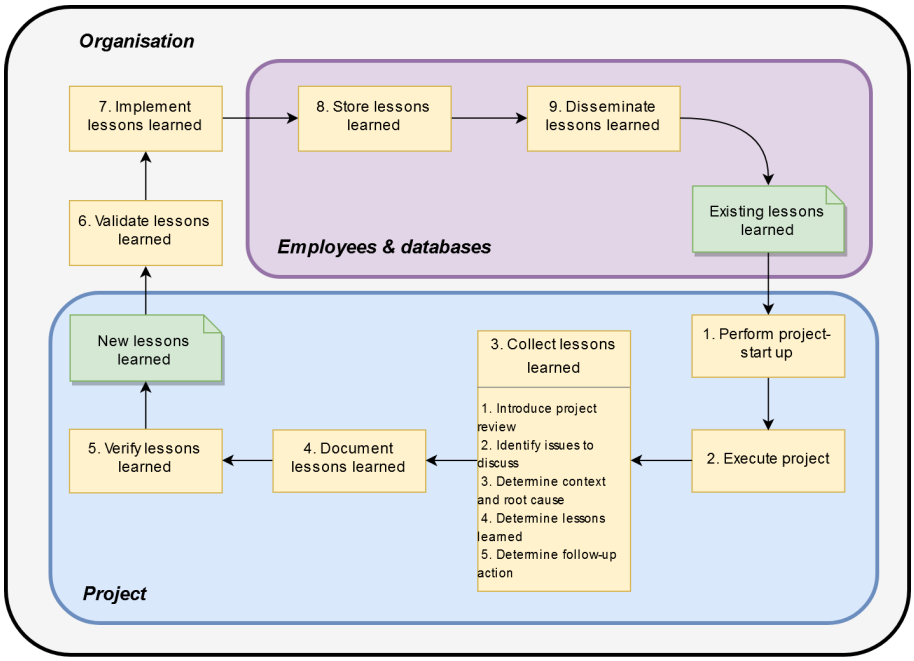


Figure 10: Lessons learned framework for projects (own illustration)

In addition to the step *executing the project (2)*, a total of eight different steps have been identified and these have been used to design the framework that is presented in Figure 10. The framework shows that projects, and employees and databases lie within an organisation. Furthermore, the framework shows that within the organisation, the lessons learned can make their way from the project to the employees and databases but several steps need to be conducted. If taking the *project start-up (1)* as a starting point, the lessons learned can be applied in future projects. A method to do this is by actively searching for existing lessons learned and discussing these during the start-up of a project.

Once the project has been *executed (2)*, lessons learned can be *collected (3)* by executing five sub-steps. Thereafter, the lessons learned need to be *documented (4)* and *verified (5)*. From thereon, the lessons learned can be *validated (6)* and *implemented (7)* within the organisation. The last steps are to *store (8)* the lessons learned in databases and *disseminate (9)* them to employees before they can be applied in future projects.

6

Validation of the lessons learned process

In this chapter a lessons learned process that can be applied within risk management will be developed. Firstly, in section 6.1 it will be explained how risk management is currently applied by the Ingenieursbureau and how the process that will be developed can fit into the current process. Thereafter, the process for learning lessons within risk management will be developed by validating it in four different steps[4] Thereafter, all the findings will be used to develop a final version of the process that will be presented in section 6.2. An overview of the findings from the four validations steps can be found in Appendix C. Lastly, in section 6.3 conclusions will be drawn and the fourth sub-question will be answered: *how can lessons be learned in risk management?*

6.1 Risk management process applied by the Ingenieursbureau

The Ingenieursbureau is involved in their projects from the initiation phase up to the completion phase, and is responsible for the risk management process of a project. To gain insight in how risk management is currently applied within the Ingenieursbureau, interviews have been conducted with risk managers and the transcripts of the interviews can be found in Appendix A.

The Ingenieursbureau applies the RISMAN-method and this is a commonly used method for risk management in construction projects in the Netherlands (Augustijn, 2006; Kuipers, 2016). This method was developed in the nineties by Twynstra Gudde in collaboration with public entities such as Rijkswaterstaat, ProRail, the Municipality of Rotterdam and Delft University of Technology (Van Well-Stam, Lindenaar, & Kinderen, 2004). The RISMAN-method is applied by large contractors such as Volkerinfra (De Ruijsscher, 2016), and by other large public organisations such as Rijkswaterstaat (Augustijn, 2006), ProRail (Ludlam, 2010) and the Municipality of the Hague (Mohan, 2011). The aim of the method is to approach risks pro-actively, make them explicit, manage them and determine control measures (T. Hartmann, Van Meerveld, Vossebeld, & Adriaanse, 2012). It is an iterative method and in every project phase a number of steps are performed at least once (Van Staveren, 2013). The five RISMAN-steps are conducted in risk sessions and the risk manager facilitates the sessions. The first step is to perform the risk analysis, the second is to choose the control measures, the third is to implement the control measures, the fourth is to evaluate the control measures and the fifth is to update the risk analysis. In this section the steps are explained briefly. The steps are shown in Figure 11 on the following page and the process that will be developed later in this chapter can facilitate learning and reusing lessons within risk management.

[4]More clarification on how the four steps have been executed can be found in section 2.2 on the research methodology.

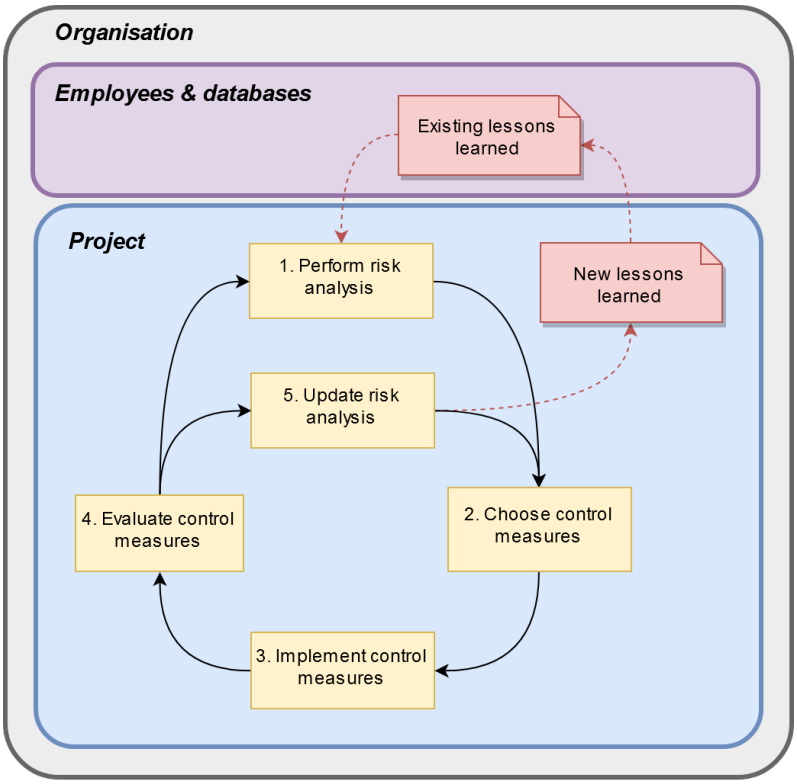


Figure 11: RISMAN-process (Source: Twynstra Gudde, 2019)

RISMAN Step 1: Perform risk analysis
The first step is to perform a risk analysis and this step consists of four sub-steps. The first step of the risk analysis is to set the project's objectives and determine the "least desirable event" (ongewenste topgebeurtenis). The risks that can effect this event get a higher quantification in the risk register. The risks with the highest quantification will become the top-risks and these will get the main focus during the rest of the following risk management steps. There are five least desirable events and they are planning, environment, costs, safety of quality. Furthermore, the second step of the risk analysis is to identify the project's risks, the third is to determine the critical risks and the fourth is to identify control measures.

RISMAN Step 2 & 3: Choose and implement control measures
The second and the third step are to choose and implement control measures. The result of the risk analysis is the critical risks and the possible control measures. When doing this, the effect of the control measure, the costs and the effort will be taken into consideration. Furthermore, the person who is responsible for the execution and implementation of the control measure is determined.

RISMAN Step 4: Evaluate control measures
The fourth step is to evaluate the control measures and during this step it is determined if the person responsible for the control measure has done his/her work correctly, and if the control measure has had the desired effect.

RISMAN Step 5: Update risk analysis
The fifth step is to update the risk analysis and during this step it is determined if any adjustments need to be made to the risk register. The adjustments mainly take place when the project phase changes because certain risks are not (as) important anymore, or have occurred. For instance, risks that are related to permits are more important during the preparation phase than during the construction phase.

6.2 Lessons learned process for risk management

The lessons learned process for projects consists of 8 main steps (Figure 10) and these have been used as input for the development of the process for risk management. The process has been developed by validating it in expert sessions, interviews and project reviews. A total of 54 findings have been found during the validation to improve the process and Table 15 shows where the findings per validation step can be found. The findings have been used to develop a final process and the results show that it consists of four main steps. The first step *to hold a project start-up or follow-up*, the second *to review the project*, the third step is *to document and verify the lessons learned* and the fourth step is *to store and disseminate the lessons learned*. These steps will be discussed in the following section.

Table 15: Overview of number of findings per validation step (own table)

Validation step	**Findings**	**Section**	**Page**
Expert session 1	12	C.1	92
Interviews	6	C.2	98
Project review 1	12	C.3	100
Project review 2	8	C.4	106
Project review 3	5	C.5	110
Expert session 2	11	C.6	112
Summary of findings	*54*	*C.7*	*116*

6.2.1 Hold project start-up and follow-up

Before the start of a new project and project phase it is important to discuss certain aspects with all the Integrated Project Management team. Firstly, the purpose and need for lessons learned during the project should be discussed to get the minds of the project team members focused on learning lessons. Secondly, the lessons learned process and strategy that will be applied should be discussed. Thirdly, it is important to discuss the lessons learned from previous projects so that they can be applied.

The project manager should ensure that this is discussed and that there is sufficient time during the project start-up to discuss the lessons learned. The project controller should be responsible for the content of the lessons learned that will be discussed. If needed, the project controller can collaborate or be assisted by the technical, environment, contract or risk manager.

6.2.2 Review project

The objective of a project review is to collect the lessons learned and this should take place at least at the end of every project phase. During the project review, the Integrated Project Management team and the risk manager should be present. The project controller should be responsible to ensure that the project reviews are planned. Furthermore, the project controller should collect the lessons learned outside of the project review. The project controller is present during the project team meetings and the risk manager is not.

The risk manager should be responsible for facilitating the project review. In the literature it was mentioned that it is important that an external facilitator is present. However, the results of this research showed that the risk manager should not be an external risks manager since an external risk manager has a knowledge deficit regarding what happened in the project. Prior to the project review, the risk manager should ensure that the risk register is up to date. For instance, the risk manager should check if the status (occurred, not occurred, expired) of the risks are correct and all the control measures are listed. Furthermore, prior to the project review, the risk manager should ensure that all

project team members that will be present should prepare the project review. There are 5 steps that need to be conducted to collect lessons learned and these are discussed below.

1: Project review introduction
In this step the risk manager should introduce the project review by discussing the purpose, process and desired outcome of the project review. Furthermore, it should be explained that future project teams can benefit from the outcome of the project review.

2: Identify risks to discuss
In this step the risk manager should determine (together with the project team) which risks will be discussed in the following steps. The term risks includes risks that occurred, risks that did not occur, risks that have expired and risks that were unforeseen. Practice showed that project team members have the tendency to want to review the risks that have occurred and had an impact. However, all risks should be considered to be discussed because the results showed that risks that have not occurred, and therefore have not had impact, can contain valuable lessons. Therefore, it is important to consider all risks meaning the risks that have had occurred, the risks that have not occurred, and the risks that have expired. Furthermore, the unforeseen risks should be determined and this can be done by discussing the "request for change" (verzoek ter wijziging) list and asking the project team what other unforeseen risks have been.

Project team members should be asked to identify the most important risks that should be discussed prior to the session. This is because it can be ineffective if all project team members look at the risk register for the first time during the session. During the session the risk manager can make a selection of the risks that are going to be discussed.

3: Determine context and root cause
This step is to firstly determine what happened (context) and secondly why (root cause) it happened. An overview of the information that needs to be determined is shown in Table 16. Firstly, the context of a risk can be determined by determining has a risk has been identified, has a risk occurred, the cause(s) of the risk, the control measure(s) that have been taken, which cause and effect a control measure may influences and if a control measure has been executed. Furthermore, an extra check should be done if all the information in the risk register is correct and if there are no control measures missing. Secondly, the root cause does not focus on the risk itself but on the control measure(s). The root cause can be determined for Risks A and C by determining why a control measure was chosen and what the effect of the control measure was on the risk. For Risks B and E, it should be determined why no control measures were taken and what the effect of not choosing a control measure was on the risk. For Risk E, it should be determined why a control measures was chosen and what the effect of the control measure was on the risk. Furthermore, for Risk E it should be determined why the risk was not identified (on time).

Table 16: Context and root cause combinations for different risk situations (own table)

	Identified	Occurred	Control measures					
			Overview	Cause	Effect	Executed	Reason	Effective
Risk A	*	*	CM A1	...	...	yes/no	...	...
			CM A2	...	...	yes/no	...	...
Risk B	*	*					...	...
Risk C	*		CM C1	...	...	yes/no	...	...
			CM C2	...	...	yes/no	...	...
Risk D	*						...	...
Risk E		*	CM E1	...	...	yes/no	...	...
			CM E2	...	...	yes/no	...	...

4: Determine lessons learned
In this step the lessons learned should be determined per control measure and this can be done by using the context and the root cause. The combination of the context and root cause contain important information and the project team should determine if and how this information can be valuable to future project teams. Furthermore, determine if lessons learned per control measure can be grouped together to form a stronger lesson learned. Thereafter, it should be determined if the lessons learned are not too specific and if generalising the lessons learned may not increase the applicability of the lesson learned in future projects.

5: Determine follow-up action
This step is to determine if a follow-up action is needed. Examples of follow-up actions are further investigation, updating a procedure or process, circulating a decision to higher management, or validating and implementing a lessons learned. If it is not clear if a follow-up action is needed, this can be done by:

1. Determine if the problem/risk that occurred, occurs in (many) other projects as well.
2. Determine if it is possible to control/influence the problem within the means a project team has.

Furthermore, if lessons learned need validating and implementing this can be considered a follow-up step.

6.2.3 Document and verify lessons learned

The third step to document the lessons learned and this should be done after the project review by the risk manager. The information that should be included in the document in shown below.

[Title of lesson learned]
Control measure: *This can be found in the risk register*
Effect of control measure:
Reason why control measure was chosen:
Control measure executed: yes/no
Lesson learned:
Follow-up action:
Responsible Integrated Project Management role:
Project type:
Project phase:
Risk category:
Risk: *This can be found in the risk register*
Identified: yes/no
Occurred: yes/no
Cause: *This can be found in the risk register*
Effect: *This can be found in the risk register*

After the documentation, the lessons learned need to be verified and this should be done by the risk manager. Firstly, the documented lessons learned should be verified with the Integrated Project Management. The project team members should have to opportunity to analyse and respond to the document to determine if the lessons learned have been formulated correctly. Thereafter, the risk manager can make adjustments to the documented lessons learned. Secondly, the lessons learned should be verified by an external risk manager. The external risk manager should verify if the lessons learned are clear, not too specific, not too general, and relevant and applicable to future projects.

6.2.4 Store and disseminate lessons learned

The fourth step is to store and disseminate the lessons learned and this should be done by the risk manager. Firstly, to store the lessons learned a database is needed. According to the literature and according to the interviewees, the most important requirement of a database is that it should be easy to use and accessible. To find information fast and easy, an index and capabilities to search for keywords can be implemented. After the lessons learned are saved they can be disseminated. It is important to send it to the Integrated Project Management team and the choice can be made to sent it too other project teams as well.

6.3 Conclusion

In Chapter 4 the conclusion was drawn that the absence of a lessons learned process is the main barrier of learning lessons within the Ingenieursbureau. All interviewees acknowledged that more should be done to learn lessons within the Ingenieursbureau and that the organisation could benefit from implementing a lessons learned process for risk management. In this chapter a lessons learned process that can be applied within risk management has been developed. The results have been used to design a framework (Figure 12) to answer sub-question 4: *how can lessons be learned in risk management?*

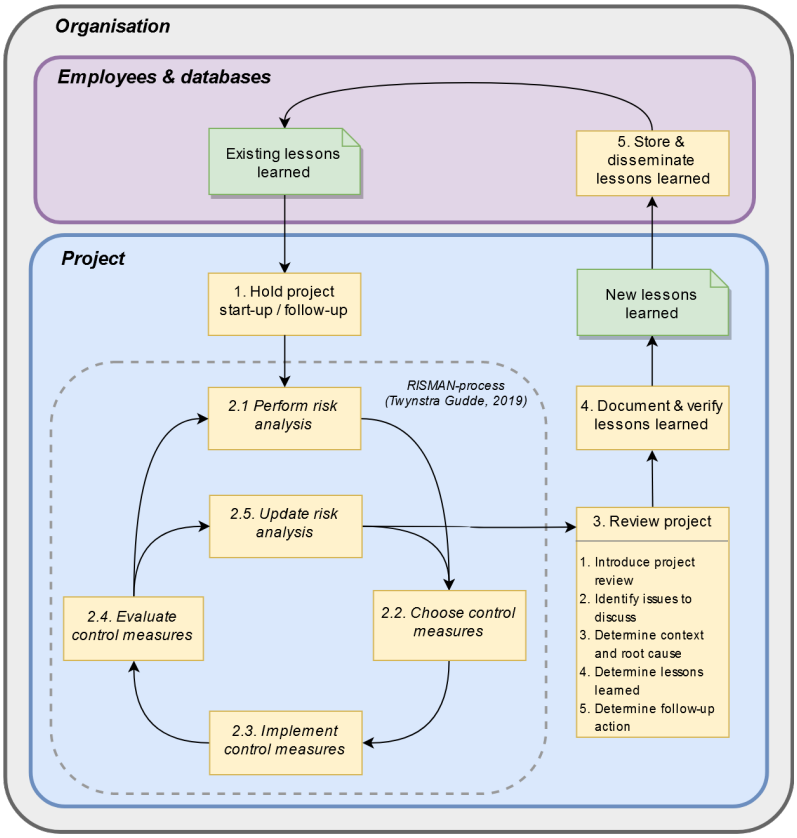


Figure 12: Lessons learned framework for risk management (own illustration)

The lessons learned process for projects that was identified in the literature study in Chapter 5 has been used as input. The process has been validated by discussing in expert sessions and interviews, and by testing it in project reviews. During the project reviews the process proved to be capable of collecting lessons learned in three projects that were all in a different project phase. The results show that four steps should be taken to learn lessons in risk management. The steps that have been discussed in this chapter have been combined with the existing RISMAN-process to design the framework that is presented in Figure 12. The framework shows that projects, and employees and databases lie within an organisation. Furthermore, the framework shows that within the organisation,

the lessons learned within risk management can make their way from the project to the employees and databases but several steps need to be conducted. The first step is to hold a *project start-up or follow-up (1)* and the Integrated Project Management team should be present. During this session the importance of lessons learned and the lessons learned process that will be applied within the project should be discussed. Furthermore, lessons learned from previous projects should be discussed. A method to do this is by actively searching for existing lessons learned and discussing these. The project manager should be responsible that these aspects are discussed and the project controller should be responsible for the content. Once *the RISMAN-process (2)* has been executed, the project can be *reviewed (3)* to collect lessons learned by executing five sub-steps. During the project review the Integrated Project Management team should be present, the project controller should plan the review and the risk manager should facilitate it. All risks should be considered to be discussed and not only risks that have occurred and created an impact. This is because risks that have not occurred, and therefore have not had impact, can contain valuable lessons. To determine lessons learned during the project review, it is important to focus on the control measures of a risk and especially on why a specific control measure has been chosen and what the effect of it has been on the risk. Thereafter, the lessons learned need to be *documented and verified (4)* by a risk manager. From thereon, the lessons learned can be *stored (5)* in databases and *disseminated (5)* to employees before they can be applied in future projects.

Phase IV

Conclusion, & discussion

7
Conclusion

The objective of this research is *to study how the facilitators and barriers can influence learning lessons in an organisation and to develop a lessons learned process for risk management.* To reach this objective, the report has been divided into two main parts that have been addressed with Phase II and Phase III. Phase II was dedicated to the facilitators and barriers and sub-questions 1 and 2. This will be discussed in section 7.1. Phase III was dedicated to the lessons learned process and sub-questions 3 and 4. This will be discussed in section 7.2. Thereafter, in section 7.3 the results from all sub-questions will be combined to answer the main research question: *How can the lessons learned of risk management be collected and applied in future construction projects?*

7.1 Answering the sub-questions of Phase II

The first part of the research focused on *studying how the facilitators and barriers can influence learning lessons in an organisation* In this research the Systemic lessons learned knowledge (Syllk) model developed by Duffield and Whitty (2012) has been used to study the facilitators and barriers of learning lessons within organisations. This model has been chosen because there are limited models that conceptualise organisational learning and this is the only model found that clearly shows how facilitators and barriers influence this. Duffield and Whitty (2012) have applied the Syllk-model within different types of organisations to identify the possible facilitators and barriers by organising a brainstorming session with employees. This has been done for a public project-based organisation that executes infrastructure projects just as the Ingenieursbureau, but these identified variables have not been copied because the validity of them is questioned. The first reason is that the outcome of such a session can be very dependent on the group composition. The second reason is that the variables may be specific for the organisation that it has been identified for. The third reason is that multiple variables are not understandable or there is overlap between the variables. Therefore, an additional literature study towards facilitators and barriers has been conducted in this research to identify variables and the Syllk-model has been used to categorise them (see Table 17). Duffield and Whitty have defined two main categories and both categories are divided into three "layers" and each layer consists of several facilitators and barriers. The first Syllk-category is *people* and this category focuses on the employees of an organisation. The layers are *learning*, *culture* and *social*, and it is considered to have a greater influence on organisational learning than the second category (Lank, 1997; Von Zedtwitz, 2002; Maqsood, 2006; Duffield & Whitty, 2012; Paranagamage et al., 2012). The second Syllk-category is *systems* and this category focuses on the systems that are required to support employees in learning. The layers are *technology*, *process* and *infrastructure.* The Syllk-model categorisation and the additional literature study have been combined to answer the first sub-question: *what are facilitators and barriers of an organisation to learn lessons within projects?* In Table 17 the results are shown in in the column *Variables literature study.*

Table 17: Facilitators and barriers: results of literature study and Ingenieursbureau (own table)

Layer		**Variables literature study**[a]	**Results Ingenieursbureau**
Learning (People)	1	Workshops and training	Insufficient workshops and training (B)
	2	Willingness to learn	Willingness to learn (F)
	3	Stimulated to share information	Insufficient stimulation to share information (B)
	4	Willingness to share information	Willingness to share information (F)
	5	Unstressed working environment	Unstressed working environment (F)
Culture (People)	6	Support from higher management	Lack of support (B)
	7	Positive feedback from colleagues	Insufficient feedback (B)
	8	Colleagues accept each other	Colleagues accept each other (F)
	9	Colleagues accept mistakes	Insufficient acceptance (B)
	10	Comfortable to speak freely	Comfortable to speak freely (F)
Social (People)	11	Sufficient collaboration within teams	Insufficient collaboration (B)
	12	Reliable colleagues	Reliable colleagues (F)
	13*	~~Honesty and integrity~~ Approachable colleagues	Approachable colleagues (F)
	14*	~~Trust~~ Social contact during work	Social contact during work (F)
	15*	~~Social contact~~ Social contact outside of work	Insufficient contact outside of work (B)
Technology (Systems)	16	Fast and efficient	Slow and inefficient (B)
	17	Reliable systems	Unreliable systems (B)
	18	Easy to use	Not easy to use (B)
	19	Clear overview of systems	Clear overview of systems (F)
	20	Interconnection	Insufficient interconnection (B)
Process (Systems)	21	Clear and well understood	Unclear and not well understood (B)
	22	Guidelines of the process are well documented	Unclear guidelines (B)
	23	Training is provided how to execute the process	Insufficient training (B)
	24	Clear outcome and desired results	Unclear outcome (B)
	25	Flexible	Inflexible (B)
Infrastructure (Systems)	26	Pleasant physical working space	Unpleasant working space (B)
	27	Open door policy	Open door policy (F)
	28	Short geographical distances	Short geographical distances (F)
	29	Training facilities and meeting rooms available	Insufficient availability (B)
	30	Clean facilities	Unclean facilities (B)

[d]Facilitators 13, 14 and 15 have been adjusted as result of the validation session.

The second sub-question is *what are the facilitators and barriers of the Ingenieursbureau to learn lessons within projects?* The Syllk-model has been applied in previous research to identify possible variables that could facilitate or hinder learning within an organisation. However, in no previous research has it been determined if these variables facilitate or hinder learning within an organisation, and therefore this research is the first. This has been done by validating the variables, creating a questionnaire of the validated variables and thereafter conducting interviews with project managers, project controllers and risk managers. The variables that were identified in the literature study (Table 17) were validated with risk managers. The results of the session showed the layer *social* had three variables that were not clear or had overlap. Firstly, feedback was that the facilitators *reliable colleagues*$_{12}$, *honesty and integrity*$_{13}$ and *trust*$_{14}$ have overlap. Therefore, these facilitators have been combined into one facilitator, namely *reliable colleagues*$_{12}$. Secondly, the risk managers agreed that a social facilitator was missing and has been defined as *approachable colleagues*$_{13*}$. Thirdly, feedback was that it was not clear how the facilitator *social contact*$_{15}$ should be interpreted because social contact can take place during work and outside of work. In section 5.1 it has been explained that social contact is of great importance for the transfer of tacit knowledge because not all lessons learned may be written down. Therefore, the facilitator has been divided into *social contact during work*$_{14*}$ and *social contact outside of work*$_{15*}$. After the validation session, the variables were used to create statements that were used in a questionnaire, and the results were discussed during the interviews with project managers, project controllers and risk managers. In the literature study, 30

variables have been identified that could facilitate or hinder learning, and the results show that 19 of these are considered to be possible barriers within the Ingenieursbureau. In Table 17 of the results of the second sub-question are shown in in the column *Results Ingenieursbureau*. The facilitators are shown in green and have a (F) behind the variable, and the barriers in red and have a (B) behind the variable. The results show that the layer *process* contains the most barriers. This is because the Ingenieursbureau does not have a process to learn lessons within the organisation.

7.2 Answering the sub-questions of Phase III

The second part of the research focused on *developing a lessons learned process for risk management* and answering sub-questions 3 and 4 was central. The steps of existing lessons learned processes are not consistent and therefore a literature study has been conducted in this research. To gain further insights, the steps of 18 different processes have been reviewed and compared. This has been used to develop a framework presented in Figure 13 to answer the third sub-question is *how can lessons be learned in projects?* The framework shows that within the organisation, lessons can be learned within projects and these can be applied in future projects but several steps need to be conducted. Figure 13 shows that the lessons learned can be applied in *the project start-up (1)* of future projects. A method to do this is by actively searching for them and discussing these during the start-up of a project. Once *the project has been executed (2)*, *new lessons learned can be collected (3)* by executing five sub-steps. Thereafter, the lessons learned need to be *documented (4)* and *verified (5)*. From thereon, the lessons learned can be *validated (6)* and *implemented (7)* within the organisation. The last steps are to *store (8)* the lessons learned in databases and *disseminate (9)* them to employees. Thereafter, these existing can be applied in future projects by discussing them during the first step in *the start-up of a project (1)*.

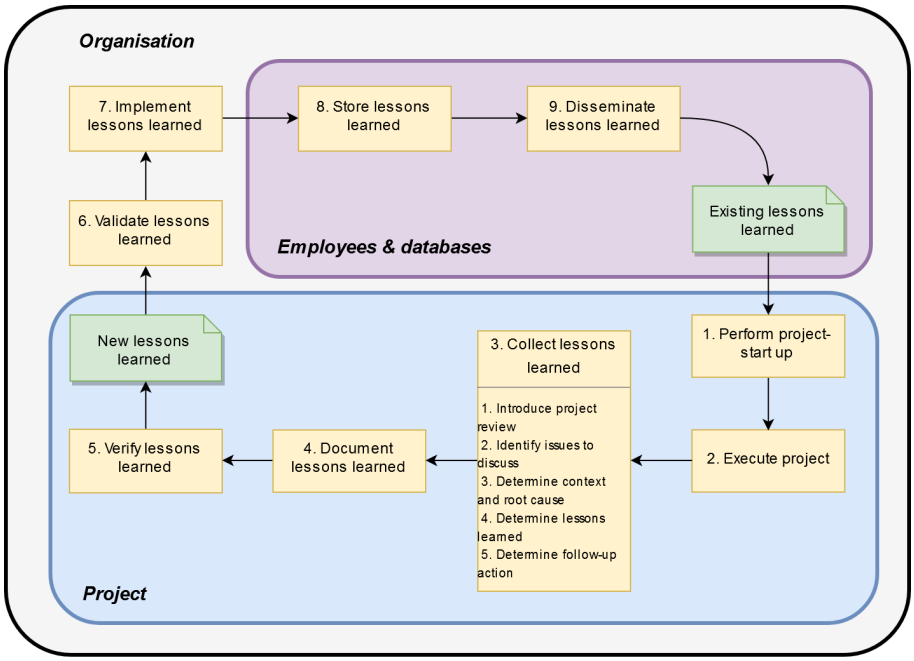


Figure 13: Lessons learned framework for projects (own illustration)

The results from sub-question 3 (Figure 13) have been used as input to develop a lessons learned process for risk management. It has been developed by discussing the process in expert sessions and interviews, and by testing it in project reviews. The findings of each steps have been used to improve the process before applying it in the following step. During the project reviews the process proved to be capable of collecting lessons learned in three projects that were all in a different project phases. The results show that four steps should be taken to learn lessons in risk management. The Ingenieursbureau applies the RISMAN-method within their projects and this is a common risk management method that is applied within construction projects in the Netherlands (Augustijn, 2006; Kuipers, 2016). The four steps have

been combined with the existing RISMAN-steps to design the framework that is presented in Figure 14 to answer the fourth sub-question is *how can lessons be learned in risk management?* The first step is to discuss the purpose of lessons learned during the project, discuss the lessons learned process and strategy that will be used during the project, and discuss existing lessons learned during *the project start-up of follow-up (1).* The second step is to execute risk management according to the *RISMAN-process (2).* Thereafter, *the project should be reviewed (3)* and the objective of this step is to collect lessons learned. *Reviewing the project (3)* consists of 5 sub-steps and these are *introduce project review, identify issues to discuss, determine context and root cause, determine lessons learned* and *determine follow-up action.* Practice showed that project team members have the tendency to want to review the risks that have occurred and had an impact. However, all risks should be considered to be discussed because the results of this research showed that risks that have not occurred, and therefore have not had impact, can contain valuable lessons. Furthermore, the results of this research showed that to determine lessons learned during the project review, it is important to focus on the control measures of a risk and especially on why a specific control measure has been chosen and what the effect of it has been on the risk. The fourth step is for the risk manager to *document and verified the lessons learned (4).* For documentation a uniform document should be used and verification should be made by the project team first and by an external risk manager as second. Lastly, the lessons learned should be *stored (5)* in databases and *disseminated (5)* to employees. It is important that the database is easy accessible for employees and user-friendly. Thereafter, existing lessons learned can be applied in new projects by discussing them during the first step in *the start-up or follow-up of a project (1).*

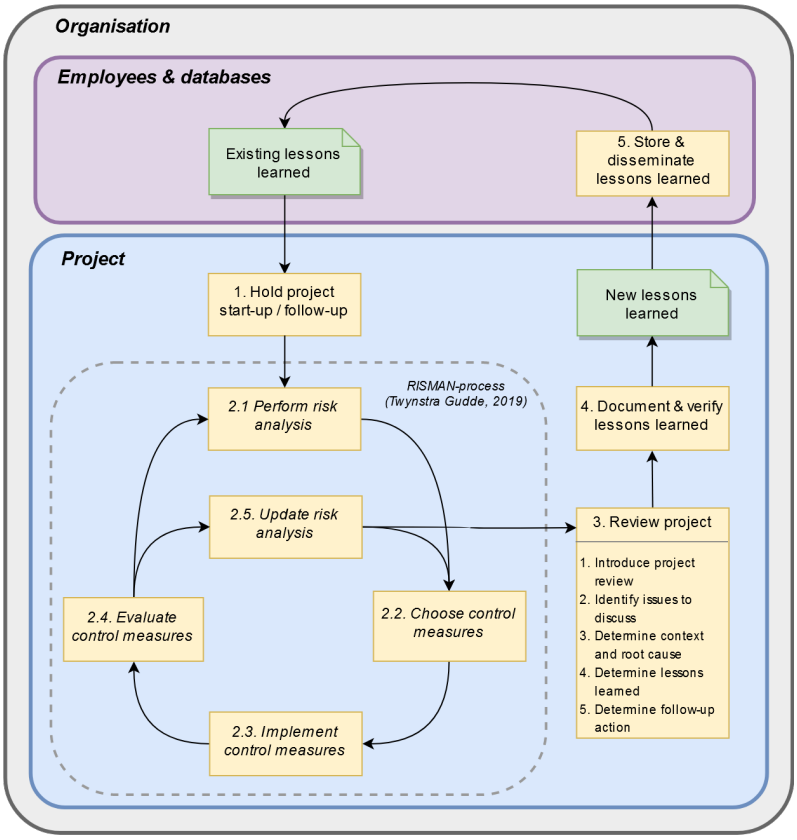


Figure 14: Lessons learned framework for risk management (own illustration)

7.3 Answering the main research question

Every construction project has risks due to the complex environment (Beltrão & Carvalho, 2019). Managing these risks is crucial for a project's success and in contrast, poor and ineffective risk management can lead to a project's failure (Eaton et al., 2016). The construction sector has rather poorly developed organisational learning capabilities (Styhre et al., 2004) and this results in lessons not being learned and applied in future projects. Lessons learned can help to reduce project risks because they form the intellectual assets of an organisation (Carrillo et al., 2013). However, two problems have been encountered during research. Firstly, no lessons process has yet been developed for risk management and learning will not occur unless a clear process has been defined within an organisation (Williams, 2008). Secondly, lessons learned processes fail to deliver and are ineffective in organisations because other variables can facilitate or hinder an organisation's ability to learn lessons (Duffield & Whitty, 2012). This research is the first to develop a lessons learned process for risk management and is also the first to study and determine the interaction of facilitators and barriers with the lessons learned processes. This research focused on filling these gaps in the known scientific literature. This has been done by combining these separate theories into a framework (Figure 15) to address the practical problems that organisations in the construction sector encounter and to answer the main research question: *how can the lessons learned of risk management be collected and applied in future construction projects?*

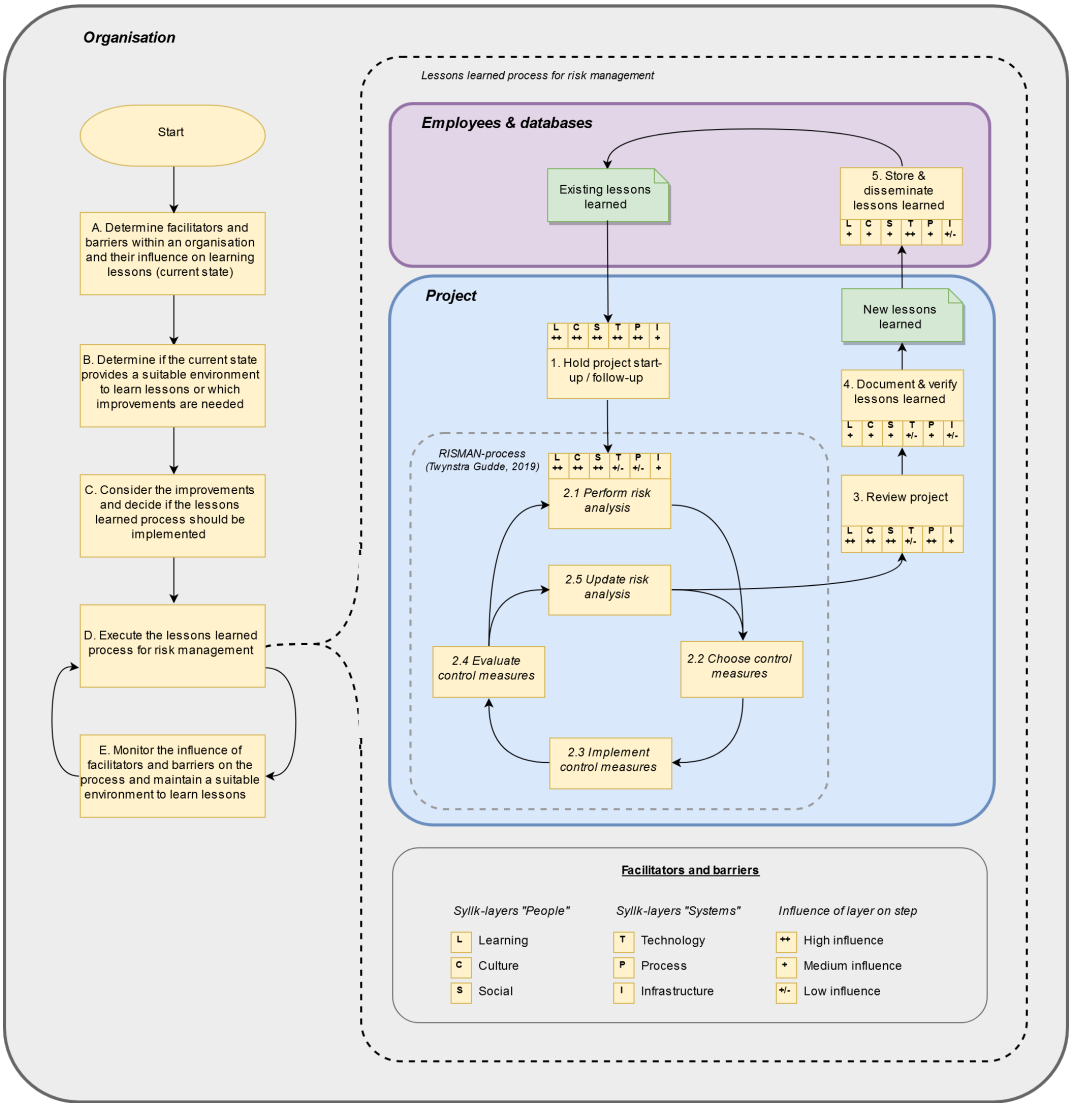


Figure 15: Final lessons learned framework for risk management (own illustration)

The framework shows the starting position followed by five steps (A-E) on the left that represent the steps that need to be taken within the organisation before and after implementation of the lessons learned process. The lessons learned process itself is shown in Step D and further detail on the process is shown within the dotted lines. It shows the interaction between the projects, and employees and databases within an organisation. A legend for the interaction of facilitators and barriers within the process is shown at the bottom. The combination of developing a lessons learned process and determining the facilitators and barriers was perceived as valuable and effective within the Ingenieursbureau. This is because the results of this research show that without properly addressing the facilitators and barriers, the implementation of the process may have failed because the organisation does not provide a suitable environment.

Step A shows that the first step is to determine what the facilitators and barriers are within an organisation. Thereafter, it should be determined how they influence learning within the organisation. This can be done by using lessons learned process in the framework (Figure 15) as it shows how the Syllk-layers influence each step. The figure shows that some layers have a greater influence on certain steps than on other steps. The results of how the Syllk-layers influence each step can be found in Appendix E. The first Syllk-category *people* represents the layers *learning*, *culture* and *social*. The results of this research show that these layers highly influence the steps *hold project start-up or follow up (1)*, *risk analysis (2.1)* and the *project review (3)*. This is because interaction and collaboration between the project team members during such sessions is of great importance. Furthermore, the results of this research show that the layers *learning*, *culture* and *social*l influence the step *document and verify lessons learned (4)* and the step *store and disseminate lessons learned (5)*. The influence is less than the other mentioned steps because these tasks are executed by a risk manager and the intensity of interaction, collaboration and the complexity of the steps are less. The second Syllk-category *systems* represents the layers *technology*, *process* and *infrastructure*. The results of this research show that the layer *process* influences most steps but highly influences the *project start-up or follow up (1)*, and the *project review (3)*. This is because the process is used to guide the project team during the sessions and expected to have a high influence on the outcomes of the sessions. During such sessions, the project team will get together and therefore the layer *infrastructure* can influence these steps because facilities will be needed for the sessions. The layer *technology* has high influence on the *project start-up or follow up (1)*, and on *storing the lessons learned (5)*. This is because a user-friendly database is required to save the lessons learned in and to retrieve them from.

Step B shows that these insights should be used to determine if the current state of the organisation is suitable and provides sufficient support to learn lessons. If this is not the case, it should be determined which improvements are needed to create this. For instance, the layer technology has high influence on storing the lessons learned. If the results of the facilitators and barriers have shown that the technology is a barrier within an organisation, it should be considered to improve the technology within the company. Thereafter, in Step C the consideration can be made to determine if the improvements are achievable to ensure the suitable environment and the decision can be made to implement the lessons learned process. This it because an organisation may not have sufficient resources to ensure the suitable environment or it may not be possible to achieve this in short-term, which can result in the process not obtaining the desired results.

If the process is implemented, the process can be executed (Step D). The lessons learned process that has been developed within this research has been tested in three project reviews. Each project was in a different project phase and the process proved capable of collecting lessons learned for each project. A concept version has been presented to the risk managers of the Ingenieursbureau and they recognise that the implementation of the process may add value to their risk management activities as it collects the lessons learned that were not addressed in the current situation. It is perceived as valuable because these lessons learned can be applied in future projects which may result in identifying risks earlier, not reinventing the wheel and not making the same mistakes. The concept version has been finalised by using their final feedback given by the risk managers to further improve it, thus improving its efficiency.

The process should be continuously monitored (Step E). This continuous interaction between executing the process and monitoring is to ensure a suitable environment and this interaction is shown in the framework. The continuous monitoring is required because the construction sector is constantly changing over time and this requires organisations to adapt to these changes (Kristiansen, Emmitt, & Bonke, 2005). It is important for an organisation to be aware that this can affect the influence of the Syllk-layers over time and may affect the outcomes of the process. For example, organisations within the sector adapt to technological changes and such changes can influence the steps in the process.

7.4 Recommendations for the Ingenieursbureau

In this section the recommendations for the Ingenieursbureau are discussed. The recommendations are based on the results obtained within this research and will be determined applying Step A, B and C that are shown in Figure 15.

7.4.1 Step A: Determine facilitators and barriers and their influence

In Chapter 4, the facilitators and barriers have been determined for the Ingenieursbureau and what their influence on learning lessons may be. In Appendix E an analysis has been performed to determine what the influence of each variable will be on each step of the process. The results from Chapter 4 and Appendix E have been combined to determine the current state within the Ingenieursbureau and the results are shown in Figure 16.

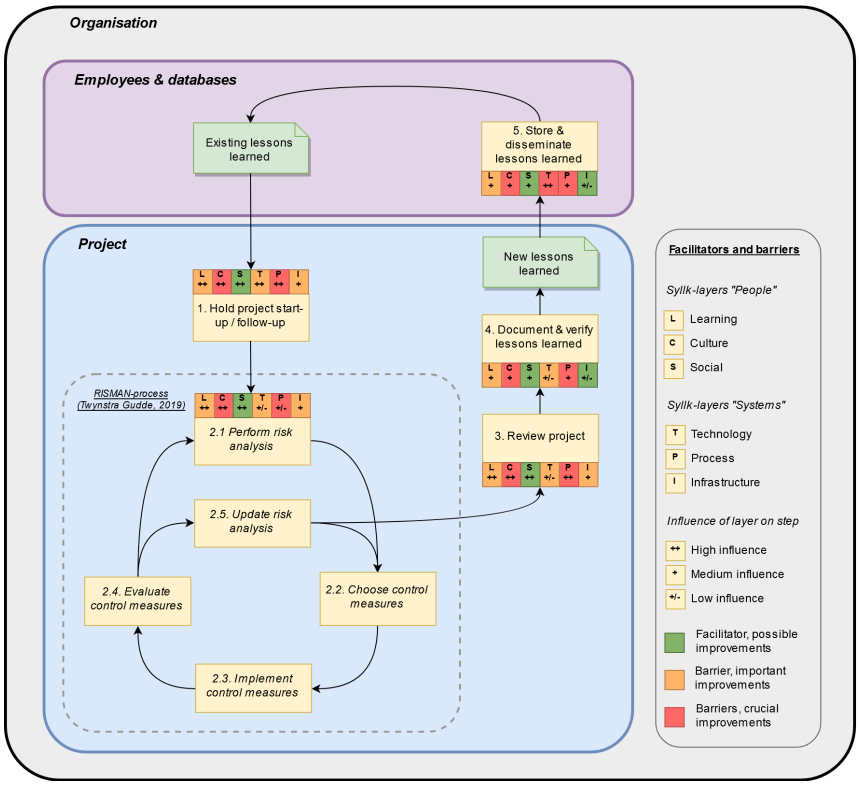


Figure 16: Current learning environment for the Ingenieursbureau (own illustration)

7.4.2 Step B: Determine possible improvements

In Chapter 4, it has been recommended to improve specific barriers and this has been combined with the insights of Figure 16. This has been done to determine if the current state provides a suitable environment to learn lessons, or which improvements are needed. The results show that the current state does not provide a suitable environment and in this section the improvements will be discussed. The improvements that are highly recommended are required to ensure a suitable environment and the recommended improvements are advised.

Learning (people)

Increase the attendance of workshops and training (recommended)

There are many possibilities to attend workshops but employees do not always make time free to attend any. Having workshops is a method to transfer tacit knowledge (Wiewiora et al., 2009) and enhancing this can be beneficial for learning. This is because the lessons learned process mainly focuses on making knowledge explicit by documenting and storing it. However, tacit knowledge is just as important (Hertogh et al., 2016). Therefore, the recommendation is to increase the number of workshops employees attend. For example, it could be made compulsory to attend a certain number of workshops a year.

Increase the stimulation to share information (recommended)

An organisation should stimulate their employees to share information and the results of the interviews showed that this should be improved. There are employees with a lot of knowledge but this is not shared within the organisation. Stimulating this could improve the sharing of explicit and tacit knowledge regarding lessons learned amongst employees. This could positively influence all the steps of the process, and especially *hold project start-up or follow-up (1)*, *perform risk analysis (2)* and *review project (3)*. Therefore, the recommendation is to increase the stimulation to share information within the organisation. For example, it could be made a compulsory element of a project to present and share the findings and lessons learned to other employees.

Culture (people)

Higher management should provide more support (highly recommended)

Figure 16 shows that the layer *culture* needs improvements that are highly recommended to be able to execute each step. This is because there is insufficient support from higher management when initiatives are implemented and this results in initiatives not succeeding. Higher management does not always check if employees adhere to initiatives, not working in a uniform working style and not knowing how their colleagues execute the same tasks at work. If the process is implemented, it is crucial that employees adhere to the guidelines of the process and work uniformly. Therefore, it is highly recommended that higher management should monitor if the process is executed uniformly and according to the guidelines. It should become a compulsory part of the project plan and work process for projects.

Focus more on mistakes than achievements (recommended)

The importance of accepting mistakes is acknowledged within the Ingenieursbureau and stimulated by project managers. However, it remains difficult because the focus within projects lies mainly on achievements and on the positive aspects of the project, and not on the negative. It is very important, especially during the *project review (3)*, that colleagues accept mistakes and are able to discuss them openly because this is how lessons are learned. Therefore, the recommendation is that the focus within projects does not only lie on the achievements but also on the mistakes.

Social (people)

Figure 16 shows that the layer *social* facilitates each step in the process and therefore no improvements are recommended.

Technology (systems)

Develop database to save lessons learned (highly recommended)

Figure 16 shows improvements that are highly recommended in the layer *technology* to execute the steps *hold project start-up or follow up (1)* and *store and disseminate lessons learned (5)*. This is because the lessons learned need to be stored in a database but this has not been developed yet within the organisation. Furthermore, the results of this research showed that the employees are not satisfied with the current computer technology and all interviewees indicated that their most important requirement is that the database is user-friendly. Therefore, it is not only highly recommended to develop a database to store lessons learned on but to ensure that the database is user-friendly. This

could be done by using keywords and other meta-data to search for lessons learned. During this research, the possibilities have been explored as to how such a database could be developed within the Ingenieursbureau. The department that is responsible for such developments indicated that this could easily be developed and implemented. However, before the decision can be made to develop such a platform, the importance and added value for the rest of the Ingenieursbureau has to be determined.

Improve computer systems (recommended)

Figure 16 shows that improvements are recommended for all steps in the layer *technology*. This is because four of the five variables of this layer were considered to hinder learning, especially the interconnection of computer systems. Therefore, it is recommended to look into the computer systems and determine how large the impact may be on learning lessons, and if improving this may be needed.

Process (systems)

Improve current lessons learned process (highly recommended)

Figure 16 shows that improvements are highly recommended for all steps in the layer *process*. This is because currently there is no process within the organisation. However, no recommendation can be made yet whether to implement the process or not. The current state and all the improvements need to be taken into consideration to make a recommendation and this is done in section 7.4.3.

Infrastructure (systems)

Improve the availability of meeting rooms (recommended)

Figure 16 shows that the layer *infrastructure* hinders the steps *hold project start and follow-ups (1)*, *perform risk analysis (2)* and *review project (3)*. This is because it is difficult to reserve meeting rooms and meeting rooms will be needed to execute these steps. It is the norm that a meeting room has to be booked 2-3 months in advance or an external meeting room has to be booked. Furthermore, it often occurs that the meeting rooms are not occupied despite that the meeting rooms have been booked. Therefore, it is recommended to look into these difficulties before implementing the process and improve the availability. This could be done by ensuring that more rooms are available to book or that the process to book meeting rooms is reviewed.

7.4.3 Consider the improvements and decide on implementing the process

In the literature study it has been concluded that the Syllk-category *people* has the most influence on learning. This is in line with the results of this research as Figure 16 shows that this category has high influence on the steps in the process that focus on learning new lessons or applying them in new projects. Therefore, it is beneficial that the results show that this category contains the main facilitators of the Ingenieursbureau. These facilitators will influence learning positively and examples of the facilitators of the Ingenieursbureau are: *approachable colleagues*, *social contact during work*, *colleagues accept each other*, *reliable colleagues*, *willingness to learn and share information*, and *comfortable to speak freely*. However, the layer *culture* does require an improvement that is highly recommended and that is that the higher management needs to provide sufficient support for the process. This can be done by monitoring the process and ensuring that it is executed uniformly according to the guidelines. The support of higher management will therefore positively influence the outcome of the process. The Syllk-category *systems* contains two improvements that are highly recommended and the first is to develop a platform to save lessons learned. The department that is responsible for such developments indicated that this could easily be developed and implemented. The second is that currently there is no lessons learned process and the implementation of this process will remove this barrier. Based on the results of this research it is recommended to implement the process provided that the highly recommended improvements are implemented in the organisation and the other recommendations are taken into account. Furthermore, it is important to continuously monitor the influence of the facilitators and barriers on the process and maintain a suitable environment to learn lessons (Step E).

8 Discussion

In this chapter the discussion is presented and consists of two sections. Firstly, in section 8.1 the scientific and practical contribution is explained. Secondly, in section 8.2 the limitations of the research are discussed.

8.1 Contribution of the research

The objective of this research is *to study how the facilitators and barriers can influence learning lessons in an organisation and to develop a lessons learned process for risk management.* This objective has been reached and the results of this research has scientific and practical contribution.

The first part of the objective is *to study how the facilitators and barriers can influence learning lessons in an organisation* and the method that has been used in this research has scientific contribution and practical contribution. It is hard for project-based organisations to collect and implement lessons learned (Williams, 2007) and a reason is organisations do not consider other facilitators and barriers that influence the ability to learn and reuse lessons (Duffield & Whitty, 2012). To gain insight into this, Duffield and Whitty (2012) developed the Syllk-model and applied this model within different organisations to identify possible facilitators and barriers. However, in their research and in no other research that could be found, the model had been applied in such a way that it was determined if each identified facilitator and barrier, facilitates or hinders the learning capabilities of an organisation. In this research a method was developed to determine this for the Ingenieursbureau. This was done by quantifying the facilitators and barriers by translating them into statements that interviewees could score and interviews were conducted to determine the reasoning behind each answer. The obtained results by the method that has been applied are considered to be valuable because they have showed important insights that have been used to provide support to the lessons learned process that has been recommended. Therefore, the method that has been applied in this research to quantify the facilitators and barriers, and later determine why it can be seen as a facilitator or barrier can be seen as a scientific and practical contribution because it has not been applied before and generates valuable insights.

The second part of the objective is *to develop a lessons learned process for risk management.* . This research has contributed to the current risk management body of knowledge by developing a (first version) of a process that can be applied to learn and reuse lessons. This contributes because no process or framework to learn lessons within risk management has been developed yet and therefore the research has scientific contribution. Learning lessons can help reduce risks in future projects (Schindler & Eppler, 2003; Howard & Smith, 2016) and effectively applying lessons learned can lead to a sustainable competitive advantage (Carrillo et al., 2010). The construction sector has poorly developed organisational capabilities (Styhre et al., 2004) and therefore the process has practical contribution because the construction companies can benefit from applying this process within their risk management process.

The two research objectives have been combined to determine the interaction of facilitators and barriers with the lessons learned process. In the known scientific literature this has not been studied and therefore this has scientific contribution.

8.2 Limitations of the research

The limitations of a research are characteristics of design or methodology that impacted or influenced the interpretation of the findings. In this research four limitations have been identified and these will be discussed below.

External validity of the recommended lessons learned process

The main objective of the project reviews was to determine how lessons learned can be collected when applying the process to risk management. To increase the external validity of this research, the choice was made to review projects that were all in a different project phase, to choose different types of projects, to choose projects with a difference in complexity and to conduct the project review with a different project team composition. However, the external validity of the process may not be high because of three reasons. Firstly, the process was only applied to 3 projects. Secondly, all projects were within the city of Amsterdam and thirdly, all projects have been executed by the Ingenieursbureau. Due to these three reasons the process cannot be implemented within other organisations without considering adjustments. Therefore, it is important that the process is validated further and this will be discussed in the recommendations.

External validity of the facilitators and barriers

Chapter 3 of this research was dedicated to determine what the facilitators and barriers of learning and reusing lessons within organisations are and Chapter 4 to determine what the facilitators and barriers are within the Ingenieursbureau. The results of Chapter 4 cannot be used in other organisations because the results are specific for the Ingenieursbureau. Therefore, if the facilitators and barriers of another organisation want to be determined the research would have to be conducted again.

Internal validity of the session to validate the facilitators and barriers

The facilitators and barriers that had been identified in this research were validated with the risk managers to determine if they are understandable, clearly, unambiguous and if they were applicable within the Ingenieursbureau. However, the validity of the validation session that was organised could have been higher because certain variables were interpreted differently during the interviews. For example, in the literature the variable stress was considered a barrier of learning within an organisation. The statement *I work in an unstressed working* was used and all the interviewees scored the variable as a barrier because they experience stress. However, when further questions were asked during the interviews all interviewees explained that they experience stress as positive and not as negative. Therefore, the variable stress has been considered as something positive and not negative, and therefore as a facilitator. This interpretation was not identified during the validation session and in this paragraph it has been mentioned that outcome of such sessions can depend on the group composition. The statement could have been phrased as *I experience the level of stress in my work as positive.* Therefore, several questions do arise about the validity of the method that was used to validate the variables. Firstly, did the risk managers thoroughly understand how the Syllk-model works and what each layer entails? Secondly, only four risk managers were present during the validation session and should this not have been more? Thirdly, the validation session was organised with risk managers only and should this not have been more diverse? For example, employees from other departments could have been present. By considering this, not only the ambiguous interpretation of the variable may have been identified but other validation improvements may have been suggested. Fourthly, after the validation session the selection of variables was finalised and a trial interview was conducted with a risk manager prior to the interviews that were planned. The validity could have been increased by conducting trial interviews with the other risk managers who were present.

Validity of the Ingenieursbureau's facilitator and barrier scores

To determine if a variable could be seen as a facilitator or a barrier of learning lessons within an organisation, the identified variables were made into statements that the interviewees could rate from strongly disagree (1) to strongly agree (4). It is possible that interviewees had interpreted a variable incorrectly because it had not been defined clearly enough. This can affect the internal validity and to increase this, the statements were discussed with the interviewees during the interviews. This resulted in all the interviewees having the same interpretation of the variables and if needed the choice (1-4) was adjusted. However, three aspects that may affect the internal validity of the scores of the variables should be discussed.

Firstly, in this research the choice was made to use the scores (1-4) to determine per variable if it is a facilitator or a barrier. To determine this, the assumption was made that if a variable scores lower than a 3 the interviewees do not (fully) agree with the statement and therefore this is considered a barrier. If the scores are higher than a 3 it is considered a facilitator. However, this choice for 3 is debatable and choosing another number would have resulted in different results. For instance, if 2.5 was chosen many other variables would have been considered a facilitator and not as a barrier. Therefore, the scores of the variables that resulted in the interpretation if it is a facilitator or a variable could be debatable.

Secondly, the interviews have only been conducted with 9 interviewees and due to this low number the results of the scores cannot be seen as externally valid.

Thirdly, the scores of variables cannot be easily compared but should be seen as an indicator because the impact of the variables on learning within an organisation are not equal. For example, the impact of colleagues willing to learn and being able to rely on each other will have a higher impact on an organisation's ability to learn than clean facilities. Therefore, it is important to judge the impact of a variable and use the scores as an indicator.

8.3 Recommendations for further research

This research has offered important insights about the research problem and these insights have led to new knowledge gaps. Therefore, recommendations will be made for further research.

Validate process further in the Ingenieursbureau
If the lessons learned process is implemented it should still be further improved because it has only been tested within 3 project reviews. The expectations are that if the process is validated further, more findings will be found to adjust and improve the process. The findings should be discussed periodically, with the risk managers for instance, to improve the process further. Furthermore, it is important to monitor and determine the effect of the lessons learned process on future projects within the organisation. It sh

Validate process further in other organisations
The lessons learned process can still be further improved because it has only been applied within 3 projects of the Ingenieursbureau. Therefore, it is recommended that the process should be further validated in other construction organisations. This can be done in other public organisations, but it may be more interesting to validate the process within projects executed by a large contractor that executes larger and more complex projects with different risks outside of a city. This is because that the findings have been found within projects of the Ingenieursbureau and these findings may not apply to such organisations. Therefore, new findings to improve the process may be found so that the process can be applied in organisations that execute larger and more complex projects.

Develop a method to determine the effect of a control measure
The lessons learned that are determined during a project review can be based on own interpretations and personal experiences of project team members. Therefore, the lessons learned may be seen as

subjective in certain cases. If a risk has been identified, control measures have been taken and executed, and the risk has not occurred it can be difficult to determine why this happened. This is because it may not be clear if the risk simply did not occur or if the control measures have been effective. Therefore, it may be difficult to determine the lessons learned about such a complex matter because the lessons learned process could benefit from having better insights on how to determine the effect of a control measure. Therefore, a recommendation is to develop a method to determine the effect a of control measure. For instance, a framework or additional process steps, or a quantitative method could be developed for this purpose.

Study the influence of each variable on the process
In Appendix E the influence of each variable has been determined on each step of the lessons learned process. These results have been taken into consideration to determine the improvements that are needed to create a suitable environment within the Ingenieursbureau to learn lessons. However, this should be studied further to determine what the exact influence of each variable on each step.

Improve method to determine facilitators and barriers of learning lessons
The insights gained regarding the facilitators and barriers in this research are considered valuable because they have contributed to the objective of the research. This is because these insights have been used to provide support to the lessons learned process that has been recommended. This research has been the first that has determined what the facilitators and barriers of an organisation are by applying quantitative and qualitative tools. However, because this was the first time this was applied this method could be improved. The method applied in this research has provided great insights and valuable information and therefore, it is recommended that such a process should be further developed. Furthermore, the limitations regarding this method that will be discussed in section 8.2 should be taken into consideration.

Improve process by adding suggested step
The lessons learned process that has been developed can be seen as an extension to the existing RISMAN-process or other risk management processes. To improve the framework, an additional extension can be suggested. The recommendation is to develop a process to compare multiple projects with each other to learn additional lessons. For example, the lessons learned of similar projects can be compared to determine if risks occur in other projects as well. If this is the case, lessons can be learned about how other project teams have dealt with the same risks. Furthermore, if it turns out that a certain risk occurs a lot in projects this information can be used to quantify the risk differently in future projects. The suggested step that could be added is shown in red in Figure 17.

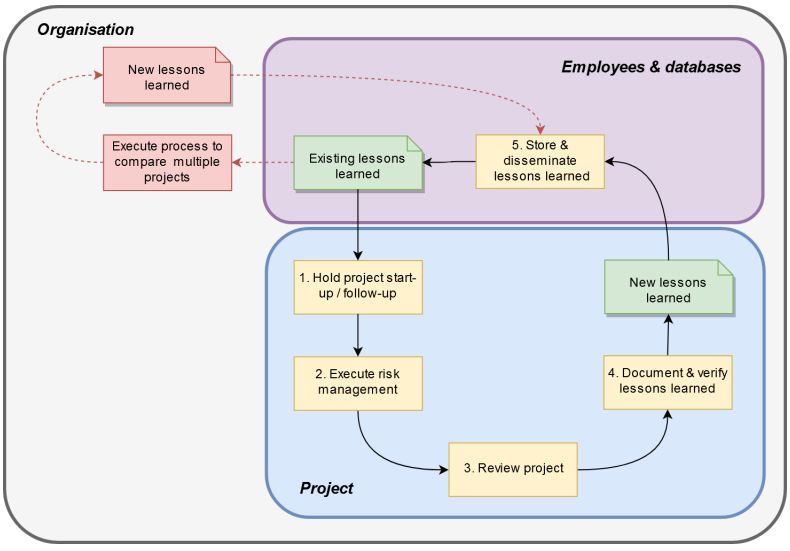


Figure 17: Suggestion for additional step to improve lessons learned process (own illustration)

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Appendices

A Interview transcripts

A.1 Risk management process

A.1.1 Risk manager 1

A.1.2 Risk manager 2

A.2 Project team: Project A

A.2.1 Project manager

A.2.2 Project controller

A.2.3 Risk manager

A.2.4 Facilitators and barriers

A.3 Project team: Project B

A.3.1 Project manager

A.3.2 Project controller

A.3.3 Risk manager

A.3.4 Facilitators and barriers

A.4 Project team: Project C

A.4.1 Project manager

A.4.2 Project controller

A.4.3 Risk manager

A.4.4 Facilitators and barriers

B Lessons learned frameworks

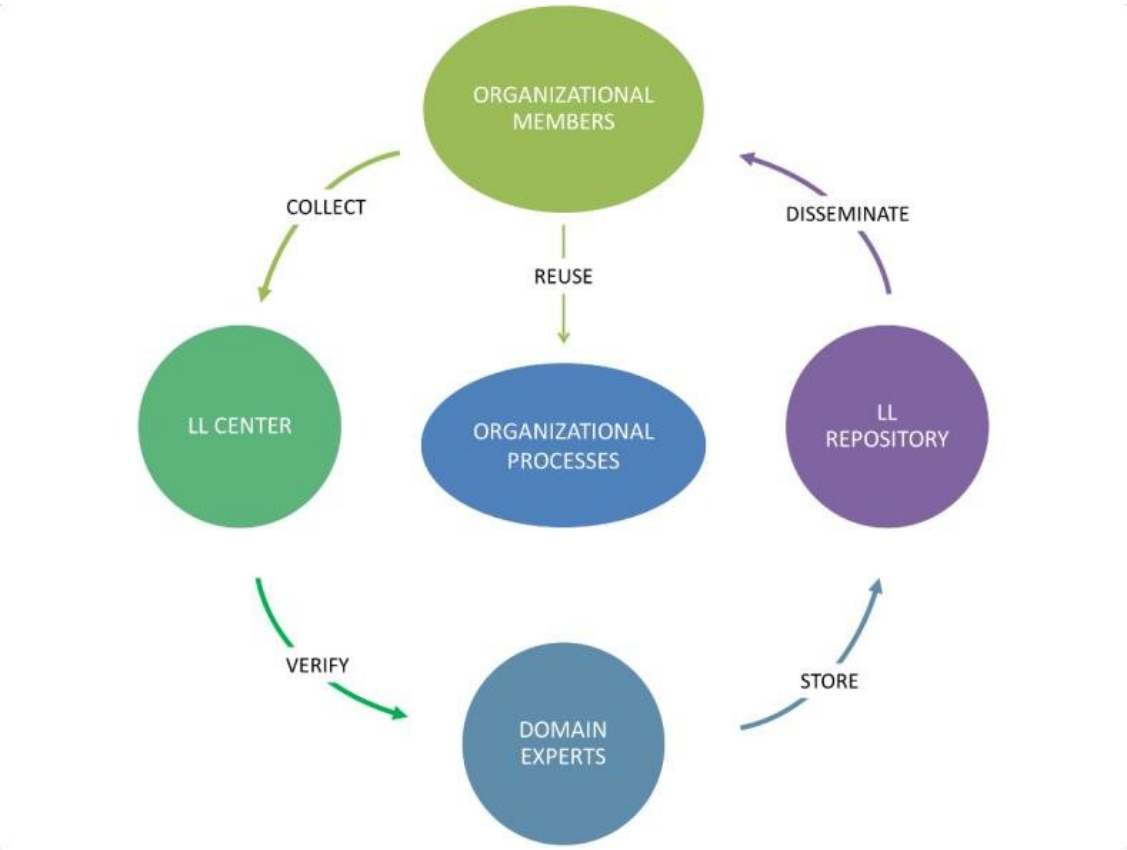

Figure 18: Lessons learned framework (Source: Weber et al., 2001)

EXHIBIT 3: THE SEMI-QUARTERLY BUSINESS REVIEW (AAR)

STEP 1	STEP 2			STEP 3	STEP /5	STEP 6
INTENT	*WHAT HAPPENED? WHY?*			*LESSONS LEARNED*	*ACTION*	*DISSEMINATING*
Objective	What happened	Why did this happen	What are the implications	What are the lessons learned	Who, what, and where?	Who needs to know
Start correlation and final test board	Not started	Unrealistic estimate by team leader	Unmet expectations	Get buy-in from team members for schedule estimates	Jack and Sue to update schedule for Test Dev. by 1/18 Jack and Sue to "start" correlation of Final Test board by next SQBR	Team leader
Complete debug of xyz board	Completed on schedule	John worked lots overtime	Stress. Any unplanned problems would have pushed out schedule since we already working max hours. No buffer	Should have allowed more time in schedule to complete this task	Review all trims to accommodate package parameters	Schedule builders
Release trim	Trim not released	Sam T. is multiplexed between too many tasks	Sam will continue to to run production trim for #1 if trim is not released. Sam will not focus on #1 if he continues to be distracted by other projects.	Release of program is jeopardized without focused resources	Release #1 trim by 2/1	Sponsors; Team leaders; Sam's manager
Deliver fully functional units in June to customer	Package cracks identified during engineering look-ahead	Assembly engineer performed tests prior to package qual.	Package being redesigned	Perform engineering look-ahead tests on new package	Results of package redesign due late May by assembly engineer	Other team leaders

Figure 19: Lessons learned framework (Source: Baird et al., 2004)

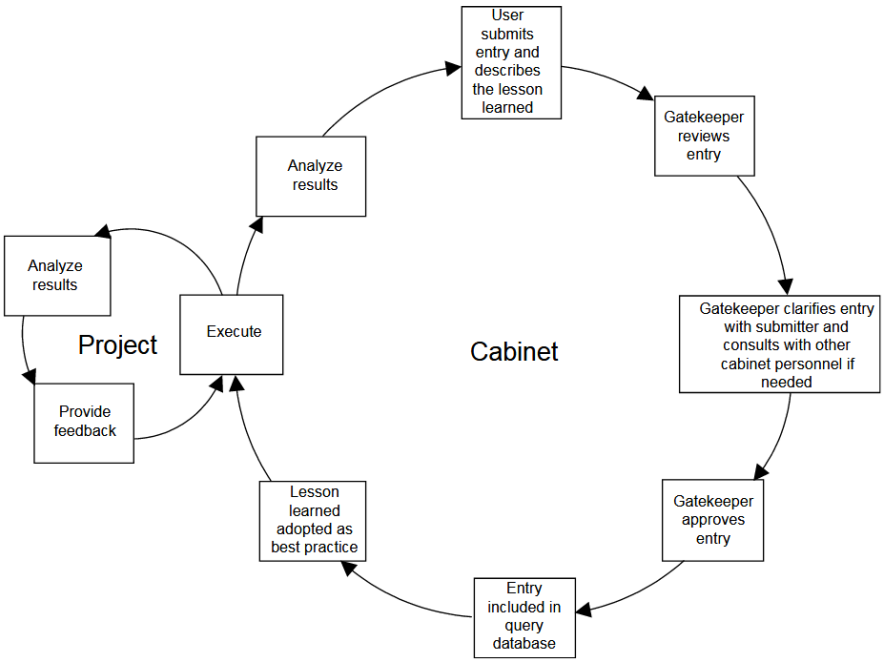

Figure 20: Lessons learned framework (Source: Goodrum et al., 2007)

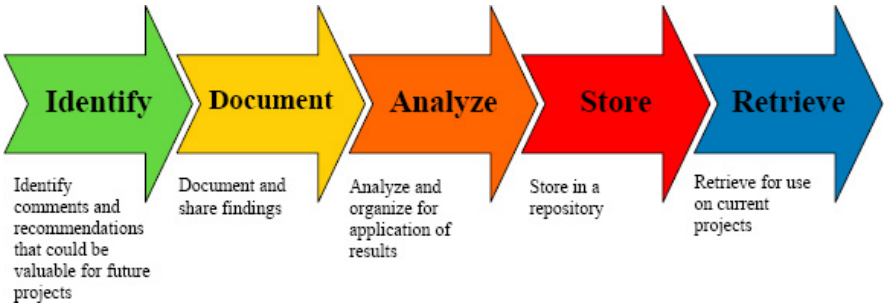

Figure 21: Lessons learned framework (Source: Rowe, 2007)

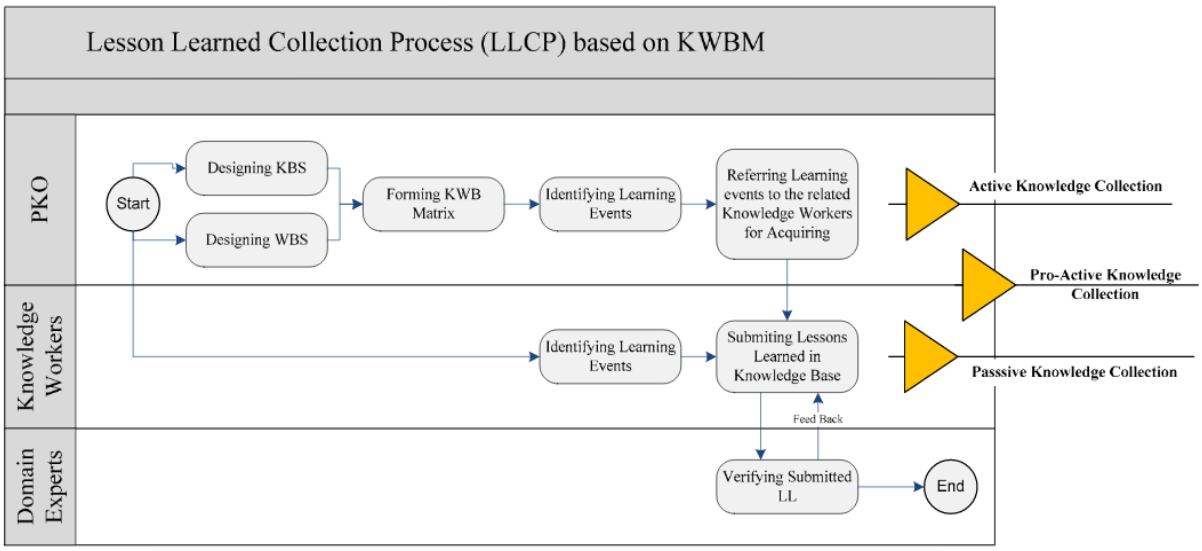

Figure 22: Lessons learned framework (Source: Jalili et al., 2011)

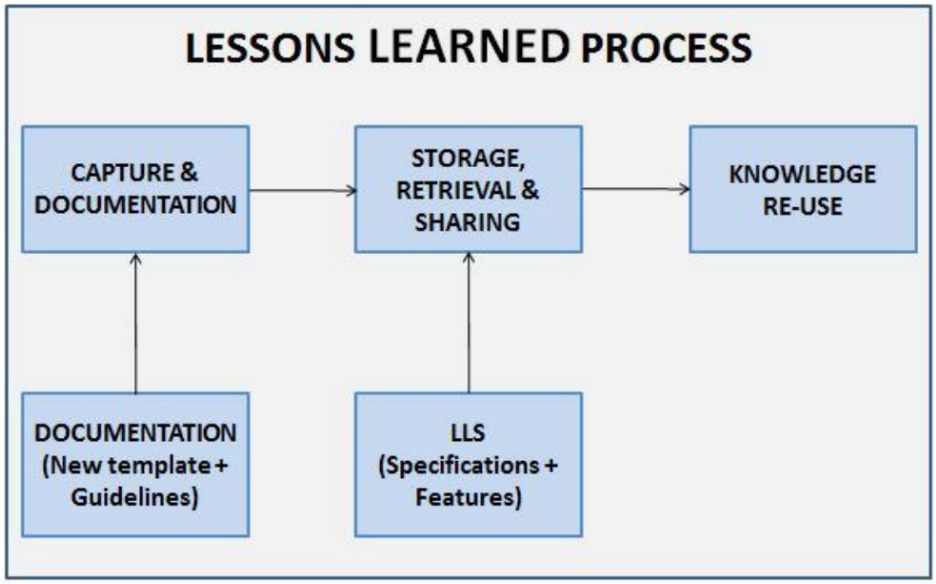

Figure 23: Lessons learned framework (Source: Benevento & Magoula, 2013)

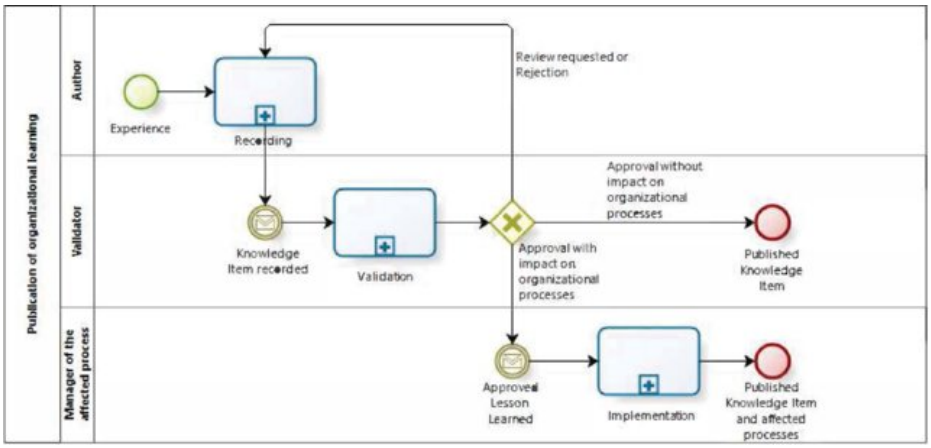

Figure 24: Lessons learned framework (Source: Lopes et al., 2015)

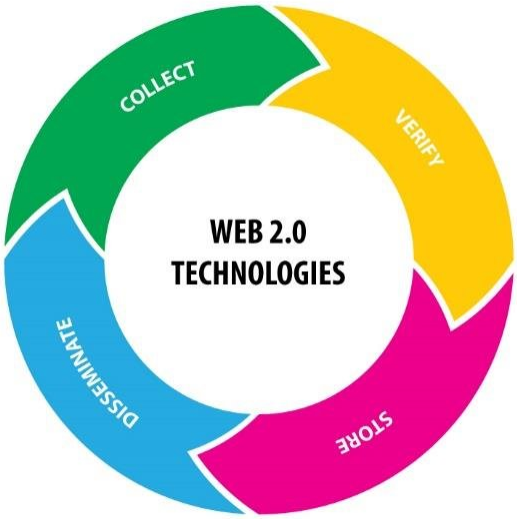

Figure 25: Lessons learned framework (Source: Chaves et al., 2016)

Figure 26: Lessons learned framework (Source: White & Cohan, 2016)

C Findings and lessons learned from validating the process

Table 19: Overview of sections of validations steps (own table)

C.1 Expert session 1

Expert session 1 is the first step of the validation process. Prior to the expert session, own adjustments have been made to the steps to learn lessons in projects that have been discussed in Chapter 5. The reason why adjustments have been made is because the identified steps focus on learning lessons in projects, and not within risk management. The adjustments to the process will be discussed during the session. The findings of the session will be discussed in section C.1.1 a summary of these findings is shown in section C.1.2. During the expert session four risk managers will be present.

C.1.1 Findings

In this section the findings of Expert session 1 will be discussed and the findings will be listed per step of the lessons learned process. The steps that have been discussed are based on the steps that have been identified in Chapter 5. If no new findings for a specific step are found during the expert session, this step will not be discussed in this section or in section C.1.2. The steps that have been discussed are:

Step 1:Project start-up

Step 2:Collect lessons learned

- Step 2.1Project review introduction
- Step 2.2Identify issues to discuss
- Step 2.3Determine context and root cause of issues
- Step 2.4Determine recommendations
- Step 2.5Determine follow up action

Step 3:Document lessons learned

Step 4:Verify lessons learned

Step 1: Project start-up

Finding 1.1: Hold project start-up at least at the start of every project phase

It is unclear if a project start-up should only be held at the beginning of a project. The reason is because a different project phase means different risks and therefore different lessons learned that are important during a specific project phase. Furthermore, another reason can be that the project team may change in the transition to a new project phase. Therefore, a project start-up should be held at the start of every project phase, and not only be done at the start of

the project. During the project start-up the project phase should be introduced and the lessons learned that are related to the specific project phase should be discussed.

Step 2: Collect lessons learned - general findings

Finding 1.2: Collect lessons learned outside of organised project reviews
It can occur that lessons learned are not collected effectively and therefore lost. The reason is because a project team member may identify a lesson learned and that should be discussed during the project review. However, because the project review is for example six weeks later and the project team member may not (exactly) remember valuable information about the lesson learned. Therefore, lessons learned should not only be collected during project reviews but should be collected outside of the organised sessions as well.

Finding 1.3: Hold project review at least at the start of every project phase
It is unclear how often a project review should be organised. Therefore, collecting lessons learned during a project review session should occur at least at the end of every project phase. Depending on the project size and duration, it may be beneficial to collect lessons learned to ensure crucial information does not disperse. The reason because it can occur that a project phase will take a long amount of time and project team members might not remember all information in the project review. Furthermore, the energy of the group is not present at the end anymore in comparison to the energy that was present at the beginning, and during the project.

Finding 1.4: All Integrated Project Management team members should be present
Who should be present during the project reviews has not been defined. Therefore, to collect lessons learned it is important to have multiple Integrated Project Management team members present to determine the context, root cause and lesson learned during the project review. The first reason is because the technical manager for instance, may have a better understanding of a technical risk better than other project team members. The second reason is because different events in a project can be interpreted in a different way. The project manager may have a different view on an event and see it as positive while the contract manager sees the same event as negative and the discussion that arises from the different point of view may contain valuable information for future projects.

Step 2.2: Collect lessons learned - Identify issues to discuss

Finding 1.5: Step 2.2: Identify ~~issues~~ risks to discuss
The name of the step was *Identify issues* but this can be changed into *Identify risks to discuss*. These risks have occurred or not, can be foreseen or not, and can have expired or not. The term risks refers to all risks. The reason is because issues can be defined as important topics or problems that should be discussed. However, risks will be discussed during the project review and not issues.

Finding 1.6: Sharpen approaches to determine which risks to discuss
The questions to determine which risk will be discussed could be made sharper because they are general and may be more effective if sharpened towards risk management. To determine which risks are going to be discussed the following approaches are suggested in the literature:

- Ask project team members to come up with successes and challenges before the meeting and bring an own personal list.
- Ask attendees to brainstorm their positive and negative successes and challenges and write them down on post-it notes.
- Map the project in a flowchart that includes the major tasks, activities and steps. Ask attendees to identify their successes and prioritise them.
- Ask attendees to identify their successes and discuss them in groups

These approaches can be specified towards risk management and after adding additional options, it results in the following approaches:

- Ask project team members to look into risk register before the session and to write the most important risks down. During the session all project team members can call out their risks and the risks with the highest priority will be discussed.
- The risk register is discussed during the session and everyone writes their most important risks down. Thereafter, project team members can call out their risks and the risks with the highest priority will be discussed.
- Determine which risk-theme was the most important during that project phase which the session is dedicated to and discuss these risks.
- Map the project in a flowchart that includes major tasks, activities and steps. Discuss the most important ones and the risks that (could) have influenced them.
- Use the change order (verzoek tot wijziging) list to identify unforeseen risks. This is a document that is kept up to date with the (scope) changes that are often unforeseen risks when working with the contractor. When identifying the risks that can be discussed, the 5 events that influenced the budget or schedule the most for instance.
- Discuss all the risks
- Discuss the top risks
- Discuss the risks that (could have) affected the main unwanted event (ongewenste top gebeurtenis)

Step 2.3 - Determine context and root cause

Finding 1.7: How to determine context and root cause of a risk

The context and the root cause have to be determined to be able to determine the lesson learned per risk, but it has not been defined how to do this. It should be determined if a risk has been identified, if it has occurred and if control measures were taken. This information can be used to determine the context, so what exactly happened and thereafter the root cause. A first approach how to do this is presented in Table 35.

Table 20: Context and root cause combinations for different risk situations (own table)

	Identified	Occurred		Not occurred		Lesson
		Control measures	No control measures	Control measures	No control measures	
Risk A	*	*				Lesson A
Risk B	*		*			Lesson B
Risk C	*			*		Lesson C
Risk D	*				*	Lesson D
Risk E			*			Lesson E

Lesson A: Why was the control measure not effective? It could have been a considered choice to take a less effective control measure, but it is relevant to determine why and if this is the right choice for future projects.

Lesson B: Why was no control measure taken? It could have been a considered choice to not take a control measure, but it is relevant to determine why and if this is the right choice for future projects.

Lesson C: Has the risk been controlled, did the risk not occur, or is this difficult to determine?

Lesson D: The correct choice has been made.

Lesson E: Why has the risk not been identified?

The suggested questions can be seen as a first step towards determining the root cause. Furthermore, per risk additional questions can be asked to determine the root cause that was originally presented in the literature:

- Apply the 5-whys method
- Ask "what", "how" and "why" questions

Step 2.4: Collect lessons learned - Determine recommendations

Finding 1.8: Sharpen the recommendations by including project related information

The questions to determine recommendations could be made sharper. The reason is because the questions to determine recommendations are general. In the literature, an example of a question that could be asked to determine recommendations is *if you were to do this again, what would you do next time?* Therefore, to specify it more towards risk management and make the recommendation sharper, the following question could be asked: *what would be your advice for the project manager who is responsible for executing the same type of project?* Or other ways of sharpening the recommendation could be by referring to projects with the same budget, schedule, etc. Furthermore, it is important to consider which lesson applies to which Integrated Project Management team role as it is now specified towards the project manager. So for instance, determine a specific lesson for the contract manager.

Step 3: Document lessons learned

Finding 1.9: Finding and quality of lessons learned more important than documentation format

The format of the document that is used to document lessons learned is not as important. The reason is because the difference between a table, summary or bullet pointed document will not make the difference for reusing the lessons learned. Therefore, less attention should be paid to the presentation and documentation, and more to the finding and the quality.

Step 7: Store lessons learned

Finding 1.10: Create a new environment to save lessons learned

It can occur that once lessons learned are documented, they are not reused. The reason is because lessons learned could just be saved in the project file to prevent lessons learned not being found and reused in the future. Therefore, a new file or destination should be created that is dedicated to the lessons learned so all project team members know where to look. A suggestion is to store the lessons learned on the improved version of intranet that will be launched in September, "Kennisbank". On this page it can be possible to make a tab for all the lessons learned, so not just for risk management. To ensure that the lessons learned are easy accessible meta data can be used to search. It could be possible to use keywords and include all the project characteristics, such as project type, budget, etc. Furthermore, on other websites and pages from the Ingenieursbureau links can be created to direct employees to the lessons learned page.

Step 8: Disseminate lessons learned

Finding 1.11: Redirect project team members to Kennisbank instead of sending them a document

Employees are not familiar with the Kennisbank (see Finding 2.13 and therefore do not search independently on the website. Therefore, it may be better to share the link of the lesson learned that redirects the receiver to Kennisbank, than to send a document with the lesson learned. The reason is because this may result in the receiver looking at other lessons learned as well. Furthermore, by redirecting project team members to the page will get them more familiar with the page, and this may result in them searching independently because they see the benefits of the page.

Finding 1.12: Make it possible to "subscribe" to certain updates

It can be beneficial is an option is included that employees can "subscribe" to certain updates. This means that when a document is uploaded and a employee has subscribed to certain criteria, the employee gets an update. For instance, contract manager can subscribe to "contract manager" and when a lesson learned is updated that includes that meta-data, the contract manager gets an update. The reason is because this may enhance the lessons learned and reused. The reason is because this may enhance the lessons learned and reused.

C.1.2 Summary

Table 21: Summary of the process modifications: Expert session 1 (own table)

Finding	Problem	Change
	Step 1: Project start-up	
1.1	It is unclear if a project start-up should only be held at the beginning of a project.	A project start-up should be held at the start of every project phase, because a new project phase means different risks and lessons learned
	Step 2: Collect lessons learned - general	
1.2	Lessons learned may not get collected, because there is a long period of time between the project reviews and the project team members may forget valuable information	Lessons learned should not only be collected during project reviews but should be collected outside of the organised sessions as well
1.3	It is unclear how often a project review should be organised	Collecting lessons learned during a project review session should occur at least at the end of every project phase, because the project team members may forget valuable information due to long durations of project phases. Furthermore, the energy of the group is not present at the end anymore in comparison to the energy that was present at the beginning, and during the project.
1.4	It is unclear who should be present during the project reviews	Multiple integrated project management team members should be present, because of their expertise and different points of view
	Step 2.2: Collect lessons learned - Identify issues to discuss	
1.5	Issues can be defined as important topics or problems that should be discussed. However, risks will be discussed during the project review and not issues. These risks have occurred or not, can be foreseen or not, and can have expired or not. The term risks refers to all risks.	The name of the step was called *Identify issues* but this can be changed into *Identify risks to discuss*, because
1.6	The approaches to determine which risks will be discussed could be made sharper towards risk management because the questions are general	The approaches to determine recommendations have been sharpened
	Step 2.3: Collect lessons learned - Determine context and root cause	
1.7	It has not been determined how the context and root cause of a risk can be determined	A first approach how to do this is presented in Table 35
	Step 2.4: Collect lessons learned - Determine recommendations	
1.8	The questions to determine recommendations could be made sharper towards risk management because the questions are general	The questions to determine recommendations have been sharpened
	Step 3: Document lessons learned	
1.9	Document format is not as important	Less attention should be paid to the presentation and documentation, and more to the quality and findability
	Step 7: Store lessons learned	
1.10	Lessons learned not found and reused because they are not saved in the right place	Create a new environment to save lessons learned, such as the Kennisbank
	Step 8: Disseminate lessons learned	
1.11	Employees do not use Kennisbank because they are not familiar with the website	Share the link of the lesson learned that redirects the receiver to Kennisbank

table continues on next page

Table 21: Summary of the process modifications: Expert session 1 (own table)

Finding	Problem	Change
1.12		In Kennisbank, included that employees can "subscribe" to certain lessons learned updates, because this may enhance the lessons learned and reused

C.2 Interviews

The interviews are the second step of the validation process. During the interviews with three project managers, three project controllers and three risk managers, short questions will be asked about their role in the process. If new insights are gained during the interviews, these will be discussed in section C.2.1. Therefore, if interviewees mention things that have been discussed during Expert session 1, it will not be documented in the section. A summary of the findings from the interviews is shown in section C.2.2. The transcripts of the interviews can be found in Appendix A.

C.2.1 Findings

In this section the findings of the interviews will be discussed and the findings will be listed per step of the lessons learned process. The steps that have been discussed are based on the steps that have been identified in Chapter 5, and adjusted in the previous validation step. If no new findings for a specific step are found during the interview, this step will not be discussed in this section or in section C.2.2. The steps that have been discussed are:

Step 1:Project start-up

Step 2:Collect lessons learned

Step 3:Document lessons learned

Step 4:Verify lessons learned

Step 1: Project start-up

Finding 2.1: Responsibilities during the project start-up
The responsibilities of discussing the lessons learned during the project start-up have not been defined. Therefore, firstly, the project manager should be responsible to ensure that this is included in the presentation and that there is sufficient time during the project start-up to discuss the lessons learned. Secondly, the content of the lessons learned, so which lessons learned should be discussed should be the responsibility of the project controller. However, the project controller can ask the technical, contract and environment manager for substantive knowledge and input regarding the lessons learned. Furthermore, the project controller can ask the risk manager for assistance if needed.

Step 2: Collect lessons learned

Finding 2.2: Responsibilities of collecting lessons learned outside project review
The responsibilities of collecting the lessons learned outside of the project review have not been defined. Therefore, collecting lessons learned outside of the project reviews should be the responsibility of the project controller. The project controller is present during all the meetings with the Integrated Project Management team, and the risk manager is not present.

Finding 2.3: Responsibilities of collecting lessons learned during project review
The responsibilities of collecting the lessons learned during the project review have not been defined. Therefore, it should be the responsibility of the project controller to ensure that the project reviews are planned. It should be the responsibility of the risk manager to facilitate the project review.

Step 3: Document lessons learned

Finding 2.4: Responsibilities of documenting lessons learned
The responsibilities of documenting the lessons learned during have not been defined. Therefore, it should be the responsibility of the risk manager to document the lessons learned.

Step 4: Verify lessons learned

Finding 2.5: Responsibilities of verifying lessons learned
The responsibilities of verifying the lessons learned have not been defined. Therefore, it should be the responsibility of the risk manager to verify the lessons learned. Firstly, the lessons learned should be verified with the project team to ensure that the lessons learned have formulated correctly. Secondly, an second risk manager should verify the documents to ensure that the lessons learned are complete, not too specific, not too general, applicable to future projects, etc.

Finding 2.6: User friendly database
During the interviews the question was asked to the interviewees what the most important aspect for them is about the storage of the lessons learned. The interviewees indicated that it is important the lessons learned are easy to find and this can be done with the use of meta-data for instance. Furthermore, the database should be user friendly.

C.2.2 Summary

Table 22: Summary of the process modifications: Interviews (own table)

Finding	Problem	Change
	Step 1: Project start-up	
2.1	The responsibilities of discussing the lessons learned during the project start-up have not been defined.	1) The project manager should be responsible to ensure that this is included in the presentation and that there is sufficient time during the project start-up to discuss the lessons learned. 2) The project controller should be responsible for the content of the lessons learned that will be discussed. If needed, the project controller can collaborate or be assisted by the technical, environment, contract or risk manager.
	Step 2: Collect lessons learned	
2.2	The responsibilities of collecting the lessons learned outside of the project review have not been defined.	The project controller should be responsible
2.3	The responsibilities of collecting the lessons learned during the project review have not been defined.	The project controller should be responsible to ensure that the project reviews are planned. The risk manager should be responsible of facilitating the project review.
	Step 3: Document lessons learned	
2.4	The responsibilities of documenting the lessons learned during have not been defined.	The risk manager should be responsible.
	Step 4: Verify lessons learned	
2.5	The responsibilities of verifying the lessons learned have not been defined.	The risk manager should be responsible. The lessons learned should first be verified by the project team and thereafter by an external risk manager.
	Step 7: Store lessons learned	
2.6	The most important criteria of storing the lessons learned is that the lessons learned are easy to find and the environment in which the database is created is user friendly.	

C.3 Project review 1: Project A

Project review 1 is the third step of the validation process. During the project review, the project controller and the risk manager will be present. The handout that is used during the project review is shown in section D.1.1. If new insights are gained during the project review, these will be discussed in section C.3.1. Lastly, a summary of the findings is shown in section C.3.2.

C.3.1 Findings

In this section the findings of Project review 1 will be discussed and the findings will be listed per step of the lessons learned process. The steps that have been discussed are based on the steps that have been identified in Chapter 5, and adjusted in the previous validation steps. If no new findings for a specific step are found during the project review, this step will not be discussed in this section or in section C.3.2. The steps that have been discussed are:

Step 1:Project start-up

Step 2:Collect lessons learned

- Step 2.1Project review introduction
- Step 2.2Identify risks to discuss
- Step 2.3Determine context and root cause of risks
- Step 2.4Determine recommendations
- Step 2.5Determine follow up action

Step 3:Document lessons learned

Step 4:Verify lessons learned

Step 2: Collect lessons learned - general findings

Finding 3.1: The facilitator of the project review should not be external
As an external facilitator it is difficult to understand what exactly has happened in the project because an external facilitator has a knowledge deficit and this is inefficient. The reason is because an external facilitator was not present during the project and it takes lots of time to explain towards the external facilitator what has happened. Therefore, the facilitator of the project review should not be an external facilitator but a project team member who has understanding and knowledge of what happened during the project.

Finding 3.2: The focus should lie on learning lessons per control measure and not per risk
While executing the steps to collect lessons learned it may become complex and unclear to determine lessons learned per risk. The reason is because multiple control measures can be taken per risk. Per risk, some control measures that have been executed may be effective, some control measures that have been executed may not be effective, and some control measures may have not been executed. This results in it being too complex to determine the lesson learned. Therefore, the focus should lie on learning lessons per control measure and not per risk.

Finding 3.3: Table 23 contains an overview of information that needs to be determined
Table 35 showed an overview of the information that needed to be determined during *Step 2: Collect lessons learned*. However, this table needs updating. The reasons will be explained in Findings 3.4, 3.5 and 3.6. Therefore, an overview of the information that needs to be determined during *Step 2: Collect lessons learned* is shown in Table 23.

Table 23: Context and root cause combinations for different risk situations (own table)

	Identified	Occurred	Control measures						Lesson
			Overview	Cause	Effect	Executed	Reason	Effective	
Risk A	*	*	CM 1	...	...	yes/no	...	...	...
			CM 2	...	...	yes/no	...	...	...
Risk B	*	*					...		...
Risk C	*		CM 3	...	...	yes/no	...	...	...
			CM 4	...	...	yes/no	...	...	...
Risk D	*						...		...
Risk E		*					...		...

Step 2.3: Collect lessons learned - Determine context and root cause

Finding 3.4: Determine which cause(s) and/or effect(s) a control measure influences

While executing the steps to collect lessons learned it may become complex and unclear to determine lessons learned per control measure. The reason is because each risk may have multiple causes and effects, and each control measure that had been chosen effected a different cause and/or effect. Therefore, to gain more understanding in the context of the control measure it is important to determine which cause(s) and/or effect(s) the control measure influences.

Finding 3.5: The definition of the context of a risk

The context of a risk was defined as identified (y/n), occurred (y/n) and control measure. However, additional information needs to be added. The reason can be found in Finding 3.4. Therefore, the context of a risk can be defined as: identified (y/n), occurred (y/n), cause, effect, control measure, control measure executed(y/n). An overview that can be used during this step is shown in Table 24.

Table 24: Context combinations for different risk situations (own table)

	Identified	Occurred	Control measures			
			Overview	Cause	Effect	Executed
Risk A	*	*	CM A1	...	...	yes/no
			CM A2	...	...	yes/no
Risk B	*	*				
Risk C	*		CM C3	...	...	yes/no
			CM C4	...	...	yes/no
Risk D	*					
Risk E		*				

Finding 3.6: Determine context and root cause separate steps

Determining the context will become a separate step,and determining the root cause will become a separate step. The reason is because new insights have been gained in Finding 3.4 and 3.7. Therefore, Step 2.3: Determine context, and Step 2.4: Determine root cause.

Finding 3.7: Determine reason why control measure is chosen and its effect

The lessons learned that were determined could not add any value to future projects. The reason was because the lessons learned that were determined were too general. During the project review, the first risk (see Appendix **??** on page **??**) that was discussed resulted in a general lesson: "be transparent to your stakeholders". This information is general knowledge within the project management and therefore this lesson may not add value to future projects. However, after

interesting discussions about the risk it seemed as if crucial information that could be applied in future projects was hidden in the reason why the control measure was chosen and the the effect of the control measure on the risk. The control measure was "to share day planning with the contractor" and the reason why this was done is to create awareness and understanding for the contractor what the delay of his task can have on the entire planning of the project. Therefore, the control measure could be seen as a method to "be transparent to your stakeholders", so a tool to achieve transparency. This control measure turned out to be very effective. This resulted in the lesson learned not being "be transparent to your stakeholders", but "an effective method to create transparency towards your stakeholders is to share the day planning of the project". This was an interesting insight and taking this into consideration, it became clear that crucial information that could be applied in future projects was hidden in the reason why the control measure was chosen and what the effect of the control measure on the risk. In the reason and in the effect lies information that project team members can use in project future projects, and therefore this information can be used to determine lessons learned. Therefore, the root cause of a risk can be defined the reason why a specific control measure was (not) chosen and what the effect of the control measure is on the risk. An overview that can be used during this step is shown in Table 25.

Table 25: Root cause combinations for different risk situations (own table)

	Identified	Occurred	Control measures		
			Overview	Reason	Effective
Risk A	*	*	CM 1	...	...
			CM 2	...	...
Risk B	*	*		...	
Risk C	*		CM 3	...	...
			CM 4	...	...
Risk D	*			...	
Risk E		*		...	

Finding 3.8: The definition of the root cause of a risk
The root cause of a risk was not clearly defined and this lead to unclear lessons learned. Therefore, the root cause of a risk should be defined as why the control measure was (not) chosen and what the effect of the control measure is on the risk. The reason is because of new insights gained in Findings 3.4, 3.5 and 3.7.

Step 2.4: Collect lessons learned - Determine recommendations

Finding 3.9: Sharper recommendation questions
The questions that could be asked to determine recommendations were *"if you were to do this again, what would you do next time?* and *What would your advice for the project team member who is responsible for executing the same type of project or task be?*. These questions are general and should be sharpened more towards risk management. The reason is because in Findings 3.5 and 3.6it was explained that information lies in the effectiveness and the reason behind control measures. Therefore, recommendation questions could be *"why would you (not) apply this control measure for such risks in future projects?* and *"would you apply another control measure for such a risk in future projects?*

Finding 3.10: Determine if recommendation can be applied in future projects
If it is determined if the recommendation can be applied in future projects, this information can add value for future project team members searching for lessons learned

Step 2.5: Collect lessons learned - Determine follow up action

Finding 3.11: Determine if risk occurs in other projects and if it can be influenced by control measures

In Expert session 1 in Finding 2.13 it was discussed that a follow up action will not always be needed. However, it was still unclear when a follow up action is needed.
During the project review, in two cases a follow up action may be needed and both these examples will be discussed. In the first example three causes were given for a risk, but no control measures were taken. The three causes were interrelated and all were caused by the culture that exists within the Ingenieursbureau, see Appendix **??** on page **??**. The first cause was that colleagues only take responsibility for their own tasks, the second cause was that colleagues are not consistent in their role, and the third was that colleagues do not trust the expertise of other colleagues. This causes problems such as that it is unclear who is responsible for what, everybody has a strong opinion about everything while they are only responsible for a small part of the project, and when someone with expertise says what they think about their part they are responsible for, no body accepts this advice. In **Finding X** it was explained that the lesson learned can be hidden in the reason why a control measure was not taken. In this case, the reason was because the conclusion was drawn that control measures could not influence this within the project, and there were no control measures that could change the culture within the Ingenieursbureau in such a short amount of time. So, the lesson learned could be that it is not possible to influence the Ingenieursbureau's culture with control measures because it cannot easily be influenced, and and therefore no control measures should be taken.
The second example was a collaboration problem that occurred with the environmental service (omgevingsdienst), see Appendix **??** on page **??**. The problem is that the project team is very dependent on the outcomes of the tests that the environmental service (omgevingsdienst) do. They are responsible for guaranteeing the safety of the tunnel, and it occurs a lot that they disapprove certain aspects that can influence the project a lot. Sometimes they disapprove certain aspects that they have seen before, and it is not clear why they have not done this before.
The reason for a follow up action in the first example can be because it is a common problem because it occurs in multiple projects and that cannot easily be influenced. A follow up action can be to report this to higher management. They should look into this, and determine if this is a problem throughout the Ingenieursbureau, how this affects the efficiency of projects and how this problem can be influenced. The reason for a follow up action in the second example can be because it is a common problem because it occurs in multiple projects and that cannot easily be influenced as well. A follow up action can be to (ask higher management to) have a meeting with the environmental service (omgevingsdienst) to discuss both parties motives and interests, and discuss how collaboration can be improved. The Ingenieursbureau can explain there motives and interests too, and such a meeting might lead to a better understanding from both sides.
Therefore, to determine if a follow up action is needed the question can be asked if the problem/risk that occurred, occurs in (a lot of) other projects as well, and if it is possible to control the problem within the means a project team has.

Step 3: Document lessons learned

Finding 3.12: Update information needed for documentation

The information that is needed to document the lessons learned needs updating. The reason is because of Findings 3.4, 3.5, 3.7 and 3.10. There is more information needed when documenting the lessons learned and using a template will become unclear. Therefore, the following information needs to be documented and can be done as following:

[Title of lesson learned]
Risk: *This can be found in the risk register*
Identified: yes/no
Occurred: yes/no
Risk category:
Integrated Project Management role:
Cause: *This can be found in the risk register*

Effect: *This can be found in the risk register*
Control measure: *This can be found in the risk register*
Control measure executed: yes/no
Effect control measure:
Reason why control measure was chosen:
Lesson learned:
Applicability in future projects:
Follow-up action:

C.3.2 Summary

Table 26: Summary of the process modifications: Project review 1 (own table)

Finding	Problem	Change
	Step 2: Collect lessons learned - general	
3.1	An external facilitator has a knowledge deficit regarding what happened in the project, because an external facilitator was not present during the project and this is inefficient.	The facilitator of the project review should not be an external facilitator but a project team member who has understanding and knowledge of what happened during the project.
3.2	Determining lessons learned for a risk may be unclear, because risks may have multiple control measures per risks	The focus should lie on learning lessons per control measure and not per risk
3.3	Table 35 needs updating, because of the new insights gained in in Findings 3.4, 3.5 and 3.7	Table 23 is an updated overview of the information that needs to be determined
	Step 2.2: Collect lessons learned - Identify risks to discuss	
	Step 2.3: Collect lessons learned - Determine context and root cause	
3.4	Determining lessons learned for a control measure may be unclear, because each risk may have multiple causes and effects, and each control measure that had been chosen effected a different cause and/or effect.	Determine which cause(s) and/or effect(s) a control measure influences
3.5	The definition of the context of a risk needs updating, because of the new insights gained in in Finding 3.4	The context of a risk can be defined as: identified (y/n), occurred (y/n), cause, effect, control measure, control measure executed (y/n). An overview that can be used during this step is shown in Table 24.
3.6	Determining the context and the root cause should become separate steps, because of the new insights gained in in Finding 3.4 and 3.7	Step 2.3: Determine context; Step 2.4: Determine root cause
3.7	The lessons learned that were determined may not add value to future projects, because the collected lessons learned were general	The root cause of a risk lies in the reason why the control measure was (not) chosen and what the effect of the control measure is on the risk. An overview that can be used during this step is shown in Table 25
3.8	The root cause of a risk was not clearly defined.	The root cause of a risk should be defined as why the control measure was (not) chosen and what the effect of the control measure is on the risk, because of the new insights gained in in Findings 3.4, 3.5 and 3.7.
	Step 2.4: Collect lessons learned - Determine recommendations	
3.9	The questions to determine recommendations are general and should be sharpened towards risk management, because of the new insights gained in in Findings 3.5 and 3.7	Recommendation questions have been sharpened
3.10	-	Determine "applicability in future projects" in this step because this information adds value for future project team members searching for lessons learned
	Step 2.5: Collect lessons learned - Determine follow up action	

table continues on next page

Table 26: Summary of the process modifications: Project review 1 (own table)

Finding	Problem	Change
3.11	It is unclear when a follow up action is needed	Determine: (1) if the problem/risk that occurred, occurs in (a lot of) other projects as well, (2) if it is possible to control/influence the problem within the means a project team has.
	Step 3: Document lessons learned	
3.12	The information needed for documentation needs updating, because of the new insights gained in in Findings 3.4, 3.5, 3.7 and 3.10	The information has been updated

C.4 Project review 2: Project B

Project review 2 is the fourth step of the validation process. During the project review, the project manager, contract/technical manager, assistant environment manager and financial advisor from the Ingenieursbureau, and the supervisor and two foremen from the contractor (KWS) will be present. The handout that is used during the project review is shown in section D.2.1. If new insights are gained during the project review, these will be discussed in section C.4.1. Lastly, a summary of the findings is shown in section C.4.2.

C.4.1 Findings

In this section the findings of Project review 2 will be discussed and the findings will be listed per step of the lessons learned process. The steps that have been discussed are based on the steps that have been identified in Chapter 5, and adjusted in the previous validation steps. If no new findings for a specific step are found during the project review, this step will not be discussed in this section or in section C.4.2. The steps that have been discussed are:

Step 1:Project start-up

Step 2:Collect lessons learned

- Step 2.1Project review introduction
- Step 2.2Identify risks to discuss
- Step 2.3Determine context
- Step 2.4Determine root cause
- Step 2.5Determine recommendations
- Step 2.6Determine follow up action

Step 3:Document lessons learned

Step 4:Verify lessons learned

Step 2: Collect lessons learned - general findings

Finding 4.1: Table 27 contains an overview of information that needs to be determined

Table 23 showed an overview of the information that needed to be determined during Step 2: Collect lessons learned. However, this table needs updating. The reasons behind the information that is needed will be explained in Finding 4.4. Therefore, an overview of the information that needs to be determined during Step 2: Collect lessons learned is shown in Table 27.

Table 27: Context and root cause combinations for different risk situations (own table)

	Identified	Occurred	Control measures						Lesson
			Overview	Cause	Effect	Executed	Reason	Effective	
Risk A	*	*	CM 1	...	...	yes/no	...	...	...
			CM 2	...	...	yes/no	...	...	...
Risk B	*	*					...		...
Risk C	*		CM 3	...	...	yes/no	...	...	...
			CM 4	...	...	yes/no	...	...	...
Risk D	*						...		...
Risk E		*	CM 5	...	...	yes/no	...	...	...
			CM 6	...	...	yes/no	...	...	...

Step 2.1: Collect lessons learned - Project review introduction

Finding 4.2: Discuss the project team's collaboration during the introduction

During the introduction, the collaboration within the project team should be discussed. The reason is because this was one during the project review and this was interesting because very good feedback was given from both all sides that will be beneficial for future collaboration.

The question *what do you remember most?* was asked and mainly answered with aspects that substantiate the good collaboration between the Ingenieursbureau and the contractor. Examples were an open working environment, efficient meetings with a lot of humour, and a solution oriented and flexible working style from both sides. Both employees from the Ingenieursbureau and from the contractor agreed that the positive collaboration style resulted in the project becoming a success. This was a good start of the session, and if the contractor would not be present during the session it can still be possible to do this with the integrated project team.

Step 2.2: Collect lessons learned - Identify risks to discuss

Finding 4.3: Determine unforeseen risks at the beginning of the project review

During the project review the question *what should we never do again?* was answered with aspects that went wrong during the execution of the project. Examples that were mentioned were problems arising from the method that was chosen to pave the road, and problems that arose due to the fact that the design was not finished on time. Both examples, and the others that were mentioned, could be seen as unforeseen risks that had not been identified and that had to be controlled on the spot. In Table 23 such risks are equivalent to Risk E. Therefore, attention should be given to collecting unforeseen risks (Risk E) at the start of the session. Questions could be asked such as *what should we never do again?*, but maybe a more direct question such as *what were the unforeseen risks?* would be more efficient.

Step 2.3: Collect lessons learned - Determine context

Finding 4.4: The control measures of the unforeseen risks are important

If a risk has not been identified it can be seen as a unforeseen risk. In Table 23, 24 and 25 it shows that no control measures are taken for unforeseen risks (Risk E). However, during the project review it became clear that control measures are taken for unforeseen risks. The reason is because despite the risks not being identified, the risks may need controlling. If a control measure is chosen, this has been done under specific and in some cases stressful situations. Which control measure has been chosen, and the reason behind this may contain valuable information. Therefore, the control measures of unforeseen risks should be taken into consideration as can be seen in Table 28

Table 28: Context combinations for different risk situations (own table)

	Identified	Occurred	Control measures			
			Overview	Cause	Effect	Executed
Risk A	*	*	CM A1	...	...	yes/no
			CM A2	...	...	yes/no
Risk B	*	*				
Risk C	*		CM C1	...	...	yes/no
			CM C2	...	...	yes/no
Risk D	*					
Risk E	*	*	CM E1	...	...	yes/no
			CM E2	...	...	yes/no

Finding 4.5: Determine if control measures were take that are not in risk register

During the project review it occurred that the risk register had not been updated. This resulted in extra control measures that had been taken not being recorded in risk register. Therefore, it is important to determine if there are any control measures not included in the risk register. The reason is because all control measures should be reviewed because valuable lessons can be learned per control measure.

Step 2.4: Collect lessons learned - Determine root cause

Finding 4.6: Table 29 contains an overview of the information for the root cause
Table 25 showed an overview of the information that needed to be determined for the root cause. However, this table needs updating. The reasons behind the information that is needed will be explained in Finding 4.4. Therefore, an overview of the information that needs to be determined for the root cause shown in Table 29.

Table 29: Root cause combinations for different risk situations (own table)

	Identified	Occurred	Control measures		
			Overview	Reason	Effective
Risk A	*	*	CM A1	...	...
			CM A2	...	...
Risk B	*	*		...	
Risk C	*		CM C1	...	...
			CM C2	...	...
Risk D	*			...	
Risk E	*		CM E1	...	...
			CM E2	...	...

Step 2.5: Collect lessons learned - Determine recommendations

Finding 4.7: Group similar lessons learned per risk together
In Finding 3.1 it was discussed that the focus of learning lessons should lie on learning lessons per control measure and not per risk. However, during the project review a risk with a single cause and single effect had four control measures and all four were effective. The lesson learned per control measure was that the control measure was effective. This resulted in four separate lessons learned for a risk, stating that the control measure was effective. Therefore, when determining the recommendations it should be determined if lessons learned can be grouped together. The reason is because combining the four loose lessons to one lesson make a stronger lesson.

Finding 4.8: Determine if lesson learned can be generalised
When determining a lessons learned the lesson learned was "Examples of effective control measures to reduce the image harm of the Municipality because of an inaccessible street" However, this is very situation specific. Therefore, the lesson learned should be generalised to "Examples of effective control measures to reduce negative effects of inaccessible street" The reason is because the lesson learned can be applied in more situations, and the chance of a future project team member finding the lesson then might be larger.

C.4.2 Summary

Table 30: Summary of the process modifications: Project review 2 (own table)

Finding	Problem	Change
	Step 2: Collect lessons learned - general	
4.1	Table 27 needs updating, because new insights have been gained in Finding 4.4	Table 27 is an updated overview of the information that needs to be determined
	Step 2.1: Collect lessons learned - Project review introduction	
4.2	The collaboration within the project team should be discussed because such feedback will be beneficial for future collaboration	Include this step into the introduction step

table continues on next page

Table 30: Summary of the process modifications: Project review 2 (own table)

Finding	Problem	Change
	Step 2.2: Collect lessons learned - Identify risks to discuss	
4.3		Collect unforeseen risks at the beginning of the session by asking for instance, *what were the unforeseen risks?*
	Step 2.3: Collect lessons learned - Determine context	
4.4	In Table 23, 24 and 25 it shows that no control measures are taken for unforeseen risks (Risk E) but this is incorrect, because control measures are taken for unforeseen risks.	Control measures of unforeseen risks should be taken into consideration as can be seen in Table 28
4.5	The risk register may not be updated, resulting in extra control measures that have been taken not being recorded	Determine if there are any control measures not included in the risk register, because all control measures should be reviewed because valuable lessons can be learned per control measure
	Step 2.4: Collect lessons learned - Determine root cause	
4.6	Table 25 needs updating, because new insights have been gained in Finding 4.4	Table 29 is an updated overview of the information that needs to be determined
	Step 2.5: Collect lessons learned - Determine recommendations	
4.7	Multiple lessons were learned for a risk that were the same	When determining recommendations it should be determined if lessons learned can be grouped together, because this can form a stronger lesson learned
4.8	Lessons learned may become very situation specific	The lesson learned should be generalised, because the lesson learned can be applied in more future situations

C.5 Project review 3: Project C

Project review 3 is the fifth step of the validation process. During the project review, the project manager, project controller, risk manager, technical manager, environment manager and contract manager will be present. The handout that is used during the project review is shown in section D.3.1. If new insights are gained during the project review, these will be discussed in section C.5.1. Lastly, a summary of the findings is shown in section C.5.3.

C.5.1 Findings

In this section the findings of Project review 3 will be discussed and the findings will be listed per step of the lessons learned process. The steps that have been discussed are based on the steps that have been identified in Chapter 5, and adjusted in the previous validation steps. If no new findings for a specific step are found during the project review, this step will not be discussed in this section or in section C.5.3. The steps that have been discussed are:

Step 1:Project start-up

Step 2:Collect lessons learned

- Step 2.1Project review introduction
- Step 2.2Identify risks to discuss
- Step 2.3Determine context
- Step 2.4Determine root cause
- Step 2.5Determine recommendations
- Step 2.6Determine follow up action

Step 3:Document lessons learned

Step 4:Verify lessons learned

Step 2: Collect lessons learned - general findings

Finding 5.1: Project team members should look into risk register before project review
It may be inefficient to determine which risks should be discussed during the project review. Therefore, project team members should look into the risk register before the project review and determine which risks they think are important. The reason is because project team members will otherwise first have to look into the risk register during the project review. Project team members may not have seen the risk register for a while and therefore have to think about what exactly happened. Furthermore, discussions may take place about risks between project team members about what happened and about what is important.

Finding 5.2: Ensure risk register is up to date
It may occur that the risk register that is discussed during the project review is not up to date. Risks may have the status “not occurred” have occurred, risks that have the status “active” have not occurred, risks that have the status “expired” have occurred, etc. Therefore, it is important that the risk register is checked before the project evaluation. For instance, this can be done by the risk manager or project controller, or each project team member can check the risks they were responsible for. The reason is because this may take extra time during the project review or valuable lessons not being learned.

Step 2.1: Collect lessons learned - Project review introduction

Finding 5.3: Ensure that goal and outcomes of project review is clear
It can occur that the goal and the desired results of the project review are not clear for project team members that are present. The reason is because this is not clearly discussed at the beginning of the project review. Therefore, it is important to discuss this and make it clear what the goal of the session is, what the desired results are and how this will be accomplished.

Step 2.2: Collect lessons learned - Identify risks to discuss

Finding 5.4: Do not only focus on risks with high impact
When determining which risks should be discussed during the project review it is important to not only focus on risks with a high impact in terms of time and money. The reason is because it risks that have not occurred because they have been controlled will then not be discussed and valuable lessons may not be learned. Therefore, all risks in the risk register should be considered to discuss.

Finding 5.5: Look into expired risks to discuss
It can occur that a risk have the status "expired" and these risks may not be discussed. Therefore, it is important to determine is any "expired" risks should be discussed during the project review. The reason is because the risk may have occurred and thereafter controlled, and valuable lessons may not be learned if these risks are not discussed.

C.5.2 Lessons learned

C.5.3 Summary

Table 31: Summary of the process modifications: Project review 3 (own table)

Finding	Problem	Change
	Step 2: Collect lessons learned - general	
5.1	It may be inefficient to determine which risks should be discussed during the project review.	Project team members should look into the risk register before the project review and determine which risks they think are important. The reason is it can take long and discussions may arise.
5.2	It may occur that the risk register that is discussed during the project review is not up to date.	The risk register is checked before the project review, because this may result in extra time or valuable lessons not being learned.
	Step 2.1: Collect lessons learned - Project review introduction	
5.3	It can occur that the goal and the desired results of the project review are not clear for project team members that are present, because this is not clearly discussed at the beginning of the project review.	It is important to discuss this and make it clear what the goal of the session is, what the desired results are and how this will be accomplished.
	Step 2.2: Collect lessons learned - Identify risks to discuss	
5.4	When determining which risks should be discussed during the project review it is important to not only focus on risks with a high impact in terms of time and money. The reason is because it risks that have not occurred because they have been controlled will then not be discussed and valuable lessons may not be learned.	All risks in the risk register should be considered to be discussed
5.5	Risks may have the status "expired" and may not be discussed.	Determine is any "expired" risks should be discussed during the project review, because the risk may have occurred and thereafter controlled, and valuable lessons may not be learned if these risks are not discussed

C.6 Expert session 2

Expert session 2 is the fifth and final step of the validation process. All the findings from the previous validation steps will be discussed during the session. If needed, last adjustments will be made to the process and the findings of the session will be discussed in section C.6.1 a summary of these findings is shown in section C.6.2. During the expert session four risk managers will be present.

C.6.1 Findings

In this section the findings of Expert session 2 will be discussed and the findings will be listed per step of the lessons learned process. The steps that have been discussed are based on the steps that have been identified in Chapter 5, and adjusted in the previous validation steps. If no new findings for a specific step are found during the expert session, this step will not be discussed in this section or in section C.6.2. The steps that have been discussed are:

Step 1:Project start-up

Step 2:Collect lessons learned

- Step 2.1Project review introduction
- Step 2.2Identify risks to discuss
- Step 2.3Determine context and root cause
- Step 2.4Determine recommendations
- Step 2.5Determine follow up action

Step 3:Document lessons learned

Step 4:Verify lessons learned

Step 2: Collect lessons learned

Finding 6.1: Change collect lessons learned into review project
It is not clear what *Step 2: Collect lessons learned* entails because it is not clear that this step refers to the project review. Using the terminology project review is more clear. Therefore, the choice has been made to change the step to *Step 2: Review project*

Step 2: Collect lessons learned - Determine follow-up action

Finding 6.2: Validation and implementation steps included as follow-up action
Validation and implementation of lessons learned are not always needed. Therefore, instead of having both as loose steps the choice has been made to include steps as follow-up actions.

Finding 6.3: Change follow-up action into further action
The termination "follow-up action" has similarities with "project follow-up" and this causes confusion. Therefore, the terminology "follow-up action" should be changed into "further action".

Step 3: Document lessons learned

Finding 6.4: Change name of heading in documentation
In the documentation from that was presented the heading *Integrated Project Team role* was listed. This can be changed into *Responsible Integrated Project Team role* and the reason is because this specifies the heading more and makes it smarter. Furthermore, this is how it is used in the risk register. The changes can be seen in Finding 6.7.

Finding 6.5: Change name of heading in documentation
In the documentation from that was presented the heading *Applicability in future projects* was listed. This can be changed into *Project type* and the reason is because this specifies the heading

more and makes it smarter. Furthermore, this is how it is used in the risk register. The changes can be seen in Finding 6.7.

Finding 6.6: Add project phase to the documentation
In the documentation from that was presented the project phase should be included and the reason is because this is valuable information for the future project teams.

Finding 6.7: Change order of documentation
In the documentation from that was presented the heading *Control measure* was listed towards the end of the document. This should be changed because the control measure is what the lesson learned has been based on and not the risk that has been listed as first. Therefore, changes should be made to the order of the documentation.

[Title of lesson learned]
Control measure: *This can be found in the risk register*
Effect control measure:
Reason why control measure was chosen:
Control measure executed: yes/no
Lesson learned:
Follow-up action:
Responsible Integrated Project Management role:
Project type:
Project phase:
Risk category:
Risk: *This can be found in the risk register*
Identified: yes/no
Occurred: yes/no
Cause: *This can be found in the risk register*
Effect: *This can be found in the risk register*

Finding 6.8: Combine the documentation and verification steps
After the lessons learned have been documented they need to be verified. The risk manager is responsible for the documentation and verification of the lessons learned. Therefore, *Step 3: Document lessons learned* and *Step 4: Verify lessons learned* are combined into one step: *Step 3: Document and verify lessons learned*

Step 5: Validate lessons learned

Finding 6.9: Include validation in Step 2.5
Step 5: Validate lessons learned is not always needed and therefore it will not be a separate step but included in *Step 2.5: Collect lessons learned - Determine follow-up action.*

Step 6: Implement lessons learned

Finding 6.10: Include implementation in Step 2.5
Step 6: Implement lessons learned is not always needed and therefore it will not be a separate step but included in *Step 2.5: Collect lessons learned - Determine follow-up action.*

Step 8: Disseminate lessons learned

Finding 6.11: Combine the store and dissemination steps
After the lessons learned have been stored they need to be disseminated. The risk manager is responsible for the storage and dissemination of the lessons learned. Therefore, *Step 7: Store lessons learned* and *Step 8: Disseminate lessons learned* are combined into one step: *Step 4: Store and disseminate lessons learned*

C.6.2 Summary

Table 32: Summary of the process modifications: Expert session 2 (own table)

Finding	Problem	Change
	Step 2: Collect lessons learned	
6.1	It is not clear what *Step 2: Collect lessons learned* entails.	The choice has been made to change the name of the step to *Step 2: Review project*
	Step 2.5: Collect lessons learned - Determine follow-up action	
6.2		Validation and implementation of lessons learned are not always needed. Therefore, instead of having both as loose steps the choice has been made to include steps as follow-up actions.
6.3	The termination "follow-up action" has similarities with "project follow-up" and this causes confusion. Therefore, the terminology "follow-up action" should be changed.	*Step 2.5: Collect lessons learned - Determine follow-up action* should be changed into *Step 2.5: Collect lessons learned - Determine further action*
	Step 3: Document lessons learned	
6.4		The heading *Integrated Project Management team role* has been changed into *Responsible Integrated Project Management team role*. The reason is because this specifies the heading more and this is how it is used in the risk register.
6.5		The heading *Applicability in future projects* has been changed into *Project type*. The reason is because this specifies the heading more and this is how it is used in the risk register.
6.6		The project phase should be included in the documentation and the reason is because this is valuable information for the future project teams.
6.7		The order of the documentation has been changed. The reason is because important information, such as the control measure, was listed below less important information.
6.8		After the lessons learned have been documented they need to be verified. The risk manager is responsible for the documentation and verification of the lessons learned. Therefore, *Step 3: Document lessons learned* and *Step 4: Verify lessons learned* are combined into one step: *Step 3: Document and verify lessons learned*
	Step 5: Validate lessons learned	
6.9		*Step 5: Validate lessons learned* is not always needed and therefore it will not be a separate step but included in *Step 2.5: Collect lessons learned - Determine follow-up action*.
	Step 6: Implement lessons learned	
6.10		*Step 6: Implement lessons learned* is not always needed and therefore it will not be a separate step but included in *Step 2.5: Collect lessons learned - Determine follow-up action*.
	Step 8: Disseminate lessons learned	
6.11		After the lessons learned have been stored they need to be disseminated. The risk manager is responsible for the storage and dissemination of the lessons learned. Therefore, *Step 7: Store lessons learned* and *Step 8: Disseminate lessons learned* are combined into one step: *Step 4: Store and disseminate lessons learned*

The project phase should be included in the documentation and the reason is because this is valuable information for the future project teams.

C.7 Summary of findings per process step

Table 33: Findings from validating the lessons learned process (own table)

Finding	Problem	Change
	Step 1: Project start-up	
1.1	It is unclear if a project start-up should only be held at the beginning of a project.	A project start-up should be held at the start of every project phase, because a new project phase means different risks and lessons learned. Within the Ingenieursbureau this is called a project follow-up
2.1	The responsibilities of discussing the lessons learned during the project start-up have not been defined.	1) The project manager should be responsible to ensure that this is included in the presentation and that there is sufficient time during the project start-up to discuss the lessons learned. 2) The project controller should be responsible for the content of the lessons learned that will be discussed. If needed, the project controller can collaborate or be assisted by the technical, environment, contract or risk manager.
	Step 2: Collect lessons learned - general	
1.2	Lessons learned may not get collected, because there is a long period of time between the project reviews and the project team members may forget valuable information	Lessons learned should not only be collected during project reviews but should be collected outside of the organised sessions as well
1.3	It is unclear how often a project review should be organised	Collecting lessons learned during a project review session should occur at least at the end of every project phase, because the project team members may forget valuable information due to long duration of project phases. Furthermore, the energy of the group is not present at the end anymore in comparison to the energy that was present at the beginning, and during the project.
1.4	It is unclear who should be present during the project reviews	Multiple integrated project management team members should be present, because of their expertise and different points of view
2.2	The responsibilities of collecting the lessons learned outside of the project review have not been defined.	The project controller should be responsible
2.3	The responsibilities of collecting the lessons learned during the project review have not been defined.	The project controller should be responsible to ensure that the project reviews are planned. The risk manager should be responsible of facilitating the project review.
3.1	An external facilitator has a knowledge deficit regarding what happened in the project, because an external facilitator was not present during the project and this is inefficient.	The facilitator of the project review should not be an external facilitator but a project team member who has understanding and knowledge of what happened during the project.
3.2	Determining lessons learned for a risk may be unclear, because risks may have multiple control measures per risks	The focus should lie on learning lessons per control measure and not per risk
3.3	Table 35 needs updating, because of the new insights gained in in Findings 3.4, 3.5 and 3.7	Table 23 is an updated overview of the information that needs to be determined
5.1	It may be inefficient to determine which risks should be discussed during the project review.	Project team members should look into the risk register before the project review and determine which risks they think are important. The reason is it can take long and discussions may arise.
5.2	It may occur that the risk register that is discussed during the project review is not up to date.	The risk register is checked before the project review, because this may result in extra time or valuable lessons not being learned.

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Table 33: Findings from validating the lessons learned process (own table)

Finding	Problem	Change
	Step 2.1: Collect lessons learned - Project review introduction	
4.2	The collaboration within the project team should be discussed because such feedback will be beneficial for future collaboration	Include this step into the introduction step
5.3	It can occur that the goal and the desired results of the project review are not clear for project team members that are present, because this is not clearly discussed at the beginning of the project review.	It is important to discuss this and make it clear what the goal of the session is, what the desired results are and how this will be accomplished.
	Step 2.2: Collect lessons learned - Identify issues to discuss	
1.5	Issues can be defined as important topics or problems that should be discussed. However, risks will be discussed during the project review and not issues. These risks have occurred or not, can be foreseen or not, and can have expired or not. The term risks refers to all risks.	The name of the step was called *Identify issues* but this can be changed into *Identify risks to discuss*, because
1.6	The approaches to determine which risks will be discussed could be made sharper towards risk management because the questions are general	The approaches to determine recommendations have been sharpened
4.3		Collect unforeseen risks at the beginning of the session by asking for instance, *what were the unforeseen risks?*
5.4	When determining which risks should be discussed during the project review it is important to not only focus on risks with a high impact in terms of time and money. The reason is because it risks that have not occurred because they have been controlled will then not be discussed and valuable lessons may not be learned.	All risks in the risk register should be considered to be discussed
5.5	Risks may have the status "expired" and may not be discussed.	Determine is any "expired" risks should be discussed during the project review, because the risk may have occurred and thereafter controlled, and valuable lessons may not be learned if these risks are not discussed
	Step 2.3: Collect lessons learned - Determine context	
1.7	It has not been determined how the context and root cause of a risk can be determined	A first approach how to do this is presented in Table 35
3.4	Determining lessons learned for a control measure may be unclear, because each risk may have multiple causes and effects, and each control measure that had been chosen effected a different cause and/or effect.	Determine which cause(s) and/or effect(s) a control measure influences
3.5	The definition of the context of a risk needs updating, because of the new insights gained in in Finding 3.4	The context of a risk can be defined as: identified (y/n), occurred (y/n), cause, effect, control measure, control measure executed (y/n). An overview that can be used during this step is shown in Table 24.
3.6	Determining the context and the root cause should become separate steps, because of the new insights gained in in Finding 3.4 and 3.7	**Step 2.3: Determine context; Step 2.4: Determine root cause**
4.4	In Table 23, 24 and 25 it shows that no control measures are taken for unforeseen risks (Risk E) but this is incorrect, because control measures are taken for unforeseen risks.	Control measures of unforeseen risks should be taken into consideration as can be seen in Table 28
4.5	The risk register may not be updated, resulting in extra control measures that have been taken not being recorded	Determine if there are any control measures not included in the risk register, because all control measures should be reviewed because valuable lessons can be learned per control measure
	Step 2.4: Collect lessons learned - Determine root cause	

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Table 33: Findings from validating the lessons learned process (own table)

Finding	Problem	Change
3.7	The lessons learned that were determined may not add value to future projects, because the collected lessons learned were general	The root cause of a risk lies in the reason why the control measure was (not) chosen and what the effect of the control measure is on the risk. An overview that can be used during this step is shown in Table 25
3.8	The root cause of a risk was not clearly defined.	The root cause of a risk should be defined as why the control measure was (not) chosen and what the effect of the control measure is on the risk, because of the new insights gained in in Findings 3.4, 3.5 and 3.7.
4.6	Table 25 needs updating, because new insights have been gained in Finding 4.4	Table 29 is an updated overview of the information that needs to be determined
	Step 2.5: Collect lessons learned - Determine recommendations	
1.8	The questions to determine recommendations could be made sharper towards risk management because the questions are general	The questions to determine recommendations have been sharpened
3.9	The questions to determine recommendations are general and should be sharpened towards risk management, because of the new insights gained in in Findings 3.5 and 3.7	Recommendation questions have been sharpened
3.10	-	Determine "applicability in future projects" in this step because this information adds value for future project team members searching for lessons learned
4.7	Multiple lessons were learned for a risk that were the same	When determining recommendations it should be determined if lessons learned can be grouped together, because this can form a stronger lesson learned
4.8	Lessons learned may become very situation specific	The lesson learned should be generalised, because the lesson learned can be applied in more future situations
	Step 2.6: Collect lessons learned - Determine follow up action	
3.11	It is unclear when a follow up action is needed	Determine: (1) if the problem/risk that occurred, occurs in (a lot of) other projects as well, (2) if it is possible to control/influence the problem within the means a project team has.
	Step 3: Document lessons learned	
1.9	Document format is not as important	Less attention should be paid to the presentation and documentation, and more to the quality and findability
2.4	The responsibilities of documenting the lessons learned during have not been defined.	The risk manager should be responsible.
3.12	The information needed for documentation needs updating, because of the new insights gained in in Findings 3.4, 3.5, 3.7 and 3.10	The information has been updated
6.4		The heading *Integrated Project Management team role* has been changed into *Responsible Integrated Project Management team role*. The reason is because this specifies the heading more and this is how it is used in the risk register.
6.5		The heading *Applicability in future projects* has been changed into *Project type*. The reason is because this specifies the heading more and this is how it is used in the risk register.
6.6		The project phase should be included in the documentation and the reason is because this is valuable information for the future project teams.

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Table 33: Findings from validating the lessons learned process (own table)

Finding	Problem	Change
6.7		The order of the documentation has been changed. The reason is because important information, such as the control measure, was listed below less important information.
	Step 4: Verify lessons learned	
2.5	The responsibilities of verifying the lessons learned have not been defined.	The risk manager should be responsible. The lessons learned should first be verified by the project team and thereafter by an external risk manager.
6.8		After the lessons learned have been documented they need to be verified. The risk manager is responsible for the documentation and verification of the lessons learned. Therefore, *Step 3: Document lessons learned* and *Step 4: Verify lessons learned* are combined into one step: *Step 3: Document and verify lessons learned*
	Step 5: Validate lessons learned	
6.9		*Step 5: Validate lessons learned* is not always needed and therefore it will not be a separate step but included in *Step 2.5: Collect lessons learned - Determine follow-up action.*
	Step 6: Implement lessons learned	
6.10		*Step 6: Implement lessons learned* is not always needed and therefore it will not be a separate step but included in *Step 2.5: Collect lessons learned - Determine follow-up action.*
	Step 7: Store lessons learned	
1.10	Lessons learned not found and reused because they are not saved in the right place	Create a new environment to save lessons learned, such as the Kennisbank
2.6	The most important criteria of storing the lessons learned is that the lessons learned are easy to find and the environment in which the database is created is user friendly.	
	Step 8: Disseminate lessons learned	
1.11	Employees do not use Kennisbank because they are not familiar with the website	Share the link of the lesson learned that redirects the receiver to Kennisbank
1.12		In Kennisbank, included that employees can "subscribe" to certain lessons learned updates, because this may enhance the lessons learned and reused
	Step 8: Disseminate lessons learned	
6.11		After the lessons learned have been stored they need to be disseminated. The risk manager is responsible for the storage and dissemination of the lessons learned. Therefore, *Step 7: Store lessons learned* and *Step 8: Disseminate lessons learned* are combined into one step: *Step 4: Store and disseminate lessons learned*

An extensive explanation for each finding can be found in the appendix. Table 19 shows an overview of where in the appendix it can be found per validation step. Furthermore, Table 19 consists of three columns and in the first column a number is shown that refers to the number of the finding. The number refers to the validation step in which the finding was found.

D Project reviews

D.1 Project A

D.1.1 Handout

Table 34 represents the information that should be determined per risk during the project review:

Table 34: Example of lessons learned template for documentation (own table)

	Identified	Occurred	Control measure	Context	Root cause	Lesson	Action
Risk A	yes/no	yes/no					

Step 1: Determine which risks will be discussed during the session

Thereafter, execute steps 2-5 per risk

Step 2: Determine the context and the root cause

Table 35: Context and root cause combinations for different risk situations (own table)

	Identified	Occurred		Not occurred		Lesson
		Control measures	No control measures	Control measures	No control measures	
Risk A	*	*				Lesson A
Risk B	*		*			Lesson B
Risk C	*			*		Lesson C
Risk D	*				*	Lesson D
Risk E			*			Lesson E

Lesson A: Why was the control measure not effective? It could have been a considered choice to take a less effective control measure, but it is relevant to determine why and if this is the right choice for future projects.

Lesson B: Why was no control measure taken? It could have been a considered choice to not take a control measure, but it is relevant to determine why and if this is the right choice for future projects.

Lesson C: Has the risk been controlled, did the risk not occur, or is this difficult to determine?

Lesson D: The correct choice has been made.

Lesson E: Why has the risk not been identified?

Step 3: Determine which lesson can be learned

- If you were to do this again, what would you do next time?
- What would be your advice for the project team member who is responsible for executing the same type of project or task? Or a project with the same budget, schedule, etc.

Step 4: Determine the follow up action

- Further investigation
- Update a procedure or process
- Circulate the lessons for others to decide on action

Step 5: Determine the risk category and project team role

D.1.2 Lessons learned

D.2 Project B

D.2.1 Handout

Step 1: Determine which risks will be discussed during the session

Thereafter, execute steps 2-6 per risk

	Identified	Occurred	Control measures						Lesson
			Overview	Cause	Effect	Executed	Reason	Effective	
Risk A	*	*	CM 1	...	...	yes/no	...	...	...
			CM 2	...	...	yes/no	...	...	...
Risk B	*	*					...		...
Risk C	*		CM 3	...	...	yes/no	...	...	...
			CM 4	...	...	yes/no	...	...	...
Risk D	*						...		...
Risk E		*					...		...

Step 2: Determine the context per risk

Determine for each risk if it has been identified, if it occurred and if control measures were taken. If control measures were taken, determine per control measure if it influences the (or multiple) cause(s) and/or effect(s). Lastly, determine if the control measure has been executed.

Step 3: Determine the root cause per risk

- Determine for Risk A and C why the choice has been made for a specific control measure and what the effect of the control measure has been.
- Determine for risks B en D why no control measures were taken.
- Determine for risk E why the risk was not identified.

Step 4: Determine which lesson can be learned

- Can lessons be learned from the reason why a control measure was chosen?
- Can lessons be learned from the effect the control measure had on the cause and/or effect?
- Ask "if you had to make the choice again, what would you do differently?"
- Ask "what is your advice for a future project team who is responsible for a similar project?

Step 5: Determine the follow up action

Does a certain risk occur a lot in other projects, and are follow up actions needed? Examples of follow up actions are:

- Further investigation
- Update a process/procedure
- Circulate the lessons for others (higher management) to decide on action

Step 6: Determine the following information

- Risk category
- Integrated project management team member rol (IPM-role)
- Applicability in future projects

D.2.2 Lessons learned

D.3 Project C

D.3.1 Handout

Step 1: Identify the unforeseen risks

Step 2: Determine which risks will be discussed during the session

Thereafter, execute steps 3-7 per risk

	Identified	Occurred	Control measures						Lesson
			Overview	Cause	Effect	Executed	Reason	Effective	
Risk A	*	*	CM 1	...	...	yes/no	...	...	...
			CM 2	...	...	yes/no	...	...	...
Risk B	*	*					...		...
Risk C	*		CM 3	...	...	yes/no	...	...	...
			CM 4	...	...	yes/no	...	...	...
Risk D	*						...		...
Risk E		*	CM 5	...	...	yes/no	...	...	...
			CM 6	...	...	yes/no	...	...	...

Step 3: Determine the context per risk

Determine for each risk if it has been identified, if it occurred and if control measures were taken. Determine if the risk register is up to date and if any control measures are not registered. If control measures were taken, determine per control measure if it influences the (or multiple) cause(s) and/or effect(s). Lastly, determine if the control measure has been executed.

Step 4: Determine the root cause per risk

- •Determine for Risk A and C why the choice has been made for a specific control measure and what the effect of the control measure has been.
- •Determine for risks B en D why no control measures were taken.
- •Determine for risk E why the risk was not identified.

Step 5: Determine which lesson can be learned

- •Can lessons be learned from the reason why a control measure was chosen?
- •Can lessons be learned from the effect the control measure had on the cause and/or effect?
- •Ask "if you had to make the choice again, what would you do differently?"
- •Ask "what is your advice for a future project team who is responsible for a similar project?

Furthermore, determine if lessons learned per control measure can be grouped together to form a stronger lesson learned. Thereafter, determine if the lessons learned are not too specific, and if generalising the lessons learned may not increase the applicability of the lesson learned in future projects.

Step 6: Determine the follow up action

Does a certain risk occur a lot in other projects, and are follow up actions needed? Examples of follow up actions are:

- •Further investigation
- •Update a process/procedure

•Circulate the lessons for others (higher management) to decide on action

Step 7: Determine the following information

•Risk category

•Integrated project management team member rol (IPM-role)

•Applicability in future projects

D.3.2 Lessons learned

E Influence of facilitators and barriers on the process

This chapter is dedicated to determine how the facilitators and barriers that may influence learning within the Ingenieursbureau can influence the lessons learned process for risk management. In Figure 27 it is shown that the facilitators and barriers can influence five steps.

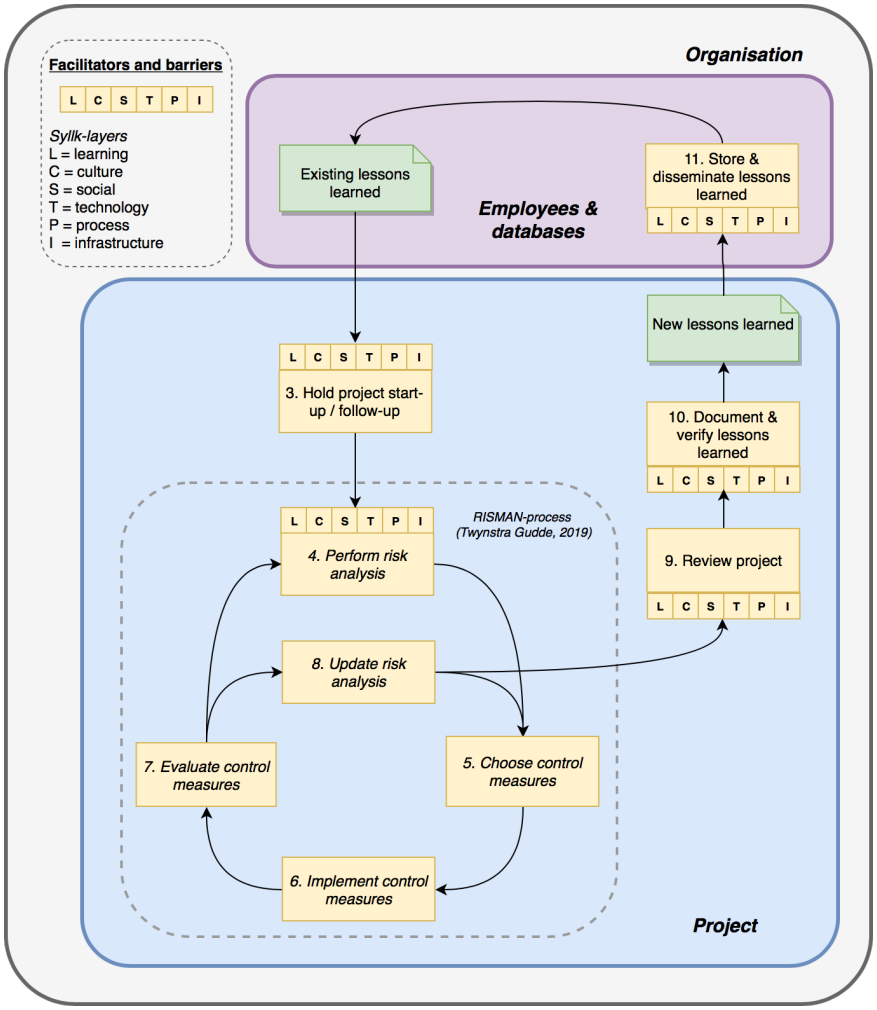

Figure 27: Lessons learned framework showing influence Syllk-layers (own illustration)

E.1 Hold project start-up or follow-up

The outcomes of the project start-up and follow up are highly influenced by the layers related to the Syllk-category *People:* learning, culture and social. This is because participants for instance need to be willing to learn, willing to share information, and be comfortable to speak freely. The technology has high influence because it is important that the project controller can retrieve the lessons learned that are stored in the databases. However, at this moment no such system is implemented within the Ingenieursbureau and this will be needed. The lessons learned process will have a high influence because this will be applied during the session. The layer infrastructure has some influence and this is mainly caused by the availability of meeting rooms to hold a session.

Table 36: Facilitators and barriers: influence on project start-up or follow-up (own table)

Layer	**Influence on step**
Learning (people)	High
Culture (people)	High
Social (people)	High
Technology (systems)	High
Process (systems)	High
Infrastructure (systems)	Medium

Table 37: Facilitators and barriers: influence on project start/follow-up (own table)

Layer		**Facilitators and barriers**	**Influence on process step**
Learning (People)	1	Workshops and training	Low
	2	Willingness to learn	High
	3	Stimulated to share information	High
	4	Willingness to share information	High
	5	Unstressed working environment	Medium
Culture (People)	6	Support from higher management	High
	7	Positive feedback from colleagues	Medium
	8	Colleagues accept each other	High
	9	Colleagues accept mistakes	High
	10	Comfortable to speak freely	High
Social (People)	11	Sufficient collaboration within teams	High
	12	Reliable colleagues	High
	13	Approachable colleagues	High
	14	Social contact during work	Medium
	15	Social contact outside of work	Low
Technology (Systems)	16	Fast and efficient	High
	17	Reliable systems	High
	18	Easy to use	High
	19	Clear overview of systems	Medium
	20	Interconnection	Medium
Process (Systems)	21	Clear and well understood	High
	22	Guidelines of the process are well documented	High
	23	Training is provided how to execute the process	Medium
	24	Clear outcome and desired results	High
	25	Flexible	Medium
Infrastructure (Systems)	26	Pleasant physical working space	Medium
	27	Open door policy	Low
	28	Short geographical distances	Medium
	29	Training facilities and meeting rooms available	High
	30	Clean facilities	Medium

E.2 Apply risk management in project

After the project start-up or follow-up, the identified lessons learned from previous projects can be applied within the new project (phase). This is highly influenced by the layers related to the Syllk-category *People:* learning, culture and social. This is because participants for instance need to be willing to share this information, comfortable to speak freely about this and collaborate well together during the project. This step mainly focuses on applying the lessons learned in the project and therefore the layer technology does not have much influence on this step, nor does the lessons learned process or infrastructure.

Table 39: Facilitators and barriers: influence on risk management application (own table)

Layer	**Influence on step**
Learning (people)	High
Culture (people)	High
Social (people)	High
Technology (systems)	Low
Process (systems)	Low
Infrastructure (systems)	Medium

Table 40: Facilitators and barriers: influence on risk management application (own table)

Layer		**Facilitators and barriers**	**Influence on process step**
Learning (People)	1	Workshops and training	Low
	2	Willingness to learn	High
	3	Stimulated to share information	High
	4	Willingness to share information	High
	5	Unstressed working environment	Medium
Culture (People)	6	Support from higher management	High
	7	Positive feedback from colleagues	Medium
	8	Colleagues accept each other	High
	9	Colleagues accept mistakes	High
	10	Comfortable to speak freely	High
Social (People)	11	Sufficient collaboration within teams	High
	12	Reliable colleagues	High
	13	Approachable colleagues	High
	14	Social contact during work	Medium
	15	Social contact outside of work	Low
Technology (Systems)	16	Fast and efficient	Low
	17	Reliable systems	Low
	18	Easy to use	Low
	19	Clear overview of systems	Low
	20	Interconnection	Low
Process (Systems)	21	Clear and well understood	Low
	22	Guidelines of the process are well documented	Low
	23	Training is provided how to execute the process	Low
	24	Clear outcome and desired results	Low
	25	Flexible	Low
Infrastructure (Systems)	26	Pleasant physical working space	Medium
	27	Open door policy	Medium
	28	Short geographical distances	Medium
	29	Training facilities and meeting rooms available	High
	30	Clean facilities	Medium

E.3 Review project

The project review is highly influenced by the layers related to the Syllk-category *People:* learning, culture and social. This is because participants for instance need to be willing to share what they have experienced during the project and collaborate well together during the project review. During this step it is very important that colleagues accept mistakes from each other and are comfortable to speak freely about this. During the project review technology will have low influence because it will not be needed. The risk manager will facilitate the project reviews

and the process that will be applied during the project review will have a high influence. The layer infrastructure has some influence and this is mainly caused by the availability of meeting rooms to hold a session.

Table 42: Facilitators and barriers: influence on project review (own table)

Layer	**Influence on step**
Learning (people)	High
Culture (people)	High
Social (people)	High
Technology (systems)	Low
Process (systems)	High
Infrastructure (systems)	Medium

Table 43: Facilitators and barriers: influence on project review (own table)

Layer		**Facilitators and barriers**	**Influence on process step**
Learning (People)	1	Workshops and training	Low
	2	Willingness to learn	High
	3	Stimulated to share information	High
	4	Willingness to share information	High
	5	Unstressed working environment	Medium
Culture (People)	6	Support from higher management	High
	7	Positive feedback from colleagues	Medium
	8	Colleagues accept each other	High
	9	Colleagues accept mistakes	High
	10	Comfortable to speak freely	High
Social (People)	11	Sufficient collaboration within teams	High
	12	Reliable colleagues	High
	13	Approachable colleagues	High
	14	Social contact during work	Medium
	15	Social contact outside of work	Low
Technology (Systems)	16	Fast and efficient	Low
	17	Reliable systems	Low
	18	Easy to use	Low
	19	Clear overview of systems	Low
	20	Interconnection	Low
Process (Systems)	21	Clear and well understood	High
	22	Guidelines of the process are well documented	High
	23	Training is provided how to execute the process	Medium
	24	Clear outcome and desired results	High
	25	Flexible	High
Infrastructure (Systems)	26	Pleasant physical working space	Medium
	27	Open door policy	Low
	28	Short geographical distances	Medium
	29	Training facilities and meeting rooms available	High
	30	Clean facilities	Medium

E.4 Document and verify lessons learned

The documentation and verification is not as influenced by the layers learning, culture and social as in the previous steps. This is because this step can executed by the risk manager and does not

take place in a group session. Within these layers there is influence present, for example the step is influenced highly influenced by the reliability of colleagues that they commit to the verification and that colleagues accept the mistakes a risk manager may have made in the documentation. Technology will be used by the risk manager to document the lessons learned and verification may be done by e-mail and therefore there is some influence. The process will influence how the lessons learned should be documented and how the verification should take place and therefore this is some influence.

Table 45: Facilitators and barriers: influence on documenting and verifying (own table)

Layer	**Influence on step**
Learning (people)	Medium
Culture (people)	Medium
Social (people)	Medium
Technology (systems)	Low
Process (systems)	Medium
Infrastructure (systems)	Low

Table 46: Facilitators and barriers: influence on documenting and verifying (own table)

Layer		**Facilitators and barriers**	**Influence on process step**
Learning (People)	1	Workshops and training	Low
	2	Willingness to learn	Medium
	3	Stimulated to share information	Medium
	4	Willingness to share information	Medium
	5	Unstressed working environment	Medium
Culture (People)	6	Support from higher management	Medium
	7	Positive feedback from colleagues	Low
	8	Colleagues accept each other	Medium
	9	Colleagues accept mistakes	High
	10	Comfortable to speak freely	High
Social (People)	11	Sufficient collaboration within teams	Medium
	12	Reliable colleagues	High
	13	Approachable colleagues	Medium
	14	Social contact during work	Medium
	15	Social contact outside of work	Low
Technology (Systems)	16	Fast and efficient	Medium
	17	Reliable systems	Medium
	18	Easy to use	Medium
	19	Clear overview of systems	Medium
	20	Interconnection	Medium
Process (Systems)	21	Clear and well understood	Medium
	22	Guidelines of the process are well documented	Medium
	23	Training is provided how to execute the process	Medium
	24	Clear outcome and desired results	Medium
	25	Flexible	Medium
Infrastructure (Systems)	26	Pleasant physical working space	Medium
	27	Open door policy	Low
	28	Short geographical distances	Low
	29	Training facilities and meeting rooms available	Low
	30	Clean facilities	Medium

E.5 Store and disseminate lessons learned

This step is mainly influenced by the technology. This is because a database is needed to store the lessons learned that is user friendly. Furthermore, the lessons learned need to be disseminated.

Table 48: Facilitators and barriers: influence on storing and disseminating (own table)

Layer	**Influence on step**
Learning (people)	Medium
Culture (people)	Medium
Social (people)	Medium
Technology (systems)	High
Process (systems)	Medium
Infrastructure (systems)	Low

Table 49: Facilitators and barriers: influence on storing and disseminating (own table)

Layer		**Facilitators and barriers**	**Influence on process step**
Learning (People)	1	Workshops and training	Low
	2	Willingness to learn	Medium
	3	Stimulated to share information	Medium
	4	Willingness to share information	Medium
	5	Unstressed working environment	Medium
Culture (People)	6	Support from higher management	Medium
	7	Positive feedback from colleagues	Low
	8	Colleagues accept each other	Medium
	9	Colleagues accept mistakes	High
	10	Comfortable to speak freely	High
Social (People)	11	Sufficient collaboration within teams	Medium
	12	Reliable colleagues	High
	13	Approachable colleagues	Medium
	14	Social contact during work	Medium
	15	Social contact outside of work	Low
Technology (Systems)	16	Fast and efficient	High
	17	Reliable systems	High
	18	Easy to use	High
	19	Clear overview of systems	Medium
	20	Interconnection	Medium
Process (Systems)	21	Clear and well understood	Medium
	22	Guidelines of the process are well documented	Medium
	23	Training is provided how to execute the process	Medium
	24	Clear outcome and desired results	Medium
	25	Flexible	Medium
Infrastructure (Systems)	26	Pleasant physical working space	Medium
	27	Open door policy	Low
	28	Short geographical distances	Low
	29	Training facilities and meeting rooms available	Low
	30	Clean facilities	Medium