PROJECT MANAGEMENT INSTRUMENTS
AND THE BARRIERS TO INTER-PROJECT LEARNING:

Re-inventing the wheel or learning from other projects

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PREFACE

This report contains the results of the study that I conducted for my master thesis at the TU Delft. This thesis is the last step in completing the Management of Technology programme and the last step in acquiring my MSc. grade. The research is performed in the form of an internship at Kennis in het Groot in Gouda. It has been a challenging period in which I learned a lot about project management in the public sector. Now, I am proud to present the interesting results that I have found in this study.

I would like to thank Kennis in het Groot for making this research possible and bringing me in touch with the large infrastructure projects in the Netherlands. Special thanks to Han van Gelder, for introducing me in the world of public projects and for giving me a very interesting and challenging time during my internship at Kennis in het Groot. The fact that Kennis in het Groot let me write a publication about the same topic that is now distributed to the projects of Rijkswaterstaat, ProRail and the city of Amsterdam made it even more special. Many thanks for the weekly support on my thesis research and the writing of the “Project Instrumenten” publication.

Also, I would like to thank Sergey Filippov, my first supervisor, for guiding the whole research process in a motivating and inspiring way. Furthermore, I want to express my thanks to Herman Mooi, the chairman of the graduation committee, and Martijn Groenleer, my second supervisor, for providing me with useful feedback at the right moments in the graduation process.

Martijn de Gans

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EXECUTIVE SUMMARY

Large infrastructure projects in the Netherlands are often subject to discussion due to large time and cost overruns. Project management instruments are developed by the projects for the efficient management of time, cost and scope. These collections of methods, tools and approaches are often modified and further developed when projects face problems and situations that are not encountered before. When projects find solutions for problems in the complex world of large infrastructure problems, other projects might benefit from these developments as well. However, the literature study in this thesis shows that projects often re-invent the wheel instead of learning from other projects. Therefore, the main research question in this master thesis is to what degree the large infrastructure projects in the Netherlands share and implement knowledge about their developed instruments, and what might be the possible barriers that disturb this process of inter-project learning.

First, a literature study is performed where all topics in the area of organizational learning, knowledge management, inter-project learning and learning barriers are explored. The findings of this study are used to develop a framework that can be used to describe the knowledge activities that are performed by the projects in the process of inter-project learning and the barriers that prevent that projects learn from each other. This framework connects learning processes inside projects with learning processes between different projects. The framework identifies four steps of knowledge activities: creation of knowledge, evaluation of knowledge, sharing of knowledge and implementation of knowledge. The barriers are present in the framework between the ‘share’ and the ‘implement’ steps and are grouped in four categories: social, organizational, project-related and knowledge-related.

The developed framework is used in case studies where 14 large infrastructure projects in the Netherlands are researched. Project managers and operational project managers (managers projectbeheersing) of these projects are interviewed in order to find out which instruments are developed in the projects, how the projects deal with the knowledge activities in the four steps of the framework and what the possible barriers to learning are. The findings show that the two barriers that are identified most are the uniqueness of projects that makes it difficult to implement knowledge from a project with a different context and the lack of a higher level knowledge management system, that establishes knowledge connections between the different projects in a structured way.

The main conclusions that can be drawn from this research are that all kinds of project management instruments are developed and that the projects are willing to share these developments with other projects. However, they are not able to see which knowledge is required in the other projects. A recommendation is to let the functional organizations use a higher level knowledge management system. People or a department from the functional organization that are on a higher level above the individual projects, should fulfill the role of ‘knowledge broker’. By having contact with the projects on a regular basis, they keep an overview of the knowledge supply and the knowledge demand. With this system, projects that can learn from each other are connected in a structured way, based on the overview of created knowledge in one project and the problems that are faced in the other project.

Inter-project learning would also be more effective when more knowledge is transferred between projects that are in the same project phase, instead of only transferring knowledge between new projects and projects that are already in a later phase or are even completed. Knowledge transfers between projects that are in the same phase are more effective because direct interaction is possible, even as sharing of tasks and mutual adjustment.
# TABLE OF CONTENTS

Preface .................................................................................................................. 2

Executive Summary ............................................................................................... 3

Table of Contents ................................................................................................... 4

1. Introduction ....................................................................................................... 6

2. Literature review .............................................................................................. 11
   2.1 Organizational learning .............................................................................. 11
   2.2 Lessons Learned ......................................................................................... 12
   2.3 Inter-project learning ................................................................................. 13
   2.4 Barriers to learning ..................................................................................... 16
   2.5 Research on large infrastructure projects .................................................... 19
   2.6 Literature review concluded ....................................................................... 20

3. Analytical Framework ....................................................................................... 21
   3.1 Project management instruments ................................................................ 21
   3.2 Inter-project learning ................................................................................. 22
   3.3 Barriers for inter-project learning ................................................................. 26

4. Research methodology ....................................................................................... 29
   4.1 Kennis in het Groot ................................................................................. 29
   4.2 Research Strategy ....................................................................................... 29
   4.3 Data Collection Method ............................................................................. 30
   4.4 Sample ........................................................................................................ 32
      4.4.1 Sample Description ............................................................................ 33
      4.4.2 Sample Representativeness ................................................................. 34

5. Findings ............................................................................................................ 35
   5.1 Which instruments are developed and how many freedom do the projects have? .. 36
      5.1.1 Empirical results: Developed instruments ........................................... 36
5.1.2 Analysis: Developed instruments..............................................................................................................40

5.1.3 Empirical results: Freedom projects have to develop own instruments and to implement instruments from other projects.................................................................................................................................42

5.1.4 Analysis: Freedom projects have to develop own instruments and to implement instruments from other projects .............................................................................................................................................44

5.2 Inter-project learning..............................................................................................................................................46

5.2.1 Empirical results: inter-project learning (create, evaluate and share) .................................................................................................................................................................................47

5.2.2 Analysis: Inter-project learning (create, evaluate and share).................................................................................................................................48

5.2.3 Empirical results: Inter-project learning (implement) .........................................................................................53

5.2.4 Analysis: Inter-project learning (implement) .............................................................................................................57

5.3 Inter-project learning barriers..................................................................................................................................61

5.3.1 Empirical results: inter-project learning barriers .................................................................................................61

5.3.2 Analysis: inter-project learning barriers ..................................................................................................................62

6. Synthesis.................................................................................................................................................................65

7. Conclusions............................................................................................................................................................70

8. Recommendations.....................................................................................................................................................73

References....................................................................................................................................................................75

Appendix 1 – Findings: Developed instruments ........................................................................................................1

Appendix 2 – Findings: Inter-project learning activities (Create, Evaluate and Share) .................................................4

Appendix 3 – Findings: Inter-project learning barriers ..................................................................................................8
1. INTRODUCTION

Large infrastructure projects are subject to discussion in the Netherlands, but also in the rest of Europe. They are becoming more complex and seem to run out of budget or out of planning most of the time (Flyvbjerg, 2003). The example of the Betuweroute project is commonly known in the Netherlands. In 1990, the estimated budget was around € 1.13 billion euros, and when the project was completed, the total costs turned out to be € 4.8 billion euros (TCI, 2004). Since there is public money involved in these projects, it is important for the projects to act as efficient as possible. Tax payers do not want their money spent on projects that are far over their budget or go far beyond their initial scope.

Project management instruments are designed for managing time, cost and scope in order to complete the project in an efficient way. These instruments are often prescribed by the functional organizations of the projects. However, sometimes it is necessary for a project to develop a new instrument that can be used to solve problems with the management of time, cost and scope inside the specific context of the project. These new developments may contribute to the efficient management of other projects as well.

This implies that instruments that are developed in one project, can be implemented by other projects. The projects exchange knowledge and learn which instruments to use in which situation. The different projects can learn from each other, often referred to as inter-project learning. However, before projects can share their knowledge about these project management instruments with others, they have to think about what they have actually learned. How is this knowledge created? Is it codified or can it only be exchanged interpersonally? Do they think about the value their created lessons learned may have for other projects? And what are the activities the project performs to share its knowledge with others? This research provides a framework which can be used for analyzing the inter-project learning activities of large infrastructure projects.

The implementation of knowledge about project management instruments by other projects is an interesting topic. Although projects may learn from each other and thereby may improve their efficiency, there are barriers that disturb this process of inter-project learning. Shared knowledge is often not implemented by other projects, and the wheel is re-invented over and over again (Keegan and Turner, 2001; Kotnour, 1999; Prusak, 1997; Von Zedtwitz, 2002; Williams, 2003; Pinto, 1999; Newell et al., 2006).

Existing research on inter-project learning recognizes this phenomenon, as can be seen in the literature review in this thesis (section 2). However, little is known about the actual barriers. What are the causes that prevent learning from other projects and implementing their knowledge? (Antoni et al, 2005; Gieskes and Ten Broeke, 2000).

This research will not only provide a framework to research the activities in the process of inter-process learning. Also the possible barriers are included that disturb this process. Based on this developed framework, case studies are performed on 14 large infrastructure projects in the Netherlands. The objective of this research is to find out to what degree these projects perform inter-project learning activities and to identify the barriers that prevent that infrastructure projects learn from each other. If there is more understanding of these barriers, project organizations might be able to use these insights in order to remove the barriers and thereby improve project management efficiency. The main research question of this thesis will be:

“To what degree is knowledge about project management instruments, that are used in large infrastructure projects, shared and implemented and what might be the barriers that disturb the process of inter-project learning about these project management instruments?”
Project management instruments

In the first place, it is important to have a clear definition of the term project management instruments. By looking at the definition of project management, the objectives of the project are fulfilled by applying knowledge, skills tools and techniques (PMI, 2003). Each area within the borders of project management has its own instruments that support project control and decision-making processes (Van Gelder et al., 2009). This research will focus on instruments that are used in large infrastructure projects for the management of time, cost and scope. These factors are often referred to as the ‘triple constraint’ of project management and the management of these three factors is seen as one of the main tasks of project management (PMI, 2003). Each factor requires different methods, tools and approaches to be managed. The management of time is concerned with the planning of the project, which activities need to be completed at which moment and what are the interrelations between the different activities. Also which milestones should be reached at which moment is part of the management of time in a project. The management of cost deals with both cost and budget, the financial aspects of the project. For example, financial overviews need to be made where the available budget and the cost of all project activities can be compared. In the management of scope, questions like what is exactly included in the objective of the project and what is not, and who is responsible for which activity should be handled. Project tasks are often divided in multiple subtasks in order to make the project manageable, also a part of scope management.

In this research, the term instruments include all methods, procedures and tools to efficiently manage time, cost and scope. Additional instruments that support these three primary project management elements, such as quality management and reporting methods, are also included. Instruments are more than only a process description and also not only a (software) tool. Although software tools are included in the term instruments in this research, also a specific approach or philosophy towards the management of time, cost or scope will be seen as an instrument. To make this definition more clear, an instrument is seen as ‘the way how a factor such as time, cost or scope is managed’. For the factor time, this might be a method used for planning. For example, all Rijkswaterstaat projects use the probabilistic PPI (Project Planningen Infrastructuur) method that lists all project activities, the time that is expected to be required for completing the activities and the milestones that should be reached. A similar probabilistic method is used for managing cost and budget, the PRI method (Project Ramingen Infrastructuur).

Two examples of instruments that are not just tools but are more a specific approach or philosophy used by the project organization are described below:

- **Integrated milestone control**: The regular planning method is used, but the project organization of project Maaswerken adds a specific approach upon this method. In this approach, a strong emphasis is put on the milestones in the planning. Milestones are used to clearly distinguish between different phases in the project and control the transitions between these phases. Agreements on which tasks should be completed in a specific phase are described in the milestone-document. If the agreements are not fulfilled, the project will not continue to the next phase. This approach becomes a shared philosophy in the organization when every project team member is aware of the fact that milestones must be reached and cannot be delayed without delaying the whole project (RWS Maaswerken, 2008).

- **TSV (Transparante Sturing en Verantwoording)**: This instrument was created in project Betuweroute in order to establish a reporting protocol that covered all levels in the organization, from the construction workers to the ministers. This is also an example of an approach where it became a shared philosophy where management information must be written down on no more than one A4-paper and transferred to an upper level in the organization. With this line of reporting throughout the whole project, contractors (construction companies) were able to give the client (project organization, government) a good overview
of the status of their activities and at the same time the decision-making process of the client was supported (Projectorganisatie Betuweroute, 2000).

This broad definition of project management instruments is deliberately chosen because interesting developments might be missed if only the ‘pure’ tools for managing time, budget and scope are included in this research. These tools have already undergone a lot of development in the last decades. Interesting developments are made when a project runs into a specific complex problem where no earlier solutions were available.

The instruments that are researched in this thesis have shared characteristics. They are newly created when a specific solution for a complex problem within the project was required. The functional organizations of the projects, in this research Rijkswaterstaat, ProRail and the city of Amsterdam, often prescribe which (standardized) instruments should be applied in which situation. However, projects develop their own methods, tools and approaches in addition to the standardized instruments or adjust existing ones, when they are not sufficient for dealing with specific problems in the context of the project. Therefore, this research does not only look at newly created instruments, because there is not always enough freedom for the projects to develop completely new instruments. It also looks at instruments that are in an innovative way derived from the set of prescriptions of the functional organizations.

To summarize, the definition of project management instruments that is used in this research is:

“The collection of methods, tools and approaches developed to manage the primary project management factors time, cost and scope, as well as the additional factors reporting and quality, that support the primary factors.”

Managerial and academic relevance

The main objective of this research is to provide insight in the inter-project learning activities in large infrastructure projects in the Netherlands, and the barriers that disturb these processes. By researching why shared knowledge about instruments that may improve project management efficiency is not implemented in other projects, more understanding will be gained in possibilities and opportunities for removing the learning barriers.

From a managerial perspective, project management efficiency can be improved with this understanding. If projects can learn more from each other than they do know, this might reduce the problems of running out of budget and time. Also, an overview is provided of the development of project management instruments in the world of large infrastructure projects. By conducting interviews with project managers and operational project managers (managers projectbeheersing), a detailed view of the instruments that are developed during the years in the Netherlands is given. The overview is completed with a description of the freedom projects have to develop and apply their own instruments. This will give insight in the actual topics and questions that play a major role in the management of large infrastructure projects in the Netherlands.

From an academic point of view, a framework is provided that makes a connection between learning processes inside the project and between different projects. Existing studies on inter-project learning focus mainly on the actual transfer of knowledge between projects, and leave the knowledge activities that precede this process out of the picture. In addition, the framework not only takes the inter-project learning process into account, but also the barriers that influence this process. Existing studies already described the subject of learning between multiple projects, but indicate that the factors that cause the barriers are explored very little yet. This study contributes to that field of research by developing a framework that includes different categories of barriers. After the development of the framework, it is used in case studies where 14 large infrastructure projects in the Netherlands are researched.
Research Objectives and Questions

To find an answer to the main research question, the study is split into three different research objectives, that are performed in a logical order. This structure and why this order is followed is described in this section.

The first step in this research will be to get insight in which project management instruments are developed and/or derived from already existing instruments. This step will cover the identification of the instruments, but also gives understanding of how much freedom the projects have to develop their own instruments or to implement knowledge from other projects. This first step is required to get more insight in how instruments are developed before the sharing and implementation of knowledge about this instruments can be researched further.

When there is an understanding of how instruments are developed in large infrastructure projects, the following step is to analyze the inter-project learning process. How do the projects deal with the sharing of knowledge about developed instruments and the implementation of knowledge from other projects? For example, in what way does a project share its knowledge with other projects when it has developed a new method for managing costs when a new way of contracting influences the financial aspects of the project? Is an evaluation-report of a specific phase of the project, for example the tender phase, distributed to other projects? Do project managers come together on a regular basis to discuss their problems and questions with each other?

The results of this second research objective on inter-project learning activities will be required for performing the third step. In this last step, the barriers that stand between the sharing of knowledge by one project and the implementation of that knowledge by another project are researched. Why are projects often not learning from each other and why are they reinventing the wheel when there is knowledge available somewhere else?

To summarize, this study is divided into the following three research objectives:

- Study developed project management instruments and the freedom the projects have to develop their own instruments or implement knowledge from other projects
- Study inter-project learning activities about developed project management instruments
- Study barriers that disturb the process of inter-project learning about project management instruments

FIGURE 1: OVERVIEW OF MAIN RESEARCH QUESTION AND RESEARCH OBJECTIVES
**Thesis outline**

This section describes the structure of the thesis in chronological order. Below, an overview is given of the chapters that follow this introductory part and their content:

<table>
<thead>
<tr>
<th>Chapter 2: Literature review</th>
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<tr>
<td>Existing studies on the concepts of organizational learning, lessons learned, inter-project learning, learning barriers and infrastructure projects are explored in this chapter.</td>
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<th>Chapter 3: Analytical framework</th>
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<tr>
<td>A framework, based on the literature in chapter 2, is developed that describes all activities in the process of inter-project learning. The barriers that disturb this process are also included. This framework will be used for the study on 14 large infrastructure projects in the Netherlands.</td>
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<th>Chapter 4: Research Methodology</th>
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<tr>
<td>This chapter will describe how the research is performed and which research strategy was followed in order to find an answer to the main question. The strategy of case studies will be described, as well as how the data for the research was collected for all the cases. A detailed description of the sample and the respondents is given in the end of the section.</td>
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<th>Chapter 5: Findings</th>
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<tr>
<td>The findings of the study will be described here. The structure of the chapter is based on the three research objectives. For each objective, the empirical results will be presented, followed by an analysis of that specific part of the research.</td>
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<th>Chapter 6: Synthesis</th>
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<tr>
<td>In the synthesis, the partial analyses that are made in chapter 5 are brought together in order to present the general findings of the research.</td>
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<th>Chapter 7: Conclusions</th>
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<tr>
<td>General conclusions will be derived, based on the empirical results and the analyses presented in chapter 5 and 6. The contribution of this research will be discussed as well as recommendations for future research.</td>
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<th>Chapter 8: Recommendations</th>
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<tr>
<td>This final chapter will present two recommendations, based on the findings and conclusions of this study, that can be used to improve the inter-project learning activities.</td>
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2. LITERATURE REVIEW

This section will explore existing studies in the field of learning between projects and the barriers that prevent this inter-project learning. In the first place, the review will start with exploring the basic topics of organizational learning and knowledge management (section 2.1). After an overview is given of existing literature in order to create a general understanding of what learning is and how knowledge management plays a role in learning in organizations, the concept of lessons learned is explored (section 2.2). A review of existing studies in the field of inter-project learning is given in the next part (section 2.3). Different frameworks and theories for the process of learning between multiple projects are described. This is followed by existing literature on possible inter-project learning barriers (section 2.4). After literature is reviewed on the relevant research topics, a separate section (section 2.5) explores what is already researched on large infrastructure projects, since studies found in the previous sections are not directly related to large infrastructure projects but often to other types of projects. A conclusion of the literature study, where a summary is given and where a gap in research is identified, can be found in the final section (section 2.6).

2.1 ORGANIZATIONAL LEARNING

For a more general understanding of how projects can learn from each other and how they can deal with the concept of lessons learned, first will be looked at theories of organizational learning. The focus will be on project-based organizations, that are for the largest part organized around projects, since this will be close to the projects that are researched in this thesis. Project-based organizations are able to benefit from knowledge that is gathered during the execution of one project and can be transferred to other projects in that organization (Prencipe and Tell, 2001). In the same article, Prencipe and Tell (2001) argue that while in functionally-based firms, the departments act as “knowledge silo’s”, project-based firms do not have the mechanisms to transfer gathered knowledge between the projects inside their organization. This can be due to the temporary nature of the projects as well as the unique and heterogeneous activities that might not be repeated in successive projects. DeFillippi and Arthur (1998) provide an illustrative example of project-based working in the film-making business, an industry that might have similarities with the projects that are regarded in this thesis. The main idea in their article is that a project is characterized by the people that are hired. There is no organizational learning because of the temporary nature of the film projects, but the people within the projects develop their own memory as well as the industry as a whole. Because the individual projects have shown what worked and what did not work, they play a role in the learning of the industry (DeFillippi and Arthur, 1998). This example shows that the temporary existence of the project and the capabilities of the hired people have a direct influence on how knowledge can be captured and transferred to other projects. If a project is characterized by the mixed group of people it is composed of, this implies that new relationships will be created when a new project is started, and therefore barriers to learning from the previous experience of others might be increased (Prencipe and Tell, 2001). If there is no organizational learning in this project-based setting, the role of the project-based organization will be facilitating, for example the facilitation of finance, the availability of people to hire and providing developed distribution channels (DeFillippi and Arthur, 1998). This idea of the project-based organization is supported by Nonaka (1994), where organizational knowledge creation is described as a process which amplifies knowledge created by individuals that is given a place in a knowledge network. In the context of this thesis the situation of individuals as part of an organization, as described in the literature about organizational learning, can be compared with individual large infrastructure projects as part of the whole group of infrastructure projects in the Netherlands.

Going one step back to the basics of knowledge management theories, the difference between tacit and explicit knowledge is a relevant subject. Explicit knowledge can be written down in formal language, and thereby easily
transferred to another person, project or organization. Tacit knowledge is difficult to communicate and to ‘codify’. It is rooted in actions, work experience and is in the head of people (Nonaka, 1994; Polanyi, 1958). Since tacit knowledge cannot be shared by writing it down in documents it has to be shared by bringing people together, referred to as socialization by Nonaka (1994). When there is a certain level of shared experience, people can talk to other people in the same work field and can in this way help each other by exchanging experiences and help each other with finding solutions for specific problems. Besides shared experience, that is necessary for the understanding of each other’s situation, a level of mutual trust is required in the process of transferring tacit knowledge (Mu, Peng and Love, 2008). This implies that for the exchange of tacit knowledge, it is important to bring people together since it cannot be transferred by documents or other codified information.

This exchange, that is necessary for organizations to learn from other organizations, is influenced by another factor: the absorptive capacity of an organization. This is the ability to value, assimilate and apply knowledge from another organization (Lane and Lubatkin, 1998). This ability will be determined by the specific type of new knowledge that is offered and the familiarity with the field of the problem. The concept of absorptive capacity can not only be applied to organizations, but also to individuals and projects. So to turn back to the context of this thesis, how projects learn from other projects may be determined by the degree of absorptive capacity. Are they able to recognize valuable knowledge that is present in other projects, and are they able to process and implement this knowledge into the own project organization. However, if projects are able to search for valuable knowledge from other projects, this knowledge must also be available, accessible and understandable. In the knowledge transfer process, there is an important role for both the sender and the receiver (Tang, F., Mu, J., MacLachlan, D.L., 2010). The receiver has to be able to implement the knowledge and the sender has to be able to clearly articulate the knowledge that is gathered in the organization or in the project. In an article by Tang, Mu and MacLachlan (2010) this ability is called the knowledge disseminative capacity. It is defined as “the ability to efficiently, effectively and convincingly frame knowledge in a way that others can understand and implement the lessons learned in practice”.

To conclude, it is more difficult to share and transfer knowledge in project-based organizations than in functional organizations. Often no mechanisms for the transfer of knowledge between projects inside the same organization are available. This is due to the characteristics of projects. In the field of knowledge management, the concepts of tacit and explicit knowledge are relevant for this research, because they determine how knowledge can be shared and implemented. However, both sender and receiver of knowledge must be able to deal with the sharing and implementation of knowledge that is created inside a project. The following section explores in what way this can be done.

### 2.2 Lessons Learned

The framing of the knowledge can be done in the form of a “lesson learned”. A lesson-learned is often described as a “catchall phrase describing what has been learned from experience” (Juran, 1988). The difficulties of sharing knowledge between the receiver and the sender, as mentioned above, can be dealt with by using lessons learned. In the first place, the sender of the knowledge needs to evaluate on the gathered knowledge. How can it be described in the form of a lesson learned and what is the value of the knowledge for others. This contributes to the ‘disseminative capacity’ of the sender.

Knowledge dissemination is a process that is commonly known as the transfer of knowledge within and across settings, with the expectation that the knowledge will be used conceptually (as learning) or instrumentally (in the form of modified or new practices) (Hutchinson and Huberman, 1994).
In the second place, the knowledge is now documented and can be recognized and implemented more easily by the receiver, thereby also helping the receiving party in increasing its absorptive capacity (Kotnour, 2000). To produce a lesson learned, the knowledge that is created in a project has to be evaluated before it can be shared with other projects. This process of creating, evaluating and sharing knowledge is described in the Plan-Do-Study-Act cycle by Deming (1993). This model starts with the steps “plan” and “do”, which describe the planning of an action and the following execution of that plan. After the actions have been performed, evaluation is required on the results and the value of the lessons-learned, the “study” step. Finally, lessons that are learned from the studied actions will be implemented in the “act” step. This sequence of knowledge activities, where knowledge is created and also used within the same project, is called intra-project learning (Fitzek, 2002). However, in this research there is a bridge between the knowledge creation and evaluation steps and the implementation of this knowledge by other projects. The first two actions, together with the sharing of the knowledge, are performed by an individual project, and the last step of implementation is performed by another project. In the Plan-Do-Study-Act cycle (Deming, 1993) the lessons-learned are implemented in the same project. It is obvious that projects will learn by implementing knowledge that is derived from evaluating their own actions, but the focus of this study will be on the implementation of knowledge by other projects. Therefore, in this thesis an analytical framework is developed (section 3) where Deming’s cycle is adapted to a new framework that can be used for describing the learning activities between different projects. This process, also referred to as inter-project learning is described in the following section.

To conclude, knowledge that is created can be transferred between the sender and the receiver by producing lessons learned. These lessons learned capture the experience that is gained inside a project. Lessons learned can be produced by evaluating the knowledge that is created in a project and by thinking about the value it might have for other projects. This process is partly described in the Plan-Do-Study-Act cycle by Deming (1993). However, this model is designed for describing learning processes inside one project (intra-project learning). Because this study aims at learning between different projects, an extra step need to be made to transfer lessons learned from one project to another. The next section explores what is already researched about this process of inter-project learning.

2.3 INTER-PROJECT LEARNING

The dissemination of knowledge between projects can be used to exploit experience that is gained in past or concurrent projects. This knowledge, in the form of lessons learned, can be used to derive important information about successful practices or procedures (Fitzek, 2002).

According to Bartezzaghi et al (1997), the process of inter-project learning is happening by repeatedly executing the intra-project learning activities of creating and evaluating knowledge. When this knowledge is shared to other projects, the learning takes place at a more abstract level and thereby becomes more complex. Bartezzaghi et al (1997) defined four steps in the inter-project learning process:

- **Abstraction and generalization:** the identification of lessons-learned that are not context specific and can be of value. In this step the project needs to think about its created knowledge and how valuable these lessons learned can be for other projects.
- **Embodiment of learning:** the selected (valuable for other projects) lessons learned are institutionalized
- **Dissemination of learning:** the actual sharing of knowledge beyond the specific context of the original project
- **Application of learning:** the implementation of knowledge from other projects to improve project management practices
These four actions can be seen as the final step of inter-project learning. The steps can be exercised between one project that is already finished and a project that is still running, or between two running projects. Fitzek (2002) recognizes this difference as a critical point in inter-project learning. He identifies two 'transfer modes': sequential transfer and concurrent transfer. In the sequential transfer mode, project A is finished and project B implements the lessons learned from this past project. In the concurrent transfer mode, both project A and B are still running and exchange lessons learned to use this knowledge in the current situation. According to Fitzek (2002), the sequential transfer mode seems to be less effective, because it is not possible to interact and communicate directly between the two projects, even as the sharing of tasks and mutual adjustment.

A framework for describing inter-project learning is given by Antoni (2000). This framework consists of five dimensions that are important for effective learning between projects:

- Knowledge dissemination (codified and personalized)
- Relationship to permanent organization
- Understanding for time
- Uniqueness
- Awareness of project change and ambiguity

According to Antoni (2000), these are the critical points that make inter-project learning possible. Knowledge dissemination describes the knowledge activities (both activities dealing with codified knowledge and tacit knowledge) between projects. The second point is the relationship with the permanent organization, which has the ability to create a bridge between comparable projects. This relationship is important since the permanent organization is the place where knowledge can be preserved. A finding that is supported by Romme (1997). In his research he notes the importance of the wider organizational structure in which teams and projects operate, in order to realize inter-team or project learning. A hierarchical structure is required to link teams together and disseminate knowledge in large organizations.
The understanding of time is about the short-term and time-focused nature of projects, which has its influence on how projects learn from each other. There is often time-pressure and knowledge and learning do not always receive high priority in the project organization.

Another critical point for inter-project learning identified by Antoni (2000) is uniqueness. Similarities need to be recognized between projects, while at the same time a certain degree of uniqueness is a common characteristic of projects. The uniqueness of projects makes knowledge ‘local’ or ‘context-specific’, in the sense that it could not be readily extended to other projects that have different contexts (Arora and Gambardella, 1994). In his article, Antoni (2000) mentions the fact that this uniqueness is sometimes reflected in the attitude of project team members and complicates knowledge exchange and inter-project learning.

The fifth factor that influences inter-project learning is the awareness of changes that might occur in the scope of the project. The client might come up with additional requirements or political changes might influence the specifications. Antoni (2000) says this influences the ability to extract lessons learned from the project.

Fitzek (2000) also developed a framework for inter-project learning where the knowledge transfer between a past project and a new project is influenced by three factors: people, organization and tools. The factor people includes the impact of leadership and people’s frames of reference on inter-project learning: how are people inspired to learn from other projects and does their personal point of view has its influence?

The second factor describes the influence of organizational structures and culture on knowledge transfer between projects. This is supported by Julian (2008). His work demonstrates that organizational routines in the project management environment can help to overcome the challenges of inter-project learning. They not only provide a formal mechanism for lessons-learned practices, but they can incorporate learning from past project experiences in the form of improved project methodologies and templates that can be transferred to future project teams.

The tool factor is about the tools that are available for supporting reviews of the projects and systematically storing the derived lessons learned.

The importance of inter-project learning is clear. In literature it is defined as: ‘a purposeful systematic approach adopted to facilitate knowledge sharing across projects to result in systematic and cumulative improvement in the process and the deliverables of a project’ (Antoni et al, 2005). In the same research it is emphasized that lessons learned that are gained in a project have to be made available to future projects in order to improve the quality of project management effort and to reduce lead times. Therefore it is necessary to realize that multiple projects have interconnections. ‘Ensuring that people pass on their experiences to others is one of the greatest challenges for success in the long term’ (Antoni et al, 2005).

2.4 BARRIERS TO LEARNING

As the previous sections show, there is widespread agreement on the fact that lessons that are learned in large infrastructure projects are valuable and might contribute to the improvement of the quality of project management of other projects. However, in practice it appears that knowledge that is gathered is often not implemented in other projects. There is a tendency to ‘reinvent’ the wheel rather than to learn from the experiences of other projects (Prusak, 1997). Little effort is spent on discovering useful lessons that can be carried over to future projects (Pinto, 1999). The ‘unnecessary’ repetition of activities and mistakes is one of the most central cost drivers (Antoni et al, 2005). Often, lessons learned are not stored, the knowledge is not managed, at the level of the functional organization above the projects. There is no systematic diffusion to new projects (Gieskes and Ten Broeke, 2000). It is the functional organization that is able to store the lessons learned and to transfer this knowledge to other projects, both concurrent as projects in the future (Antoni et al, 2005).

One of the explanations for the fact that lessons learned are not implemented in other projects, is the temporary nature of the project organization. When a new project is started, project teams often start finding new solutions for problems they encounter rather than learning from experiences of past projects (Scarbrough et al, 2004). This is also recognized in the research of Gieskes and Ten Broeke (2000). If it is not sure that knowledge is used in other projects in a different setting with different partners, these partners do not want to put much effort into learning and knowledge management activities. They add to this temporary nature the competition between the partners in the project. It might be not in their interest to share lessons learned.

Gieskes and Ten Broeke (2000) identified two other factors that might be barriers for learning between projects. The first is the on-site character of projects. They argue that in a project, communication is only about the operational project management. To establish inter-project learning, there should also be communication on a more strategic level between the functional organizations of the different partners in the project. Because a project is often considered as an island, isolated from the rest of the organization, this strategic communication is not happening.

The second factor is related to the organizational culture of the infrastructure sector. Gieskes and Ten Broeke (2000) argue that this sector is dominated by engineers, who are by nature more focused on the technical aspects of the project than the organizational aspects such as learning. This results in a culture that is short-term oriented and less focused on long-term strategic learning and improvement.

Another learning barrier might be the uniqueness of the projects. This is unique nature is one of the main characteristics in the definition of a project (PMI, 2003). Each project has its own design, different location, different contractors, that makes it different from other projects. However, this uniqueness is questioned in literature. Since there is often a high number of routine elements in each project, it is actually a composition of not so unique sub-processes (Antoni et al, 2005). It is unlikely that no part of a project is repeated. This research states
that when a project is part of a larger functional organization where its knowledge can be stored, the uniqueness becomes even more unlikely.

Like the barrier of the ‘engineering-culture’, where the people working in the project influence the learning attitude, there are more barriers that have to do with social aspects and politics in the project. If a project manager explicitly states that, for example, documentation of a project is not necessary, the learning attitude of the project members will be influenced (Sense and Antoni, 2003). This can be linked to the inter-project learning framework by Fitzek (2002), as described in section 2.3, where the inspiration of people by their leader is one of the influencing factors on the knowledge transfer between projects. If a project manager clearly emphasizes the importance of learning from experiences in other projects, the learning attitude of the project members will be positively influenced. Learning between projects is also dependent on social patterns, practices and processes in social networks and communities of practice (Bresnen et al, 2003). In these networks, where people from projects come together, tacit knowledge can be shared. As mentioned before, tacit knowledge can only be transferred interpersonally. Social networks and relationships within these networks are therefore highly important for the exchange of this knowledge. Politics in the project environment are therefore influencing this form of inter-project learning. The relationships and power positions between the people in this groups determine if specific knowledge is shared or not (Julian, 2008).

Defensive routines, such as face-saving may also distort inter-project learning (Julian, 2008). People often do not want to look back at what went wrong during the project, because they are afraid this will have negative effects for themselves. However, when mistakes are not recognized and discussed it is also not possible to derive lessons learned from these situations.

This is what often happens in post-project reviews, one of the most structured ways of acquiring knowledge about a project and transferring this knowledge to a future project (Von Zedtwitz, 2002). These post-project reviews can be seen as evaluating the project after it has been completed and thereby identifying lessons learned. If this form of evaluation deals with major variances in the project, lessons learned and recommendations for other projects, this will support the success of projects in the future (Anbari, 1985). However, Keegan and Turner (2001) did a study on a large number of projects where they discovered that there were indeed post-project reviews, but that the lessons learned are not used in other projects. Also Williams (2003) mentions in his study that management is rarely adapting its behavior when lessons learned from executed projects become available.

Von Zedtwitz (2002), researched barriers to learn from post-project reviews in R&D projects. One of the explanations why such reviews do not lead to acting on the lessons-learned might be that reviewing the project involves looking back at problems and critical events in the past (Von Zedtwitz, 2002). In the same research, it is also mentioned that the human mind is not able to generalize project-specific experiences. With this difficulty, it is not possible to generalize in such a way that the knowledge can be applied to future projects. If this statement is linked to the disseminative capacity mentioned earlier in section 2.2, it is again obvious that that gained knowledge needs to be codified in such a generalized way that it is also understandable and applicable for other projects.

Von Zedtwitz (2002) developed a framework for the identification of barriers that withhold R&D projects and people from evaluating their experiences and producing lessons-learned (figure 4). It has to be noted that this research is fully applied to R&D projects, that may have important differences in multiple dimensions when compared to large infrastructure projects.
Kransdorff (1996) argues that the problem with post-project reviews, internal audits and/or oral post-mortems as a way to learn to derive lessons learned is that they are undertaken retrospectively. This implies that they are influenced by subjectivity, caused by the selective memory of the reviewed project managers.

Another framework for describing the inter-project learning barriers is given by Fitzek (2002). Three main barriers are described that disturb the process of inter-project learning: social, temporal and physical distance. The larger these distances are, the more difficult it is to share knowledge between projects. Most of the possible barriers that are mentioned before in this chapter, can be seen again in one of the three distances in this framework. Social distance contains hierarchical, functional and cultural distances. The attitude towards knowledge sharing and implementing lessons learned from other projects is also included in the social distance. The temporal distance or time barriers are related to the management of knowledge that is created in past projects. The temporary nature of a project is one of these time barriers. A second time barrier is the relationship with the functional organization. How do they capture, store and share lessons learned that are created in their projects. The physical barrier deals with the distributed locations of the projects. It includes problems with the technological tools that are used for the transfer of knowledge between projects.

To conclude, the barriers mentioned in this section describe various reasons for the fact that shared knowledge is not always implemented in other projects. They have different natures but also sometimes show similarity. Four main barriers can be identified based on the literature review:

- **Social barriers**: Include all factors that have to do with people and social behaviour towards the process of inter-project learning.
- **Organizational barriers**: An organizational culture where there is a strong focus on the operational aspects and very little or zero attention for the creation and sharing of knowledge can be one of the barriers in this group.
- **Project-related barriers**: Barriers that are directly related to the nature of projects, for example the temporary nature and the uniqueness.
- **Knowledge-related barriers**: Some barriers are left that are related to knowledge management and related issues, such as the difficulty to generalize lessons learned from a project or to transfer tacit knowledge. These barriers can be placed in the ‘knowledge-related’ main barrier.
This categorization will be used in the development of the analytical framework in section 3. In this part of the thesis, all barriers found in literature will be categorized in one of the four main barrier groups.

2.5 RESEARCH ON LARGE INFRASTRUCTURE PROJECTS

The literature about organizational learning and learning in project-based organizations can for a large extent be applied to the large infrastructure projects that are researched in this thesis. In addition to these theories, this section will explore what is already researched about large infrastructure projects in existing literature. From this review it appears that there is mainly research done on the cost overruns and the complexity of this kind of projects.

Flyvbjerg, states that it is remarkable that there are enormous sums of money spent on infrastructure projects all over the world, but there exists little systematic and reliable knowledge about the costs, benefits and risks that are involved (Flyvbjerg et al., 2003). This statement might support the idea of this thesis that projects could more actively capture their knowledge and share this with other projects. When, according to Flyvbjerg (2003), 9 out of 10 projects have to deal with cost escalation, it can be questioned if enough learning and knowledge exchange takes place between the projects. This idea is even supported by another article in 2002 (Flyvbjerg et al., 2002), where is concluded that cost underestimation can be best explained by strategic behaviour, and not just by error. Causes of these failures may be explained by the characteristics of large infrastructure projects that are shown in the list below (Flyvbjerg and COWI, 2004):

- Large infrastructure projects are inherently risky because of long planning horizons and complex interfaces.
- Technology is often not standard.
- Decision-making and planning are often multi-actor processes with conflicting interests.
- Often the project scope or ambition level will change significantly over time.
- Large infrastructure projects are inherently risky because of long planning horizons and complex interfaces.
- Statistical evidence shows that such unplanned events are often unaccounted for, leaving budget contingencies sorely inadequate.
- As a consequence, misinformation about costs, benefits, and risks is the norm.
- The results are cost overruns and/or benefit shortfalls for the majority of projects.

The list of characteristics illustrates the high level of complexity of large infrastructure projects. However, this does not imply that these characteristics should be ‘taken for granted’ and that it should be accepted that nothing can be done to deal with this complexity. Project managers can try to find patterns and similar situations in other projects. Learning from other projects will support the understanding of the characteristics of the own project (Hertogh and Westerveld, 2009). Hertogh and Westerveld (2009) did research on complexity in large infrastructure projects in Europe. It turned out that the social complexity in projects was the most difficult form of complexity to manage. This can be linked to one of the characteristics in the list above, where is mentioned that decision-making in projects often involves multiple stakeholders with conflicting interests. The project is initiated by the government and executed by the project organization and the underlying subcontractors. But besides the influences from the principle and the contractor, there are other actors who will try to influence the execution of the project. Environmental groups demand that the project will be as environmental-friendly as possible and people who have to leave their houses will often not accept this without tough negotiations. There are even many other actors that will try to maximize their interest, depending on their own position, in this multi-actor decision-
making process. Hertogh and Westerveld (2009), proposed a project management approach that is a balance between the more traditional systems management, where the project is controlled by tight monitoring and steering of costs, time and scope, and interactive management, where stakeholder satisfaction and flexibility are the key factors. According to Hertogh and Westerveld (2009), this flexible approach is the solution for the complexity issues in large infrastructure projects, because the management approach can be fitted into the context of the project.

2.6 LITERATURE REVIEW CONCLUDED

Reviewing literature about learning in project-based organizations shows that learning between different projects can be difficult due to the barriers that are present in the inter-project learning process, as described in section 2.4. In order to effectively share knowledge that is gained from experience in a project, lessons learned need to be produced. These lessons learned are a codification of knowledge where experience is added and are useful for both the sender and the receiver of the knowledge. Projects must be able to recognize and implement knowledge from other projects, but the project that wants to send the knowledge also needs to ‘codify’ it in an accessible and understandable way.

Different models and frameworks are developed to describe the process of inter-project learning. They describe what actions need to be performed when lessons learned that are created in one project need to be transferred to another project. That shared knowledge is not always implemented in other projects, although it can be useful for the improvement of project management efficiency, is recognized by multiple existing studies. Therefore, barriers that stand between the sharing of knowledge and the implementation in another project are researched as well. However, little literature is found that gives more insight in the explanatory factors that cause these barriers. It is recommended as an important area for future research by Antoni et al (2005) and Gieskes and Ten Broeke (2000).

A conclusion that can be drawn from this literature review is that very little literature about learning can be found that is directly focusing on infrastructure projects. Articles that are available about infrastructure projects primarily deal with cost escalation and planning issues, and a recent research on complexity. There is no existing literature found about knowledge management and learning processes in and between projects in the infrastructure sector. For example, the framework for learning barriers that is developed by Von Zedtwitz (2002) is fully applied to R&D projects, that are executed in a different organizational context. The large infrastructure projects that are researched in this thesis have other characteristics and it cannot be assumed that the same framework and the same barriers apply to these projects. The reason that this assumption cannot be made without any reservations is that the main objective of R&D projects is to innovate and come up with new developments, often for companies or groups of companies. In infrastructure projects, there is public money involved and there is a large group of different types of stakeholders that all have their influence on the execution of the project. The projects in this research have the label ‘large’ infrastructure projects because their budgets are in the range of hundreds of millions or even billions. Only the size of these projects on its own is already a reason to consider them as different from the projects studied in the reviewed literature.
3. **ANALYTICAL FRAMEWORK**

This section will present the analytical framework that is used in this research. The framework is developed to describe inter-project learning and the barriers that prevent the implementation of knowledge from other projects. A distinction is made between the inter-project learning activities that include creating, evaluating, sharing and implementing knowledge and the learning barriers. The framework is developed based on existing literature and existing frameworks in the field of knowledge management, organizational learning and inter-project learning.

3.1 **PROJECT MANAGEMENT INSTRUMENTS**

This research aims at inter-project learning about project management instruments. Therefore, in the first place an overview will be made of recently developed instruments in large infrastructure projects in the Netherlands. As described in section 1, the definition used in this research for the term management instruments is: “The collection of methods, tools and approaches developed to manage the primary project management factors time, cost and scope, as well as the additional elements reporting and quality that support the primary factors.” These factors, described in literature as the primary elements on which to manage a project (PMI, 2003), will be used as a framework for identifying the developed instruments in the studied projects. The project management elements quality and reporting are added and considered in this study as additional project management factors since they support the management of the primary factors. It is assumed that risk management is the overall process that is used to assess project risks and create probabilistic estimations for the three primary project management factors.

![FIGURE 5: FRAMEWORK OF PROJECT MANAGEMENT FACTORS FOR RESEARCHING DEVELOPED INSTRUMENTS](image)

**Freedom to develop instruments or implement from other projects**

Not only the developed instruments are identified and described in this study, also the freedom that projects have to develop their own instruments or implement from other projects is researched. The term ‘freedom’ in this thesis is referring to the degree of freedom that individual projects receive, from the functional organization they are connected with. This is not about freedom to make operational decisions within the project organization, but the freedom a project receives from the functional organization to make its own decisions regarding project management instruments. Are they allowed to develop their own instruments when a problem is encountered and no existing applicable instruments are available? Or are they forced to stick to a standardized set of methods and
tools that is prescribed by the functional organization? Is there freedom to implement knowledge about instruments from other projects? The importance of the relationship with the functional organization for inter-project learning can be found in the framework by Antoni (2000), described in section 2.3. If there is no freedom to develop instruments or implement knowledge about instruments from other projects, there will be no inter-project learning.

3.2 INTER-PROJECT LEARNING

Lessons learned play an important role in the improvement of project management efficiency since they are an instrument for both creating and sharing of knowledge (Kotnour, 2000). In this research, a framework is developed where the different knowledge activities in the inter-project learning process can be described. This framework is based on the Plan-Do-Study-Act (PDSA) cycle by Deming (1993). The PDSA cycle covers all activities that are needed to produce lessons learned from the knowledge that is gained inside a project, as described in section 2.2. However, Deming’s model is designed for describing learning processes inside one project organization (intra-project learning) and this study focuses on learning between multiple projects (inter-project learning).

Where existing studies on inter-project learning, found in the literature review (section 2.3), focus only on the actual transfer of knowledge between two different projects, this research will make a connection between intra-project learning and inter-project learning. The learning activities inside the project, such as evaluating knowledge that is created in the project and producing lessons learned, will be combined in this framework with learning activities between different projects, such as sharing and implementing knowledge. This approach is deliberately chosen because it is assumed that the knowledge activities inside one project have a large influence on the execution of the inter-project learning process. First, projects have to create their own lessons learned and evaluate the value of this knowledge for other projects, before knowledge sharing and implementation activities can be performed.

![FIGURE 6. THE PLAN-DO-STUDY-ACT CYCLE BY DEMING (1993)](image-url)
The PDSA cycle is based on the creation of knowledge by planning and executing the intended actions. After the execution phase, the study step evaluates the actions. The outcomes of this evaluation are implemented in the final ‘act’ step. However, the framework used in this research will not be used for intra-project learning, where the PDSA model is designed for. This study will look at learning between different projects. This implies that the knowledge that is created and evaluated will not be implemented in the same project, but will be shared to other projects. The final step where the knowledge is implemented takes place in another project than the project that shared its lessons learned. Therefore, the framework that is developed for this research also has a share step and an implement step.

In the implementation step, the four actions of abstraction and generalization, embodiment of learning, dissemination of learning and application of learning, as described in the framework of Bartezzaghi (1997) will be performed. In this research is explicitly chosen to see these four actions as one step, since the objective is to study if shared knowledge is later implemented and applied in other projects. The purpose of this study is not to research how the different steps inside the process of implementation are exactly performed in the studied projects.

FIGURE 7: FRAMEWORK FOR THE IMPLEMENTATION OF KNOWLEDGE FROM OTHER PROJECTS

When developing a framework for inter-project learning that is derived from Deming’s Plan-Do-Study-Act cycle, plan and do can be mapped onto create. This is the step where the knowledge about project management instruments is created. The evaluation of this created knowledge by looking at how valuable it might be for other projects is done in the evaluate step of the framework. This step is similar to the study step in the PDSA cycle. In Deming’s model the act step is about implementing the results of the evaluation. In this framework ‘act’ will be called ‘implement’, because the four inter-project learning activities as illustrated in figure 7 are included. The ‘share’ step will be placed between evaluate and implement, because the implementation of knowledge happens in another project.

This framework will be called the lessons-learned cycle and will be used to research how the activities of creating, evaluating, sharing and implementing knowledge are performed in large infrastructure projects in the Netherlands.
A more detailed description of the four steps in the framework and the activities that are performed within these steps is given below:

**Creating knowledge**

Knowledge is created in a project when approaches for completing tasks are discussed and when a solution has to be found for a problem (Kotnour, 2000). The central question in this step of the cycle is how knowledge about new or innovative instruments is created. First, a distinction has to be made between the concepts of information and knowledge. To let information be knowledge, we need to add action and application to the information (Fitzek, 2002). A common definition of organizational knowledge is:

“Knowing which information is needed (know-what); knowing how information must be processed (know-how); knowing why information is needed (know-why); and knowing where information can be found to achieve a specific result (know-where); knowing when which information is needed (know-when)” (Van der Spek and Spijkervet, 1996).

Based on this definition, it can be stated that only the storage of project documents into an electronic archive is not the creation of knowledge. If these documents contain information about how the instruments should be used in which situation and what the experiences with these instruments are, it can be called created knowledge or lessons learned. This is in line with the definition of lessons learned that is given in the literature review (section 2.2), where lessons learned are described as ‘a catchall phrase describing what has been learned from experience’ (Juran, 1988).

The project organization decides if created knowledge is only used for overcoming the problem at that moment or if they try to capture and store this knowledge somewhere for future use.
A proactive knowledge creation attitude implies that the project organization understands the need of capturing knowledge for future use instead of only using it once for a single situation. Producing lessons learned is part of proactive knowledge creation. By describing the actions that were taken in a specific situation to come up with a solution for a specific problem, the created knowledge can be documented (Kotnour, 2000). Once the knowledge is documented, the project organization can use these lessons learned for reflection and sharing them with other projects.

**Evaluating knowledge**

The second step in the lessons learned cycle is the evaluation of the lessons learned. In this step, the project can be evaluated using the created knowledge and the project can decide which lessons learned should be shared with other projects. By performing a post-project evaluation, the successes of the project can be identified (Von Zedtwitz, 2002). With an evaluation, the organization gets insight in what exactly caused a success or a failure during the execution of the project. These causes can then be linked to the produced lessons learned, in order to decide which lessons learned should be shared to other projects (Anbari, 1985). The question if created knowledge about developed instruments is evaluated in the project is the main question for getting insight in how actively the evaluation step is implemented in the organization.

**Sharing knowledge**

After a project has decided that its knowledge should be shared with other projects in the ‘evaluation’ step, because the project believes that other projects will improve their project management efficiency by implementing its lessons learned, the actual sharing process begins. The question is how this sharing could be done efficiently and how it is done in actual projects. In this step of the framework, it can be assumed that the knowledge is already converted to lessons learned. These lessons learned now need to be transferred to other projects. This can be done in a formal way, by explicitly codifying the knowledge and making the documents available to other projects. Another option is to share lessons learned in a more informal way, by direct communication between two members of different projects. An example of this informal information sharing is the “Kring van King” initiative, by knowledge management institute Kennis in het Groot. This is a regularly meeting between project directors and project managers of the different large infrastructure projects in the Netherlands, where they exchange information about their experiences or the problems they encounter (Kennis in het Groot, 2010).
Implementing knowledge

The implementation step is the final step in the lessons learned cycle and is the point where knowledge that is created in one project is implemented in another. Where the first three steps of the cycle are carried out inside the same project, this last step is performed in another concurrent or future project.

The cycle is again back at the first step when a project decides to improve an instrument or come up with a new one, based on knowledge that was implemented from another project before. When they decide to create a lesson learned based on this knowledge, the knowledge creations phase starts again.

The implementation step is where the difficulties are. Other research initiatives already noticed that projects often have the tendency to ‘reinvent’ the wheel rather than learn from each other (Prusak, 1997). But until this moment it is not clear why this is the case in large infrastructure projects. New instruments are developed to solve problems in these kind of projects more easily or more efficient. Based on this argument, it would be an expected result that other projects will implement these new instruments to make their processes more efficient as well, however this is often not happening (Keegan and Turner, 2001; Kotnour, 1999; Prusak, 1997; Von Zedtwitz, 2002; Williams, 2003; Pinto, 1999; Newell et al., 2006). For example, the Dutch Court of Audit (Algemene Rekenkamer) stated in a report that the TSV (Transparante Sturing en Verantwoording) reporting method was a good instrument that helped in improving the project management efficiency. Although this was stated, the method was not seen again in other projects.

Therefore, in addition to the study of the inter-project learning process, the barriers that disturb this process will be researched. The elements that will be added to this inter-project learning framework that are used for identifying this barriers in the world of large infrastructure projects are described in the next section.

3.3 BARRIERS FOR INTER-PROJECT LEARNING

The literature review on learning barriers (section 2.4) presents the barriers that are identified in existing studies. The first step to include all these barriers in the inter-project learning framework is to group them in different categories. By looking at the barriers and their nature, they can be divided into four categories: social, organizational, project-related and knowledge-related. An overview of the four categories and their barriers is given in table 1.

The learning barriers in the world of large infrastructure projects can now be studied based on these four categories. The second step is to include the categorized barriers into the inter-project learning framework. Based on the literature review, inter-project learning occurs between the step where a project shares its knowledge and the step where another project implements this knowledge. According to these studies, the barriers will be placed between the steps ‘share’ and ‘implement’ in the framework (figure 9).

This will be the entire framework that will be used to find an answer to the main research question. All the activities in the inter-project learning process are included, as well as the barriers that disturb this process. The next chapter will describe the methodology that is used in this study.
<table>
<thead>
<tr>
<th>Social</th>
<th>Organizational</th>
<th>Project-related</th>
<th>Knowledge-related</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Defensive routines (Julian, 2008)</td>
<td>- Organizational culture (Gieskes and Ten Broeke, 2000)</td>
<td>- Temporary nature of projects (Scarbrough, 2004; Gieskes and Ten Broeke, 2000)</td>
<td>- Difficult to generalize (Von Zedtwitz, 2002)</td>
</tr>
<tr>
<td>- Memory bias (Von Zedtwitz, 2002)</td>
<td>- Bureaucratic overhead (Von Zedtwitz, 2002)</td>
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<td>- Reluctance to blame (Von Zedtwitz, 2002)</td>
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<td>- Poor internal communication (Von Zedtwitz, 2002)</td>
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<tr>
<td>- Relationships in networks, politics and power positions (Sense and Antoni, 2003; Fizek, 2002; Bresnen et al, 2003; Julian, 2008)</td>
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TABLE 1: FOUR CATEGORIES FOR INTER-PROJECT LEARNING BARRIERS
FIGURE 9: RESEARCH FRAMEWORK: LESSONS LEARNED CYCLE WITH LEARNING BARRIERS INCLUDED
4. RESEARCH METHODOLOGY
This chapter will describe how the research is performed and which research strategy was followed in order to find an answer to the main research question. The strategy of case studies will be described, as well as how the data for the research was collected in all the different cases. A detailed description of the sample and the respondents is given in the end of the chapter.

4.1 KENNIS IN HET GROOT
The research is performed in the form of an internship at Kennis in het Groot (King). King is a cooperative program between Rijkswaterstaat, ProRail and the city of Amsterdam. They are focusing on knowledge that is created in large infrastructure projects in the Netherlands and the exchange of this knowledge between the projects. This is done by dividing project management in different knowledge domains, such as communication, culture, innovation, operational project management (projectbeheersing), ‘omgevingsmanagement’ and politics. King’s objective is to improve the quality of project management in the large infrastructure projects in the Netherlands. Kennis in het Groot is supported by Stichting Traverse, an organization specialized in knowledge management.

The benefits of doing the research together with King is the availability of the network of projects attached to King. The 19 large infrastructure projects that are in this network include railway, highway and water projects with a high level of complexity and a large number of stakeholders involved, what gives them the characteristics of complex large infrastructure projects.

4.2 RESEARCH STRATEGY
This research will be performed as a qualitative explorative research. By combining existing literature with findings from the case studies, the objective is to give insight in the development of project management instruments, the inter-project learning process in the world of large infrastructure projects in the Netherlands and the barriers that disturb this process. The research is exploratory because, to the author’s knowledge, no earlier research exists where the inter-project learning process and the learning barriers are explored for projects in the infrastructure sector. Frameworks that are developed in existing studies focus on projects and organizations in other sectors. Also, existing inter-project frameworks mainly focus on the actual knowledge transfer, where the framework in this study makes a connection between intra-project learning and inter-project learning activities. Little is known about the barriers that are present in infrastructure projects that disturb the inter-project learning process. By conducting exploratory research, it can be studied if the developed framework for inter-project learning, including the barriers that are identified in previous research initiatives, applies for projects in the infrastructure sector. Performing the study in a qualitative way provides insight in the developed instruments, what kind of knowledge activities are performed and what and why barriers might be present that disturb the learning processes.

Case studies

By researching the 19 infrastructure projects connected to Kennis in het Groot as multiple cases, the developed instruments can be identified as well as how projects deal with knowledge that is created about these instruments.
After performing the case studies, overviews can be made of the developed instruments, the activities that are performed in order to share knowledge and implement knowledge from other projects and the possible barriers that stand in between.

4.3 DATA COLLECTION METHOD

The best way to collect data from the 19 different cases is by conducting interviews. By using the data collection method of interviewing, a large and broad set of information can be gathered on the three research objectives. It might be sometimes necessary to come back to a certain question or topic during the conversation, and conducting interviews is then the most suitable way. This is not possible when using structured methods such as questionnaires. Conducting semi-structured interviews, where there is a rough structure but also flexibility to explore ‘around’ the research topics, will lead to broad insights and understanding of the topics. By choosing respondents with a representative function and position in the project organization, useful data can be collected.

To find an answer to the main research question and the three research objectives, multiple interview questions are developed in order to structure the interview into logical parts. The questions are connected to the framework, as presented in chapter 3, and derived from the underlying literature.

The first research objective of identifying developed instruments and the freedom can be studied by connecting the following three interview questions to the framework for developed instruments (section 3.1):

- Which instruments are newly developed or derived from existing project management instruments by the project?
- To what extent are the already existing instruments sufficient for managing time, budget and scope, and to what extent was it necessary for the project to develop new instruments?
- How many freedom had the project in developing its own instruments, regarding the relationship with the functional organization?

The first interview question will provide an overview of the developed instruments. This will include newly derived instruments as well as modifications to already existing instruments. If all existing instruments were already sufficient, this might have influences on the other findings in the research. Therefore, it is necessary to ask the projects to what extent new developments were required. If there are no developments at all, there is no new knowledge that can be transferred to other projects in the inter-project learning process. The third question will give insight in the level of freedom projects get from the functional organization to develop new instruments and to implement
The following set of interview questions is developed to study how the inter-project learning process takes place in large infrastructure projects. They follow the four steps of the framework: create, evaluate, share and implement. Each project will be asked how they deal with the steps of creating and codifying knowledge, and evaluating how this knowledge can be useful for other large infrastructure projects. Next, the initiatives that are taken to actually share their lessons learned are questioned.

In the following four questions, the projects are asked how they implement knowledge about instruments from other projects. Are they looking at other projects how they came to a solution for a specific problem and are they looking at how other projects deal with the management of time, cost and scope? This is a two-way question. The projects are asked if they use instruments from other projects and they are also asked if other projects came to them to learn about the instruments they are using.

In the last interview question, the projects are asked about possible barriers for inter-project learning they experience in their daily work in the project. What do they think that the barriers are that disturb learning from each other and cause ‘reinventing the wheel’.

Figure 10 illustrates how the interview questions about the inter-project learning process and the learning barriers are connected to the analytical framework of this research:

![Figure 10: Interview Questions Connected to the Research Framework](image-url)
4.4 Sample

To be able to research which project management instruments are developed, what activities are performed in the inter-project learning process and if there are learning barriers in the world of large infrastructure projects, a representative sample needs to be selected to work with during the research. Since the set of projects connected to Kennis in het Groot represents the most large infrastructure projects in the Netherlands, a representative sample can be formed. The most relevant and complex railway, highway and waterway projects in the Netherlands can be found in this selection.

Respondents

Following the research strategy described before, each project is studied based on the three research objectives. The people in the projects that have the most knowledge on these topics are the project managers who deal with the management of time, cost and scope. How this function is positioned within the project organization is dependent on the functional organization the project is connected with. For ProRail projects, the project manager turned out to be the most representative respondent for the interviews. Rijkswaterstaat has a different organizational structure. They designed the IPM-model for Integral Project Management. In this model, there are five different roles on the top-level of the project organization:

- **Project manager**: deals with highest level strategical decisions of the project
- **Operational project manager (manager projectbeheersing)**: responsible for the management of time, budget and scope
- **Stakeholder manager (omgevingsmanager)**: managing all involved stakeholders and environmental issues
- **Chief engineer (technisch manager)**: responsible for technical engineering part
- **Contract manager**: managing contractors and subcontractors

Within this organizational structure, the operational project manager (manager projectbeheersing) is the person who is directly responsible for the management of time, cost and scope of the project. The role of project manager is in this structure on a higher, more strategic level. The operational project manager (manager projectbeheersing) is in Rijkswaterstaat projects the one with the most knowledge about the development and application of project management instruments. The close cooperation with the project manager implies that the operational project manager also has knowledge about the strategic issues that play a role in the project.

The people that are interviewed all have the function of operational project manager (manager projectbeheersing) and project manager in the largest infrastructure projects in the Netherlands. Working in these large projects implies that the selected people already have built a good reputation in earlier smaller projects. This high level of experience makes them the most representative respondents for this research.

**Single informant bias**

Conducting interviews with only one person from one project organization could lead to information that is only shown from the perspective of this person. The information that is given by the interviewed project- or ‘projectbeheersings’-manager might be influenced by experience and personal attitude. During the research, there was awareness of this single informant bias and the subjective information was filtered out as much as possible. The author acknowledges that interviewing one person per project introduces limitations for the research. However, to reduce these limitations as much as possible, for each project the most representative respondent with the right degree of knowledge and experience was selected.
Response rate

17 King projects were approached and asked to participate in this research. The reason why not all 19 projects were approached is that projects Ijsei and Renovatie Oostlijn were not connected to King during the research. After approaching the project managers and ‘projectbeheersings’ managers, 12 people responded and were willing to participate. The projects Hanzelijn and OV SAAL have the same project manager, as well as the projects KOSMOS and ‘Spoedaanpak projecten’. Therefore, in the presentation of the empirical results, these projects will be combined because the information was gathered in the same interview. However, during the interviews both projects were discussed. Projects A73, ‘Grote Stationslokaties’ and ‘Spoorzone Delft’ were not able to participate due to time issues or other reasons.

4.4.1 Sample Description

The projects in the sample that have participated in this research are listed in table 2.

<table>
<thead>
<tr>
<th>Project</th>
<th>Functional organization</th>
<th>Project phase</th>
<th>Project type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maaswerken</td>
<td>RWS</td>
<td>Execution</td>
<td>Waterway</td>
</tr>
<tr>
<td>Schiphol-Amsterdam-Almere (SAA)</td>
<td>RWS</td>
<td>Planning</td>
<td>Highway</td>
</tr>
<tr>
<td>A2 Maastricht</td>
<td>RWS</td>
<td>Planning</td>
<td>Highway</td>
</tr>
<tr>
<td>A4 Delft – Schiedam</td>
<td>RWS</td>
<td>Planning</td>
<td>Highway</td>
</tr>
<tr>
<td>Hanzelijn</td>
<td>ProRail</td>
<td>Execution</td>
<td>Railway</td>
</tr>
<tr>
<td>OV SAAL</td>
<td>ProRail</td>
<td>Planning</td>
<td>Railway</td>
</tr>
<tr>
<td>KOSMOS</td>
<td>RWS</td>
<td>Complete</td>
<td>Maintenance</td>
</tr>
<tr>
<td>Maasvlakte – Vaanplein (MaVa)</td>
<td>RWS</td>
<td>Planning</td>
<td>Waterway</td>
</tr>
<tr>
<td>Tweede Coentunnel</td>
<td>RWS</td>
<td>Execution</td>
<td>Highway</td>
</tr>
<tr>
<td>Ruimte voor de Rivier</td>
<td>RWS</td>
<td>Execution</td>
<td>Highway</td>
</tr>
<tr>
<td>Spoedaanpak projecten</td>
<td>RWS</td>
<td>Execution</td>
<td>Highway</td>
</tr>
<tr>
<td>Noord / Zuidlijn</td>
<td>Amsterdam</td>
<td>Execution</td>
<td>Highway</td>
</tr>
<tr>
<td>Betuweroute</td>
<td>ProRail</td>
<td>Complete</td>
<td>Railway</td>
</tr>
<tr>
<td>HSL-Zuid</td>
<td>RWS</td>
<td>Complete</td>
<td>Railway</td>
</tr>
</tbody>
</table>

Table 2: Case Descriptions
4.4.2 Sample Representativeness

There is a variation in this sample on the following dimensions:

**Railway, highway, waterway**

Since the 14 largest infrastructure projects in the Netherlands are included in the sample, there are both railway, highway and waterway projects represented. The purpose of the projects and the tasks that need to be completed in order to reach the projects’ objectives are completely different. Where in the Betuweroute project a railway had to be built from the port of Rotterdam to the German borders, in project Maaswerken the Maas river has to be enlarged in order to increase the river’s capacity and to protect the Netherlands from high water levels. Just an example of the variety in the purpose and the way of execution of the different projects.

**Project phase**

The phase of the projects differ in this sample. The actual progress of the project can be classified into planning, execution or complete. This is according to the names that are given to the phases in the lifecycles of the infrastructure projects of Rijkswaterstaat, ProRail and Amsterdam: exploration, planning, execution and complete. Often the complete phase is not the end of the project, since this phase is also called the monitoring and control or project closure phase. However, for the description of this sample the label ‘complete’ is used, to indicate that the infrastructure is build and ready for use. For the exchange of knowledge across the projects, the project phase might have its influence. Projects that are already completed might be approached more by others because they have interesting lessons learned. Projects that are still in the planning phase could learn from others who are already in a further stage in the lifecycle.

**Functional organization**

The projects in the sample are initiated by three different functional organizations: Rijkswaterstaat, ProRail and the city of Amsterdam. The functional organizations often prescribe which instruments should be used for the management of time, budget and scope in the project. This will vary per organization and will result in different views on how to apply specific instruments or develop new ones. This variation will in its turn imply that the problem-specific solutions, where new or uniquely derived instruments are developed for, are also different from each other, depending on the project-specific situation.

**Project organization**

Each project organization in the sample is set up as an individual organization with a project manager, a management team and a support staff. Below this level, private construction companies are contracted for the realization of the project. Because of this combination of people and companies, that is different for each project, there will be variation in organizational culture and the way of developing project management instruments.
5. Findings

In this chapter, the results from the interviews that were conducted with the operational project managers (managers projectbeheersing) and project managers are presented. According to the framework on which the interviews are based and the three research objectives, this chapter will also be divided into three parts. The findings will be structured so that for every research objective the empirical results are shown, followed by the analysis of that specific part. In this way, the empirical results and the related analysis are clearly structured to the three different research objectives: developed instruments, inter-project learning and inter-project learning barriers.

The first section is split into two subsections, one for the overview of the developed instruments and one for the freedom the projects have to develop or implement instruments. The second section is also split into two parts, because a distinction is made between the inter-project learning steps ‘create’, ‘evaluate’ and ‘share’ that are performed inside the same project and the ‘implement’ step.

Figure 11 gives an illustrated overview of the structure of this chapter:

![Figure 11: Structure of the Findings Chapter](image-url)
5.1 Which instruments are developed and how many freedom do the projects have?

In the first place, an overview will be given of the instruments that are newly developed or that are modifications of existing instruments (section 5.1.1). This information is collected in the interviews when the respondents were asked which instruments are unique in this project. Unique in this sense means that an instrument is not applied in other projects in exactly the same way.

This implies that this part will focus on instruments that are regarded as new or derived from existing instruments by the project managers and operational project managers (managers projectbeheersing). In this research, the developed instruments can be used to make inter-project learning visible. If one project indicates it has developed a specific instrument, and in another interview it turns out that this instrument is implemented in another project, this is a case where projects learned from each other. This means that it is not relevant for this study to have an exhaustive overview of all instruments that are being used in the projects. By identifying unique or excelling instruments, the exchange of knowledge can be seen when these instruments appear again in another project. For example, a project that uses a new form of contracting might require the development of a new instrument for the management of cost. By identifying these kind of unique instruments, inter-project learning can be made visible when another project that uses the same type of contracts also uses this new instrument. It is also possible that this other project developed its own instrument, what shows that there is an occasion of reinventing the wheel instead of learning from each other.

Section 5.1.3 will describe the amount of freedom that is perceived by the respondents to develop own instruments and to implement knowledge about project management instruments from other projects.

5.1.1 Empirical results: Developed instruments

The interviews were structured in such a way that in every interview the project management elements time, cost and scope were discussed, together with the additional elements quality and reporting. The respondents were asked to indicate if there are unique instruments developed or implemented in their project. The structure is based on the framework for researching developed project management instruments (section 3.1).

The empirical results will be presented in this section, where the developed instruments for every projects are structured on the project management factors time, cost, scope, quality, reporting. A sixth factor, organizational, is added where instruments will be presented that are related to the organizational context of the project and that could not be fitted into one of the other five categories.

A complete overview of all developed instruments per project can be found in the table in appendix 1. There are a few cells in the table that are not filled. At those points, the respondents indicated that there were no unique developments in the field of that specific project management factor. This does not influence the outcome of this research, since the focus is only on unique and/or excelling developments that help to make inter-project learning visible. For example, if project A develops a planning instrument that is unique compared to other projects, it is visible when used in project B.

Trying to detect inter-project learning activities will be much more difficult and complex when looking at standard instruments that are applied in almost every project. Therefore, the focus of this research is on the developed instruments that are perceived by the projects as new or unique in comparison to the instruments used in other infrastructure projects in the Netherlands.
The following part will describe the instruments that are discussed in the interviews, but on a higher level and not per project. The purpose of this part is to clarify the findings in appendix 1 and present additional relevant information about these findings as told by the respondents in the interviews.

**Time**

For the management of time and planning, the software applications Primavera and Microsoft Project are being used. Respondents indicated that the first application is better suited for large complex infrastructure projects.

Projects have the option to use a deterministic or a probabilistic planning. A deterministic planning uses single values and time paths. In a probabilistic planning method, risks that might occur are taken into account. This method works with time margins and a most likely time path instead of the single values in a deterministic planning. In 2001, Rijkswaterstaat developed the PPI (Project Planningen Infrastructuur) method, that is now included in the standardized instrument package for all projects. The objective is to indicate a more realistic end date, because a built-in risk buffer is used. However, one project (‘Spoedaanpak projecten’) explicitly chooses for using a deterministic planning method. The argument for this choice is that they think that a probabilistic planning has negative influences on the effectiveness of prioritizing. They argue that the built-in risk buffer is often used as an excuse for postponing activities. People start activities later because they think there is more time because of this buffer. The organization of ‘Spoedaanpak projecten’ thinks the management of time is more direct with a deterministic planning. “When an activity has to be finished today, it is not an option to do it tomorrow”. This is an example where a project deliberately chooses to deviate from the standard approach for the management of time applied in other RWS projects. The PPI method is prescribed by the functional organization, and ‘Spoedaanpak projecten’ argues that their approach is better suited for the specific context of their projects.

As already mentioned, Rijkswaterstaat has a standardized instrument package (‘Werkwijzer Aanleg’) that prescribes the PPI instrument for managing time. ProRail projects use a similar instrument.

The purpose of creating a planning is to indicate realistic expectations of when specific milestones in the project are reached. Project Maaswerken has chosen to do more with these milestones. They explicitly steer on the milestones in the planning. The end of each phase is marked by a milestone. At the end of a phase, the project evaluates if the milestone is reached within the agreed boundaries. When there is an agreement, the boundaries for the next phase are written down. With this ‘integrated milestone control’ method, it is important that everyone in the organization is aware of the fact that milestones must be reached and that there is no possibility for delay. An example where an approach becomes a shared philosophy in the organization. “Even if unforeseen situations occur, the milestone is fixed and needs to be reached within the agreed time. Delaying the project is not an option”.

**Cost**

When the financial management instruments were discussed during the interviews, the main finding was that both Rijkswaterstaat projects as ProRail projects are obliged to use the SAP enterprise resource planning system of the functional organization. Multiple projects indicated in the interviews that this system is not able to provide them with the desired financial overviews. This implies that it is in this cases necessary for the projects to develop their own financial overviews in the form of Microsoft Excel sheets. Most projects work with this additional administration, although they recognize the inefficiency of this process.
**Scope**

During the project, it is possible that changes occur in the scope of the project. This might happen because unexpected events occur that entail scope changes. Because it is important for the projects that these changes do not influence the execution of the project too much, instruments are required for managing scope changes. If there is a change in the scope of the project, the effects on the time and budget elements need to be managed as well. It is possible that at a certain level a change seems to be the best solution, but this change might be suboptimal at the highest level. In the interview with project HSL-Zuid, a good example was given. In this project, the organization was aware of the fact that it is important to look at the project from the high-level perspective of the total transport system. A change in the design of a bridge might seem the optimal solution for that part of the project, but might have negative influences on other parts of the high-speed railway. Only when looking at the system from the highest level, these effects will become visible. Project HSL-Zuid developed an instrument for managing scope changes, the VTW (Voorstel-Tot-Wijziging) procedure. With this instrument, the scope change can be assessed from the right level and perspective. Criteria in this procedure include: To what extent is the project planning influenced by the scope change? Is the scope change part of the critical path of the project? Why are the extra costs for the government and not for the contractor?

Systems Engineering is another topic in the field of scope management. The V-model is often used in large infrastructure projects. In this model, the project objective is divided and decoupled into smaller workpackages. Later in the project, these workpackages are coupled again and tested. This V-model helps dividing a complex project objective into tangible tasks. The inputs and outputs can be described, as well as who is responsible for the package. A disadvantage of this method is that integral testing can only be done at the end of the project, when all packages are coupled again. When problems arise at this point, there is often no time left to fix them because the project already arrived at the end of its planning. This is the reason why project A4 Delft – Schiedam modified the V-model to the W-model. In this model, the integral testing can be done in an earlier phase of the project, because these tests can be done in parallel. The complete system, for example a tunnel with all systems included (safety, air quality, etc...), can be tested on a smaller scale. This is possible because very often it does not make any difference if 10 meter is tested instead of 5 kilometer.

**Quality**

In the first place, a difference can be made between internal and external quality management. For internal quality management the projects use electronic archives, intranet and datarooms. The most projects use the software application Hummingbird as content management system. Datarooms are used for information exchange between the project and other involved parties like contractors and residents near the project. In the interviews, this dataroom turned out to be a good example of how knowledge about instruments flows through the projects. Project Tweede Coentunnel started with using the method, followed by project MaVa where it was introduced as official pilot. After this pilot session, Project Lunetten-Veenendaal also implemented the dataroom. In the interview with Project SAA it became clear that they also use the dataroom and that they learned this from Lunetten-Veenendaal.

External quality management (*externe kwaliteitsborging*) takes place between the client and the contractor. Project HSL-Zuid was the first project where this system was used, due to the fact they had to work with complex adjacent contracts and multiple contractors. It was not possible for the project to verify the quality of all products themselves, so they expected from the contractors to have their own quality management system. The product testing was now performed by the contractors, instead of the project organization. They were only involved with testing the process. The contractor must be able to show, during and after the work, that they meet all quality...
requirements. After this EKB (Externe Kwaliteitsborging) instrument turned out to be a success, Rijkswaterstaat included it into the standardized instrument package for all D&C (Design and Construct) and DBFM (Design – Build – Finance – Maintain) contracts. In this standardization it is called ‘systeemgerichte contractbeheersing’.

**Reporting**

In Project Betuweroute, the reporting method of TSV (Transparante Sturing en Verantwoording) was developed. This instrument was created in order to establish a reporting protocol that covered all levels in the organization, from the construction workers to the ministers. With this line of reporting throughout the whole project, contractors were able to give the contract owners a good overview of the status of their activities and at the same time the decision-making process of the contract owners was supported. The idea behind this method is that management information needs to be easily communicable. The information should be sent to a higher level in the organization, written down on only one A4 paper.

Another reporting instrument is the integral dashboard. The projects A4 Delft – Schiedam and MaVa developed a dashboard where all management information is shown in a clear graphical representation. The emphasis is on the relationships between the management elements time, budget and scope and how changes in one element influence the other two. Project Ruimte voor de Rivier also works with dashboards for reporting. However, this is a program with multiple underlying projects, leading to the development of other dashboard reporting methods. Within the projects of Ruimte voor de Rivier, a dashboard is used where management information and the status of all activities are visualized. At the highest level of the program management, they want to monitor the status of all underlying projects. Therefore, a dashboard is developed that gives an overview of the status of all projects. Per project, three clocks are illustrated representing the status of time, budget and scope. With this instrument, the program management can easily see where the problems are and at which point intervention is required.

**Organizational**

Project A4 Delft – Schiedam and Project MaVa put a lot of emphasis on integral project management. This means that there is awareness of relationships between the management elements time, budget and scope. Although there may be good instruments for managing these elements, they are still functioning mono-disciplinary. If there is a change in the scope, this has influences on the elements time and budget. For example, extra activities that need to be done increase the required time for completing the project and project costs might increase as well. The software application Relatics is used as an instrument for managing the project integral. This instrument is able to make the relationships between the elements visible and show the consequences of changes and possible events. Project SAA also indicated that they want to use Relatics as an instrument, where also a connection with Systems Engineering can be made.

Project A2 Maastricht sees managing quality as the most important management element. This is also a unique position for operational project management ([projectbeheersing](#)), since other projects manage the project mainly on the factors time and/or budget. This approach implies that the project organization takes a step back and let the contractors do more on operational project management. This goes together with new ways of contracting, where the contractor gets more freedom and the client less direct controlling influences. For the contracting phase of the project, Project A2 Maastricht developed its own quality management system. With this system, knowledge could be exchanged between the contractors (construction companies) and the project organization. The same project designed a completely new management model because there is not just one client, but there is involvement of the cities Maastricht and Meerssen, the province of Limburg and Rijkswaterstaat. This cooperation
of four public parties instead of just one raised the need for another management model, where the relationships with the stakeholders are different and quality is the key factor.

5.1.2 Analysis: Developed Instruments

What follows from the interviews, is that developed instruments in projects are rarely totally new or unique. In most cases, already existing instruments have been further developed or are used in a different way than other projects did before. This shows that developments and innovation can also be found in a different interpretation and application of an already existing instrument. An example is the integrated milestone control instrument that is developed by project Maaswerken. Setting up a project planning is not new or unique, this is done in every infrastructure project. The innovation here can be found in the way the project organization considers the importance of the milestones. The approach has become a shared philosophy for the people who work in the organization: milestones must be reached and it is not an option to delay activities that are included in the milestone agreement. This is an example where an instruments is not purely a tool or a method, but more an approach for the management of time. In this research, also approaches are included in the definition of instruments and thereby the integrated milestone control is regarded as an instrument. This application of the instrument can be seen as unique, since other projects do not use the planning instrument in the same way. Therefore, in this research, the identification of developments is not limited to only completely new instruments. A unique way of applying an existing instrument is also regarded as a development. Knowledge can be shared about this development and inter-project learning can take place.

In table 3, an overview is made of the project management instruments that are considered as unique by the respondents. They were asked to indicate which instruments that are developed in their project are unique when compared to the instruments that are used in other projects. Their answers are based on their large experience in the world of infrastructure projects, their contacts with members from other projects and their contacts with the functional organization.

Remarkable in this overview is that some projects are present even multiple times and others stay out. The projects that are not listed indicated in the interviews that they are using the complete package of standardized instruments and are not using instruments that are unique if compared to other projects. Another explanation might be that some project organizations are more innovative than others. Some operational project managers (managers projectbeheersing) and project managers have the attitude that they want to improve project management and therefore try to develop new instruments, while others are satisfied with the already available instruments. Project organizations also have to perform under heavy time pressure. They indicated in the interviews that they are willing to spend time on the development of new instruments or the implementation of instruments of other projects, but the problem is that there is no time left next to the daily activities that needs to be completed.

Projects who are the first to come up with a solution for a specific problem, are more likely to develop new instruments, because there is no earlier solution yet available. When another project faces the same problem a few years later, there are now instruments developed by the other projects and the situation is not new anymore. Projects Betuweroute and HSL-Zuid were both two large infrastructure projects in the Netherlands who faced a lot of new unknown problems situations and had two come up with solutions for these problems. Much of the knowledge that is gathered within these projects can now be found in the standardized instrument packages of Rijkswaterstaat and ProRail.
<table>
<thead>
<tr>
<th>Management factor</th>
<th>Instrument</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>Integrated milestone control <em>(Mijlpalensturing)</em> – <strong>Maaswerken</strong></td>
</tr>
<tr>
<td>Cost</td>
<td>Systems Engineering W-model – <strong>A4 Delft – Schiedam</strong></td>
</tr>
<tr>
<td>Scope</td>
<td>VTW procedure for scope changes – <strong>HSL-Zuid</strong></td>
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<td>Quality</td>
<td>Dataroom – Tweede Coentunnel, <strong>MaVa, Lunetten-Veenendaal, SAA, A2 Maastricht</strong></td>
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<td>EKB external quality management – <strong>HSL – Zuid</strong></td>
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<td>Reporting</td>
<td>Dashboard – <strong>MaVa, A4 Delft – Schiedam, Ruimte voor de Rivier</strong></td>
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<td>TSV <em>(Transparante Sturing en Verantwoording)</em> - <strong>Betuweroute</strong></td>
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<td>Organizational</td>
<td>Quality as most important management factor – <strong>A2 Maastricht</strong></td>
</tr>
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<td></td>
<td>Relatics for integral project management – <strong>MaVa, A4 Delft Schiedam, SAA</strong></td>
</tr>
</tbody>
</table>

**TABLE 3: OVERVIEW OF UNIQUE AND EXCELING DEVELOPMENTS**

Project Noord/Zuidlijn, where the functional organization is not ProRail or Rijkswaterstaat but the city of Amsterdam, said it uses no new or unique instruments. It took some time before the project had a clear definition of ‘projectbeheersing’ and its position in the organization. After this was accomplished, the manager projectbeheersing told in the interview that no new instruments were developed, but that the approaches from the projects Betuweroute and HSL-Zuid were implemented and combined. This would imply that the transfer mode, concurrent or sequential (Fitzek, 2002), has influence on the transfer of knowledge between infrastructure projects. Knowledge from projects that are completed is implemented in the standardized instruments packages of the functional organizations. This is an example of sequential knowledge transfer. The transfer of knowledge from the projects Betuweroute and HSL-Zuid to project Noord/Zuidlijn is an example of concurrent transfer. None of the three projects was finished in the time the instruments were implemented in project Noord/Zuidlijn. However, Betuweroute and HSL-Zuid were in a more advanced project phase than Noord/Zuidlijn, so it was in some way also a sequential transfer. The model by Fitzek (2002) for the two transfer modes does not take the project phase into account, so according to his theory it is a concurrent transfer, although one project might be in the first project phase and the other project already in the last.

No unique or new instruments for the management of cost were discovered during the interviews. The reason is that every respondent indicated that they are obliged to use the SAP enterprise resource planning system of the functional organization they are connected with.
Empirical results: Freedom projects have to develop own instruments and to implement instruments from other projects

In the interviews, every project was questioned about the amount of freedom they perceive in developing their own instruments. Are they free to develop new or modify existing instruments? And how free are they to implement knowledge about instruments from other projects?

The amount of freedom a project has in choosing its own instruments or implementing knowledge about instruments from other projects is dependent on the connection with the functional organization. Some projects that participated in this research were closer connected to the functional organization and some projects had a more independent position in the organizational structure. There were also two projects, Ruimte voor de Rivier en Spoed aanpak Projecten, that are part of a program. This implies that the freedom and independency of the underlying projects is determined by the program management.

An example of a highly independent organization is project HSL-Zuid. Within the organization of Rijkswaterstaat, it got the status of independent project organization (zelfstandige projectdirectie). This status implied that the project was free to choose the instruments they wanted to use and to develop for managing time, budget and scope. Apart from that, they also needed this freedom because the project faced situations that were new and unfamiliar. New instruments had to be developed in order to be able to manage the complexity of the project. Another example of an independent project organization is A2 Maastricht. The project is a cooperation between the cities Maastricht and Meeressen, the province of Limburg and Rijkswaterstaat. This cooperation with four public parties results in more freedom for the project to choose their own instruments, because there is not one direct functional organization involved that has all power over the project. The project was in the position to make a selection of the most suitable instruments out of the four organizations. Project Noord/Zuidlijn also indicated to have complete freedom to choose and develop its own instruments. With this project, also the relation between the independency of the organization and the freedom in instruments can be shown. Noord/Zuidlijn does not have a functional organization it is directly connected with that prescribes a standardized and obligatory package of instruments.

When the functional organizations Rijkswaterstaat and ProRail became aware that it is not efficient when every project develops its own instruments, they invested a lot of time in the standardization of operational project management (projectbeheersing). Lessons learned and best-practices from the earlier projects, such as Betuwerooute and HSL-Zuid were gathered and combined into standardized packages of instruments, that cover the whole spectrum of operational project management. Knowledge and expert groups were created to collect knowledge and lessons learned to improve project management in the infrastructure projects. However, in the interviews it turned out that this standardization must be performed in a ‘healthy way’. This means that not too much effort should be invested in standardizing every situation that passed by. If every situation leads to a new rule or exception in the standardization and the standardized instrument package (for Rijkswaterstaat this is called: ‘Werkwijzer Aanleg’), there will be too many rules and too specific instruments. The risk is then that there are too many project-specific rules and instruments in the standardization, which makes it not useful anymore for the projects in general. A solution that was offered in an interview with project Ruimte voor de Rivier was to standardize 80 percent and let the 20 percent of the very project-specific situations out of the general standardization package for all projects. This makes it useful and applicable for all projects.

Projects that are closer positioned to the functional organization, like Mava, Tweede Coentunnel and A4 Delft – Schiedam, indicated that there was very few or even no freedom at all for changing something in the standardized collection of instruments. The functional organization determines which instruments should be used in which
situation, based on the standardized instrument packages that are composed over the years based on lessons learned of earlier projects. For example in Rijkswaterstaat projects, there is a PPI (Project Planningen Infrastructuur) instrument for managing time, a PRI (Project Ramingen Infrastructuur) for managing the financial side of the project, etcetera. Although the projects told in the interviews that the standardized instruments are sufficient for managing the project in most cases, they also acknowledge that they still encounter situations and problems that have no direct solution available yet. To bring in any changes in the standardized instrument landscape requires explicit permission from the functional organization. This creates a tension between the project organization and the line organization. When projects have the feeling nothing is done with their initiatives or it makes no sense to develop something new, this might hamper innovation.

Figure 12 gives a graphical representation of the amount of perceived freedom by the different respondents. In the interviews, the respondents were asked how much freedom they perceive. In this figure their answers are positioned on an ordinal scale from no freedom to complete freedom. The positions of the different projects are relative and the distances in between cannot be compared in rational measurements. The purpose of the illustration is to give an idea of how much variation exists in the perceived freedom of the different infrastructure projects.

![Figure 12: Perceived freedom in developing own instruments or implementing knowledge from other projects](image-url)
5.1.4 **Analysis: Freedom projects have to develop own instruments and to implement instruments from other projects**

In order to make an analysis of the results presented in section 5.1.3, the perceived freedom of the respondents of the studied infrastructure projects is presented again in table 4. In this table, the projects are sorted by the amount of freedom they perceive.

The table is sorted with the least freedom on top. The Rijkswaterstaat projects represent the whole upper segment of the table: The minimum amount of freedom the Rijkswaterstaat projects experience can be explained by the obligation to use only the prescribed standardized instruments. However, this does not mean that no new developments are made in this projects. At the same time, these are the projects that are most present in the overview of developed instruments (section 5.1.2). Project SAA said in the interview: “When you formally ask for a change, you will not get permission, but they will not stop you if you still just do it”. This means that although the projects perceive a very low degree of freedom, this does not decrease the level of innovation. It will depend on the creativity and innovativeness of the people who work in the project organization. The other way around, when projects perceive complete freedom this does not automatically imply that there are more new instruments developed. The level of innovation might be even lower with this higher level of freedom, because these projects are free to implement already existing instruments from other projects.

The high amount of experienced freedom for the ProRail projects Hanzelijn and OV SAAL might be explained because the project manager, who is the same for both projects, has a good reputation in the organization. In the interview he said: “I took all my experience from the Betuweroute to the new projects and the ProRail organization sees me as a leading person. Therefore they give me the freedom to choose and develop the instruments I want”. For this reason, the amount of freedom for this ProRail projects will not imply the same amount for other ProRail projects. As already mentioned, the projects A2 Maastricht and Noord/Zuidlijn are not directly related to one functional organization with standardized instruments, resulting in a maximum amount of freedom.

A conclusion that can be drawn from this analysis is that the amount of freedom is not always influencing the process of inter-project learning. The findings in this section have shown that also projects with very little perceived freedom do implement knowledge from other projects and develop own instruments. It might be not allowed formally by the functional organization, but this does not seem to stop the development of new instruments. A second conclusion that is related to these findings is that other concepts, such as creativity and innovativeness, need to be introduced to further explain why some projects have more developments than others. However, this is beyond the scope of this research and could be a recommendation for future research.
<table>
<thead>
<tr>
<th>Project</th>
<th>Functional organization</th>
<th>Perceived freedom</th>
</tr>
</thead>
<tbody>
<tr>
<td>MaVa</td>
<td>Rijkswaterstaat</td>
<td>--</td>
</tr>
<tr>
<td>Tweede Coentunnel</td>
<td>Rijkswaterstaat</td>
<td>--</td>
</tr>
<tr>
<td>A4 Delft – Schiedam</td>
<td>Rijkswaterstaat</td>
<td>--</td>
</tr>
<tr>
<td>KOSMOS / Spoedaanpak projecten</td>
<td>Rijkswaterstaat</td>
<td>-</td>
</tr>
<tr>
<td>Ruimte voor de Rivier</td>
<td>Rijkswaterstaat</td>
<td>-</td>
</tr>
<tr>
<td>Maaswerken</td>
<td>Rijkswaterstaat</td>
<td>+</td>
</tr>
<tr>
<td>SAA</td>
<td>Rijkswaterstaat</td>
<td>+</td>
</tr>
<tr>
<td>Hanzelijn / OV SAAL</td>
<td>ProRail</td>
<td>+</td>
</tr>
<tr>
<td>HSL-Zuid</td>
<td>Rijkswaterstaat</td>
<td>++</td>
</tr>
<tr>
<td>Betuweroute</td>
<td>ProRail</td>
<td>++</td>
</tr>
<tr>
<td>A2 Maastricht</td>
<td>Cooperation between city of Maastricht, city of Meerssen, province of Limburg and Rijkswaterstaat</td>
<td>++</td>
</tr>
<tr>
<td>Noord/Zuidlijn</td>
<td>City of Amsterdam</td>
<td>++</td>
</tr>
</tbody>
</table>

**TABLE 4: PROJECTS WITH FUNCTIONAL ORGANIZATION LISTED, SORTED BY PERCEIVED FREEDOM**
5.2 INTER-PROJECT LEARNING

Developed instruments help the projects to complete the project objectives in an efficient manageable way. The instruments that are newly developed or uniquely derived from existing projects can also have added value for other projects. A reporting method that is successfully applied in one project might be implemented by another project as well. Experiences with managing project financials while using new contract types like DBFM could be valuable for other projects that also want to use these types of contracts. This part of the research gives insight in the way projects deal with knowledge about developed project management instruments.

The interviews and their findings are based on the analytical framework for inter-project learning and the barriers that disturb inter-project learning that is developed based on the literature review (sections 3.2 and 3.3). The respondents were asked how their projects follow the four steps of create, evaluate, share and implement that can be found in the framework.

This first part (section 5.1.1 and 5.2.2) focuses on the first three steps create, evaluate and share. These are the steps that are performed within one project and therefore can be combined in one part of the research. How is knowledge created and how do projects evaluate if their knowledge might be valuable for other projects? What initiatives are taken to share knowledge with other projects? The last ‘implement’ step, where knowledge is implemented from other projects, will be studied in a separate part (section 5.2.3 and section 5.2.4).

FIGURE 13: ANALYTICAL FRAMEWORK OF THIS RESEARCH: THE LESSONS LEARNED CYCLE
### 5.2.1 EMPIRICAL RESULTS: INTER-PROJECT LEARNING (CREATE, EVALUATE AND SHARE)

The logical order of the four steps in the framework stimulated the respondents to think about their knowledge activities in a structured way. The findings are grouped by the activities of knowledge creation, knowledge evaluation and knowledge sharing. The knowledge activities per project are listed in table 15 in appendix 2. Not every cell of the table is filled. In these cases, the projects did not give explicit answers on the activities in that step. For example, some respondents had no direct answer to the question how they create (and/or codify) knowledge about instruments. However, in earlier parts of the interviews they indicated to use quality management systems and electronic archives. This implies that there are indeed knowledge creation activities, but they are not recognized in such a way by the respondents when explicitly asked. In the table in appendix 2, quotes are added sometimes when they reflect the way the project deals with one of the knowledge activities or when they reflect the project’s attitude towards knowledge management.

This section will present an overview of the highlights (table 5) that are derived from the table with all findings in appendix 2.

<table>
<thead>
<tr>
<th>Inter-project learning step</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Create</strong></td>
<td>1. Electronic project archive for storing knowledge and lessons learned.</td>
</tr>
<tr>
<td></td>
<td>2. Books that contain experience and lessons learned.</td>
</tr>
<tr>
<td></td>
<td>3. Knowledge management is explicit project objective.</td>
</tr>
<tr>
<td></td>
<td>4. Knowledge management department within project organization.</td>
</tr>
<tr>
<td></td>
<td>5. Teambuilding meetings to discuss created knowledge and produce lessons learned.</td>
</tr>
<tr>
<td><strong>Evaluate</strong></td>
<td>1. Audits and evaluation reports.</td>
</tr>
<tr>
<td><strong>Share</strong></td>
<td>1. Presentations about audits and evaluation reports.</td>
</tr>
<tr>
<td></td>
<td>2. Participation in knowledge networks.</td>
</tr>
<tr>
<td></td>
<td>3. Traineeship for operational project managers (<em>managers projectbeheersing</em>).</td>
</tr>
<tr>
<td></td>
<td>4. Workgroup “Leren van de Noord/Zuidlijn”.</td>
</tr>
<tr>
<td></td>
<td>5. Blog on the internet every two weeks written by project manager.</td>
</tr>
<tr>
<td></td>
<td>6. One-to-one contacts with other projects: knowledge on demand.</td>
</tr>
<tr>
<td></td>
<td>7. Contacts with foreign projects.</td>
</tr>
<tr>
<td></td>
<td>8. Website (kennis.betuweroute.nl) with documents and descriptions about procedures, methods and tools used during the project.</td>
</tr>
</tbody>
</table>

**TABLE 5: OVERVIEW OF HIGHLIGHTS FROM FINDINGS ON INTER-PROJECT LEARNING ACTIVITIES CREATE, EVALUATE AND SHARE**
5.2.2 ANALYSIS: INTER-PROJECT LEARNING (CREATE, EVALUATE AND SHARE)

The findings on the inter-project learning activities that are presented in the previous section will be analyzed based on the four steps in the lessons learned cycle, the analytical framework of this study.

Create

During the processing of the interviews it turned out that there is sometimes overlap in the steps of create and evaluate. If, for example, a project creates an evaluation report they evaluate their lessons learned and the possible value for other projects, but at the same time knowledge is created. So the writing down of their lessons learned could also be regarded as a knowledge creation activity that happens before the actual evaluation is performed. Not always is the same activity mentioned in the interviews as both a knowledge creation and evaluation activity.

In the first place, already in the part of the research about developed instruments, some projects indicated to use internal quality management systems and electronic project archives. The presence of these systems shows that these projects think about how they can store the knowledge they have created. However, it can be questioned if this is already the creation of knowledge or if this is only a way of organizing information. To come to an answer, the theory of the hierarchy of knowledge needs to be introduced here. If we start with the concept of data (facts, images or sounds) and we add interpretation and meaning to this we come to the concept of information (formatted, filtered and summarized data). To let information be knowledge, we need to add action and application to the information (Fitzek, 2002).

Based on the definition of knowledge that is given in section 3.2, it can be stated that only the storage of project documents into an electronic archive is not the creation of knowledge. If these documents contain information about how the instruments should be used in which situation and what the experiences with these instruments are, it can be called created knowledge or lessons learned. This is in line with the definition of lessons learned that is given in the literature review (section 2.2), where lessons learned are described as ‘a catchall phrase describing what has been learned from experience’.

To conclude on this part, the use of electronic archives and quality management systems does not automatically imply the creation of knowledge. It is the ‘experience’ that needs to be added to the information in order to speak about created knowledge and lessons learned.

A second conclusion can be derived when looking at the quotes about knowledge creation in the findings table (appendix 2). Five respondents (projects: SAA, A2 Maastricht, Hanzelijn / OV SAAL, Maasvlakte – Vaanplein and Ruimte voor de Rivier) indicated to have difficulties with the creation of knowledge. SAA gives as reason that there is a shortage of people in the project organization and that there is time pressure, what results in a low priority for the creation of knowledge. The same reason is given by the operational project manager of project A2 Maastricht. Also time pressure and the small project organization have a negative influence on the creation of knowledge in this project. The ‘time constraints’ barrier to inter-project learning in the framework of Von Zedtwitz (2002) possibly already starts here, in the step where knowledge is created. Projects are unable to spend time on the creation of knowledge when all their time is occupied by the operational activities.

Project Tweede Coentunnel indicated that they have to report which knowledge management activities they have performed in their report to the client (opdrachtgever). In project Noord/Zuidlijn, knowledge management even has a more prominent position. In their project plan, knowledge is seen as the second objective of the project. Next to the first objective of building a working transport system, the second objective is to create knowledge for
other infrastructure projects. This objective resulted in the establishment of a dedicated department for knowledge management within the project organization. Such a knowledge project within the complete project also existed in the Betuweroute project, although this was part of the project objectives from the beginning.

The project manager of the projects Hanzelijn and OV SAAL indicated that they recognize the value of their created knowledge, but that they have often difficulties with how to store the lessons learned. This is the problem of the tacitness of knowledge (Von Zedtwitz, 2002). How can knowledge that is in the heads of people, in their experience and rooted in actions be codified and stored.

The projects Maasvlakte – Vaanplein and Ruimte voor de Rivier gave the organizational culture as explanation for a lack of structured knowledge creation in the projects. Maasvlakte – Vaanplein states that they think about the importance of knowledge creation, but that the processes for doing this are not well enough designed in both the project and functional organization. Ruimte voor de Rivier supports this by saying that there is a lack of good processes for knowledge management in the whole organization of Rijkswaterstaat. The importance of the influence of organizational culture on knowledge creation is also supported by the projects KOSMOS and Spoedaanpak projecten. The respondent from these projects argued that in order to create lessons learned, an organizational culture is required with a high degree of ‘openness’ and trust so that people will not only tell their good experiences, but also the faults they made.

To conclude, five projects from the sample indicated explicitly that they have difficulties with creating knowledge and for the projects that use an electronic archive or quality management system cannot always be said that they indeed create knowledge. Only archiving project documents is storing information and cannot be considered as the creation of knowledge and lessons learned. The problems with creating knowledge are to a certain extent similar to some of the barriers for inter-project learning. The conclusion that can be drawn from this is that there are not only barriers between the ‘share’ and ‘implement’ steps, but that the difficulties already start in the ‘create’ step. If projects have problems with creating knowledge and deriving lessons learned from their experience, they will not proceed to the next steps of evaluation and sharing.

Evaluate

When in the interviews was asked if they also think about the value that their created knowledge might have for other projects, the most respondents started about the different evaluations that are conducted in the form of audits and evaluation reports. It turned out that most of the projects did these kind of evaluations. Often this is done about a specific phase or time period in the project, for example the tender phase or the OTB (Ontwerp Tracébesluit) planning phase. According to Deming’s Plan-Do-Study-Act cycle (Deming, 1993) this is a good way for a project organization to review the actions, derive the lessons learned and think about how changes can be made to improve the current project management processes. However, the question is to what extent these evaluations are conducted in order to think about how valuable the lessons learned are for other projects. This can only be concluded when the outcomes of the evaluations are shared in the ‘share’ step of the lessons learned cycle, where the actual sharing happens.

When the respondents were asked if they think about the value of their knowledge for other projects, the projects A4 Delft – Schiedam, Maasvlakte – Vaanplein, Hanzelijn / OV SAAL and Tweede Coentunnel answered that they do want to share knowledge, but they want to do this on-demand. This means that they not want to think about what the value for other project possible could be, but they want to know what the questions and problems of the other projects are. “If there is no demand for it, we do not want to spend valuable time on sharing knowledge that is never used again.” All projects indicated that the management of this supply and demand of knowledge should be
done by the functional organizations of Rijkswaterstaat and ProRail. Below a list of the quotes of the respondents of three projects that expressed the same opinion:

<table>
<thead>
<tr>
<th>Project</th>
<th>Quote</th>
</tr>
</thead>
<tbody>
<tr>
<td>A4 Delft – Schiedam</td>
<td>“It is not clear which knowledge is needed in which project at this moment. The functional organization should play a facilitating role where an overview is of which projects need which knowledge”</td>
</tr>
<tr>
<td>Maasvlakte – Vaanplein</td>
<td>“We are missing a facilitating role of the functional organization, that lets us display our knowledge to other projects connected to Rijkswaterstaat”</td>
</tr>
<tr>
<td>Tweede Coentunnel</td>
<td>“We are missing a general database for all RWS projects where knowledge is stored. At this moment there is no archive where knowledge from other projects can be easily found”</td>
</tr>
</tbody>
</table>

**TABLE 6: OPINION OF THREE PROJECTS ABOUT FACILITATING ROLE OF FUNCTIONAL ORGANIZATION**

A conclusion that can be drawn from these findings is that projects are willing to evaluate their work. None of them did explicitly state that they did this in order to study the value of their lessons learned for other projects. In the first place, the evaluations are used for intra-project learning. However, when in the ‘share’ step of the framework, the reports about these evaluations are shared to other projects, they recognize the fact that it is useful for others as well. A second conclusion is that projects like to share their knowledge, but want to do this demand-driven. Sharing initiatives when the knowledge is not used again in the future are seen as a loss of valuable project time. Multiple projects suggested that the functional organization should play a facilitating role. According to the respondents, the functional organization should manage the supply and demand of knowledge, by having overviews of the developments and the knowledge that is created in projects on one side, and the demand for knowledge of projects that encounter specific problems or situations on the other side.

**Share**

The first analysis that can be made is that there is no project in the project sample that does not put any effort in knowledge sharing activities. So the first conclusion that can be already drawn is that there is no project with a zero degree of knowledge sharing about its developed instruments. The differences between the projects can be found in the number and in the type of these activities.

According to the general theories of knowledge management, a distinction needs to be made between the sharing of explicit and tacit knowledge (Nonaka, 1994). Explicit knowledge can be codified in the form of documents and other easily transferrable media. Tacit knowledge is rooted in actions, work experience and is in the head of people, and thereby difficult to ‘codify’ and share with other people (see literature review section 2.1). An example of explicit knowledge sharing activities in this study is the sharing of an audit report or giving presentations about an evaluation. Tacit knowledge sharing activities include the participation in knowledge networks where people from different projects come together to discuss problems or a ‘learning on the job’ traineeship for operational project managers.

To start with, the knowledge sharing activities of the projects can be divided into two groups (explicit and tacit).
<table>
<thead>
<tr>
<th>Project</th>
<th>Explicit</th>
<th>Tacit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maaswerken</td>
<td>1. Presentations about reports and audits</td>
<td>1. Participation in knowledge networks</td>
</tr>
<tr>
<td>SAA</td>
<td>1. Presentations about Systems Engineering for functional organization</td>
<td>1. Traineeship for operational project managers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Workgroup “Leren van de Noord/Zuidlijn”</td>
</tr>
<tr>
<td>A2 Maastricht</td>
<td>1. Presentations about project management approach</td>
<td>1. A2 Maastricht conference</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Participation in knowledge networks</td>
</tr>
<tr>
<td>A4 Delft – Schiedam</td>
<td>1. Weblog with new posts every two weeks by the project manager</td>
<td>1. Meetings with other operational project managers</td>
</tr>
<tr>
<td></td>
<td>2. Presentations to Rijkswaterstaat organization</td>
<td>2. One-to-one contacts with other projects: ‘knowledge on demand’</td>
</tr>
<tr>
<td>Hanzelijn / OV SAAL</td>
<td>1. Books that contain experience and lessons learned</td>
<td>1. Connected to Rijksprojecten Academie (RPA)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Participation in knowledge networks</td>
</tr>
<tr>
<td>Maasvlakte - Vaanplein</td>
<td></td>
<td>1. Share knowledge about developed management model with contacts inside functional organization</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. One-to-one sharing: sharing on demand with colleagues</td>
</tr>
<tr>
<td>Tweede Coentunnel</td>
<td>1. Presentation about managing costs while working with DBFM contracts in Berlin</td>
<td>1. Contacts with foreign projects about managing costs in DBFM contracting</td>
</tr>
<tr>
<td></td>
<td>2. Presentation for project ‘Lange Wapper’ in Antwerpen</td>
<td>2. Meetings with department of project management within functional organization</td>
</tr>
<tr>
<td>Ruimte voor de Rivier</td>
<td>1. Presentations for Rijkswaterstaat organization</td>
<td>1. Lunch presentations</td>
</tr>
<tr>
<td></td>
<td>2. Distribution of evaluation reports</td>
<td></td>
</tr>
<tr>
<td>Noord/Zuidlijn</td>
<td></td>
<td>1. Contacts with other projects in</td>
</tr>
</tbody>
</table>
Almost every project, except Noord/Zuidlijn and Hanzelijn / OV SAAL, mentioned in the interviews that they give presentations where they show the interesting aspects of their project to others. These ‘others’ could be other projects, but also the functional organization or other interested parties. This is the method that is used most for sharing explicit knowledge, next to the distribution of reports of audits and evaluations. Two explicit knowledge methods that stand out if looking at table 7 are the use of a weblog and a website where all documents are publicly accessible. The project manager of project A4 Delft – Schiedam writes a text about the problems he encounter in the management of a large infrastructure project on the internet, every two weeks. People from other projects can subscribe to this weblog. By reading his ‘blogs’, they have the possibility to think about the value of this shared knowledge for their own projects. Project Betuweroute started a knowledge management project with the underlying idea that the valuable knowledge that is created during a long time period should not be gone after the project is completed. Therefore, the website kennis.betuweroute.nl has been developed where information can be found about the project, together with the authentic documents about the instruments that are used for managing the project.

In the area of tacit knowledge sharing, the most common activity is participation in knowledge networks. All projects in this sample are connected to the network of ‘Kennis in het Groot’, where all kind of tacit knowledge sharing activities are organized. Examples are communities of practice and other interactive meetings about different areas of project management. Also the knowledge network of Netlipse (www.netlipse.eu) was mentioned. From the interviews it turned out that knowledge in the form of experiences and lessons learned can best be shared when people are physically together in meetings where they can interact and discuss their problems with each other. It helps people in the projects to reflect on their own knowledge and see where improvements can be made with the shared knowledge of others. This supports the statement of Fitzek (2002) that knowledge is kept alive by the dynamic processes of reflection, learning and understanding. “Knowledge, which is not connected to these dynamic processes, does not flow, does not grow, and eventually ages and becomes

**TABLE 7: EXPLICIT AND TACIT KNOWLEDGE SHARING ACTIVITIES PER PROJECT**

<table>
<thead>
<tr>
<th>Project</th>
<th>Amsterdam</th>
<th>Betuweroute</th>
<th>KOSMOS / Spoedaanpak projecten</th>
</tr>
</thead>
<tbody>
<tr>
<td>HSL-Zuid</td>
<td>1. Series of presentations about operational project management</td>
<td>1. Applied own knowledge in performing audit of Noord/Zuidlijn project</td>
<td>1. Meetings with project managers of other projects in the ‘Spoedaanpak projecten’ program</td>
</tr>
<tr>
<td></td>
<td>2. Document about the evaluation sessions shared with other projects</td>
<td>2. Knowledge exchange sessions with foreign projects (New Orleans, Indonesia)</td>
<td></td>
</tr>
<tr>
<td>Betuweroute</td>
<td>1. Presentations</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Website (kennis.betuweroute.nl) with documents, procedures and descriptions of instruments used during the project</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

52
obsolete and useless. By contrast, knowledge that flows by being shared, acquired and exchanged generates new knowledge” (Fitzek, 2002).

One of the tacit knowledge sharing activities that stands out in comparison to the other findings is the development of a traineeship for operational project managers (managers projectbeheersing). Project SAA invites operational project managers that are new or from other projects to do an internship in the project. By learning how operational project management is executed in this large project (SAA is with a budget of 3.2 billion one of the largest infrastructure projects of Rijkswaterstaat). With this traineeship, knowledge can be shared by ‘learning on the job’ activities. If others experience how the project approaches the management of time, cost and scope and other supporting management factors, they can transfer this knowledge to their own project.

The project manager of the projects Hanzelijn / OV SAAL is participating in the educational institute for project management, the Rijksprojecten Academie (RPA). In this position, he can implement lessons learned from his projects into the training program for new project managers.

A conclusion that can be derived from this analysis, next to the conclusion that almost every project is performing both explicit and tacit knowledge sharing activities, is that the focus lies on the transfer of tacit knowledge. The projects recognize that knowledge about how to manage time, budget, scope and the other supporting management factors cannot be easily transferred by codifying this knowledge. Presentations are given to interested parties, but the projects indicated during the interviews that most knowledge about developed instruments is shared by personal contacts. This is done in organized knowledge networks, but the most knowledge transfers are executed between people that are already in each other’s personal networks. Operational project managers already knew each other from previous meetings or past projects. They indicated to sometimes contact these persons when they encounter problems or have specific questions. However, this implies that this sharing of knowledge is constrained to the size of the personal networks of the operational project managers (managers projectbeheersing). They are not aware that a solution for a problem might be in another project that is not in their social network.

5.2.3 Empirical results: Inter-project learning (implement)

In the interviews, not only questions about the different knowledge activities in the steps of ‘create’, ‘evaluate’ and ‘share’ were asked, but also the actual implementation in the final step of the framework was studied. Did projects really look at each other’s created knowledge? The respondents were asked if they implemented instruments from other projects and the other way around. Did other projects come to them with their questions and did they ‘copy’ some of the instruments in order to improve their own project management?

The findings from the interview are presented in table 8. For every project, the answers of the respondents on the questions about the implementation of knowledge about project management instruments are divided into two groups: knowledge that is implemented IN other projects and knowledge that is implemented FROM other projects.
<table>
<thead>
<tr>
<th>Project</th>
<th>Implemented in other projects</th>
<th>Implemented from other projects</th>
</tr>
</thead>
</table>
| **Maaswerken**   | 1. The former project director of Maaswerken is now in the management team of project Ruimte voor de Rivier. He implemented our financial reporting method, including the actual prognosis for the budget, in his new project.  
2. Multiple people who worked in this project now work in project Ruimte voor de Rivier, they took their knowledge with them. | 1. Our approach for the management of time can be found in the industrial sector in the building of hospitals and facilities. People who work in this project also worked in projects in this sector. |
| **SAA**          |                                                                                                                                  | 1. We implemented knowledge from the lessons learned that can be found in the audit of project Noord / Zuidlijn and the workgroup that was established to analyze this report.  
2. We use a dataroom for the exchange of knowledge with contractors (aannemers) that is developed in the projects Tweede Coentunnel, A12 Lunetten – Veenendaal and Maasvlakte – Vaanplein. |
| **A2 Maastricht**| 1. Our developed dataroom for knowledge exchange with contractors is implemented by project Sluiskiltunnel  
2. Project MaVa wanted to know how we approached the transition between the planning and the realization phase. | 1. One of our project members worked in project HSL-Zuid before, he brings that knowledge into our project.  
2. We looked at project Tweede Coentunnel for their lessons learned in the tender-phase (aanbestedingsfase). A part of that knowledge is used in our own tender phase. |
| **A4 Delft - Schiedam** | 1. Our dashboard reporting instrument is implemented by the regional departments of Rijkwaterstaat Oost-Nederland, Noord-Nederland and Zeeland.  
2. Project SAA asked us to help writing a project plan. | 1. We looked at the lessons learned of the tunnel projects A73, Tweede Coentunnel and A2 Utrecht.  
2. Our project manager was project manager in project Tweede Maasvlakte before. As well as other project members worked in that project.  
3. I worked in project Betuweroute before, and experienced the benefits of the reporting method (Transparante Sturing en Verantwoording) there and implemented this |
1. Project Spoorzone Delft asked multiple times how we approached specific problems.

2. We implemented the experiences with D&C contracts from the Betuweroute.

3. For the design of the alliance contract for OV SAAL, we looked at other existing alliance contracts in the Netherlands, such as project A2 Utrecht and project N201.

<table>
<thead>
<tr>
<th>Hanzelijn / OV SAAL</th>
<th>Maasvlakte – Vaanplein</th>
<th>Tweede Coentunnel</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Hanzelijn / OV SAAL implemented almost all processes from the Betuweroute. Also, but less, from HSL-Zuid.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. We implemented the experiences with D&amp;C contracts from the Betuweroute.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. For the design of the alliance contract for OV SAAL, we looked at other existing alliance contracts in the Netherlands, such as project A2 Utrecht and project N201.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Project MaVa is visited by many other projects. Our knowledge is often implemented in those other projects, Relatics is a good example.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. We implemented lessons learned from A2 Maastricht, how they approached the transition between the planning and realization phase.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. We often implement knowledge from project Tweede Coentunnel and A12 Lunetten – Veenendaal.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. We implemented knowledge from HSL-Zuid about how to design the information management systems.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. We implemented knowledge from the auditreport of project Noord/Zuidlijn.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Projects MaVa, SAA and A12 Lunetten - Veenendaal implemented our knowledge about managing costs in DBFM contracts.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. A delegation of Turkish project managers came to our project to look at how we manage DBFM contracts.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. We implemented knowledge about tunnels from the tunnel projects A73 en A2 Utrecht.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. We implemented lessons learned of foreign projects in Belgium and England because no knowledge was available in the Netherlands about managing costs DBFM contracts.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. We implemented lessons learned about managing DBFM contracts from projects A59 en N31.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project</td>
<td>Findings</td>
<td></td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Ruimte voor de Rivier</td>
<td>1. Our project plan is labeled as ‘best practices’ and used by other projects 1. We learned from projects Maaswerken and Tweede Maasvlakte how to structure the project organization</td>
<td></td>
</tr>
<tr>
<td>Noord / Zuidlijn</td>
<td>1. Other projects in Amsterdam, such as project Zuid-As implement knowledge about our approach of risk management and our general project management approach and philosophy. 1. There are multiple people working in this project who worked in projects Betuweroute and HSL-Zuid before. 2. We implemented knowledge from project Ruimte voor de Rivier about how to deal with politics, environment and communication 3. For our quality management instruments, we implemented knowledge from projects Betuweroute and HSL-Zuid</td>
<td></td>
</tr>
<tr>
<td>HSL-Zuid</td>
<td>1. A large share of all our lessons learned is implemented in the standardized prescribed instruments of Rijkswaterstaat 1. We implemented knowledge from project Betuweroute about close-down processes.</td>
<td></td>
</tr>
<tr>
<td>Betuweroute</td>
<td>1. Projects Noord / Zuidlijn and Maasvlakte 2 directly implemented knowledge from this project. 1. I used my personal knowledge from other smaller projects I worked in before.</td>
<td></td>
</tr>
<tr>
<td>KOSMOS / Spoedaanpak projecten</td>
<td>1. Project managers of other ‘Spoedaanpak projecten’ projects implement knowledge from my project. 1. I use knowledge that is created in project KOSMOS now as a project manager in one of the projects of the ‘Spoedaanpak projecten’ program. 2. We implemented knowledge about external quality management (<em>systeemgerichte contractbeheersing</em>) from project HSL-Zuid.</td>
<td></td>
</tr>
</tbody>
</table>

**Table 8: Overview of Interview Findings on Knowledge Implementation**
5.2.4 ANALYSIS: INTER-PROJECT LEARNING (IMPLEMENT)

In order to analyze the findings on the implementation of knowledge in the projects, the ‘knowledge implementation’ relationships need to be made visible. The connections between projects that implemented knowledge from each other, as presented in table 8, are illustrated in the graph in figure 14. Projects are connected by arrows when knowledge about instruments is shared by one project and implemented by the other project. An arrow from project A to project B indicates that project B implemented knowledge that was shared by project A.

In the graph, the ‘knowledge implementation connections’ are shown by the arrows, as a value that can be true or false. Knowledge is implemented from project A by project B or not. The limitation of this graph is that no information is given about the content of the knowledge that is shared. However, for this research this is not seen as a limitation, since the main research question wants to find out to what degree knowledge about project management instruments is shared and implemented and wants to find possible barriers that stand in between the steps of ‘share’ and ‘implement’. Figure 14 shows that next to the number of sharing initiatives as described in sections 5.2.1 and 5.2.2, there is also a large number of ‘implementation connections’ between infrastructure projects in the Netherlands.
As can be seen in the graph (figure 14), some projects have more implementation connections than other projects. For example, the projects HSL-Zuid and Betuweroute have the most outgoing arrows when compared to the other projects in the graph. When comparing the phases these projects are in with the other projects, HSL-Zuid and Betuweroute are now complete or almost complete (project phases can be found in the sample description in section 4.4.1). This implies that all arrows from these two projects represent sequential knowledge transfer (Fitzek, 2002). As already discussed in section 5.1.2, in this study a knowledge transfer from a project in a later phase to a project in an earlier phase is considered as a sequential transfer. The phases of a project are not taken into account in the knowledge transfer model by Fitzek (2002). Multiple projects indicated in the interviews that the most lessons learned are created in the projects Betuweroute and HSL-Zuid, since they were the first that had to come up with solutions for problems that were never encountered before. This difference in time period is an explanation for the large number of outgoing arrows.

In order to complete the information, the projects A12 Lunetten – Veenendaal, Sluiskiltunnel, A2 Utrecht, Maasvlakte 2, A73 and Spoorzone Delft are mentioned in the interview results but are not part of the sample. A12 Lunetten – Veenendaal and Sluiskiltunnel are in the planning phase and project A73 is complete. The other three projects are in the phase of realization.

Given the above explanation, it is interesting for the analysis to pick projects that are in the same phase to see if there are also concurrent knowledge transfers. The following projects are in the planning phase:

- SAA
- A2 Maastricht
- A4 Delft – Schiedam
- OV SAAL
- Maasvlakte – Vaanplein
- A12 Lunetten - Veenendaal

When looking at the graph in figure 14, it can be seen that there are also concurrent knowledge transfers. So it is not true that there is only sequential knowledge transfer between the large infrastructure projects in the Netherlands. Also projects that are in the same project phase implement knowledge from each other.

It is true that there is concurrent knowledge transfer between projects that are in the planning phase. But is it also true for projects that are in the ‘execution’ phase? The following list shows the projects that are in the execution phase:

- Maaswerken
- Hanzelijn
- Tweede Coentunnel
- Ruimte voor de Rivier
- Spoedaanpak projecten
- Noord / Zuidlijn
- A2 Utrecht
- Maasvlakte 2
- Spoorzone Delft

By studying the graph in figure 14 again, it becomes clear that there is also concurrent knowledge transfer between projects in the execution phase.
Now the interesting question remains if there are more sequential knowledge transfers than concurrent knowledge transfers or vice versa. The answer is interesting because this indicates the way projects are learning from each other. Is only knowledge implemented from projects that are already in a later phase or is knowledge exchanged by projects in the same phase as well? To find an answer, the implementation connections of the projects that are in the youngest phase in the sample (planning) are explored. In this table, the connections with projects that are not in the sample are not counted, because there are no respondents interviewed from these projects. For this reason, no complete information can be given about the number of implementation connections from and to these projects.

<table>
<thead>
<tr>
<th>Project</th>
<th>Number of connections with projects in planning phase</th>
<th>Number of connections with projects in realization phase</th>
<th>Number of connections with complete projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAA</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>A2 Maastricht</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>A4 Delft – Schiedam</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>OV SAAL</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Maasvlakte – Vaanplein</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>1.6</strong></td>
<td><strong>1.4</strong></td>
<td><strong>1.4</strong></td>
</tr>
<tr>
<td><strong>Average concurrent transfers compared to average sequential transfers</strong></td>
<td><strong>1.6</strong></td>
<td><strong>2.8</strong></td>
<td></td>
</tr>
</tbody>
</table>

**TABLE 9: NUMBER OF CONCURRENT TRANSFERS COMPARED TO NUMBER OF SEQUENTIAL TRANSFERS**

The calculation in table 9 shows that on average there are far more sequential knowledge transfers than concurrent knowledge transfers. The observation that can be made from these results is that more learning takes place from projects that are already in a later phase or are even completed. However, to repeat what is found in the literature review (section 2.3): the sequential transfer mode seems to be less effective, because it is not possible to interact and communicate directly between the two projects, even as sharing of tasks and mutual adjustment (Fitzek, 2002). Based on this findings, better inter-project learning could take place when there are more concurrent knowledge transfers.

Another observation is that there are also projects with significantly more incoming arrows than other projects. The projects A2 Maastricht, Maasvlakte – Vaanplein, A4 Delft – Schiedam, SAA and Noord / Zuidlijn all have more than four incoming arrows. These projects have implemented significantly more knowledge than other projects in the research sample. And as discussed in the text above, the connections do not only represent sequential knowledge transfers. Neither are they all in the same project phase.
Geographical location is also an influencing factor, as turned out from the interviews. Project Maaswerken indicated that because it is located in Maastricht, there are knowledge implementation connections with nearby projects, like Ruimte voor de Rivier, but less connections with more remote projects in other areas of the Netherlands. However, for project A2 Maastricht this is not the case, since the graph visualizes that they have implemented knowledge from four projects and have also shared with project Maasvlakte – Vaanplein. All projects that are not in the direct surroundings of Maastricht.

Project managers and operational project managers that moved from project A to project B, often implemented the previously created knowledge in the new project. For example, the project manager of project Hanzelijn was project manager in a part of the Betuweroute project before. Project Noord/Zuidlijn also indicated that there are working multiple people in the organization now who also worked in the projects Betuweroute and HSL-Zuid. The same type of implementation connections can be found between Hanzelijn and OV SAAL and between KOSMOS and ‘Spoedaanpak projecten’.

Two of the projects in the sample, Spoedaanpak projecten and Ruimte voor de Rivier, are part of a program with multiple underlying projects. The respondents from both projects indicated that most knowledge transfer happens between projects in the same program. They said that a program with its underlying projects is more distanced from the other projects of the functional organization. Therefore, there are also less implementation connections with projects outside the programs. (Operational) project managers from the underlying projects come together and share lessons learned with each other, but not with (operational) project managers from other projects.

To conclude, this research found out that in the world of large infrastructure projects in the Netherlands both sequential and concurrent knowledge transfers happen. However, the findings show that there are significantly more sequential than concurrent transfers. Based on existing literature, the latter is said to be a more effective way of inter-project learning.

The observation that the graph that shows the implementation connections is not a fully connected graph can be added to derive a second conclusion. There are various connections between the different projects, but there is no structure that can be found. Implementation connections are, like the conclusion in the analysis of the ‘share’ step, often based on connections in the personal networks of the operational project managers.
5.3 INTER-PROJECT LEARNING BARRIERS

Where in the previous section all inter-project knowledge activities are explored that are performed in the large infrastructure projects in the Netherlands, this section studies possible barriers that disturb the process of knowledge sharing and knowledge implementation. In the analytical framework of this research (section 3.3), the barriers to inter-project learning that are found in existing literature are grouped into four categories: social, organizational, project-related and knowledge-related. In this section, the findings from the interviews are presented and analyzed based on this framework. Each respondent was asked to identify possible barriers that might prevent that knowledge about project management instruments is shared and implement in other projects.

5.3.1 EMPIRICAL RESULTS: INTER-PROJECT LEARNING BARRIERS

Based on the answers of the respondents to the question what the possible barriers are that cause reinventing the wheel instead of learning from other projects, the table in appendix 3 is constructed. This table shows the answers to the question and places these identified barriers in one the four categories of the analytical framework (section 3.3).

The barriers that are identified by the respondents in the interviews are already grouped into the categories of the analytical framework in table 16 in appendix 3. To make an overview of how many barriers are identified and to which category they belong, they are listed and counted in table 10. Also the duplicates are removed from the list. This overview gives an understanding of which types and categories of barriers are present in the large infrastructure projects in the Netherlands. The table is sorted with the barrier that is the most times identified on top.

<table>
<thead>
<tr>
<th>Barrier category</th>
<th>Barrier</th>
<th>Number of identifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project-related</td>
<td>The context of a project makes it difficult to implement knowledge from other projects.</td>
<td>6</td>
</tr>
<tr>
<td>Organizational</td>
<td>Projects are not able to see which knowledge is available in other projects. There is no overall knowledge management system in the functional organization that connects projects that could possibly learn from each other.</td>
<td>5</td>
</tr>
<tr>
<td>Organizational</td>
<td>The ‘engineering’ culture in projects stimulates to develop own instruments instead of implementing knowledge from other projects.</td>
<td>2</td>
</tr>
<tr>
<td>Project-related</td>
<td>The different geographical locations of projects makes it difficult to directly interact and exchange knowledge.</td>
<td>2</td>
</tr>
<tr>
<td>Social</td>
<td>Developing own instruments instead of implementing from others results in identity and pride for the project team.</td>
<td>1</td>
</tr>
<tr>
<td>Social</td>
<td>Finding solutions for complex problems results in job satisfaction for project members. Taking away the ‘puzzling’ part by implementing solutions from other projects results</td>
<td>1</td>
</tr>
</tbody>
</table>
If people leave the project, knowledge is often not shared and stored in the organization.

Too much explicit knowledge causes information-overload. There should be more initiatives where people are brought together.

Hired parties have a commercial interest to develop new instruments instead of implementing existing knowledge.

Due to the time-consuming daily operational processes in a project, there is no time left for knowledge sharing and implementation.

### TABLE 10: OVERVIEW OF IDENTIFIED BARRIERS SORTED ON NUMBER OF IDENTIFICATIONS

<table>
<thead>
<tr>
<th>Category</th>
<th>Barrier Description</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project-related</td>
<td>In lower job satisfaction.</td>
<td></td>
</tr>
<tr>
<td>Knowledge-related</td>
<td>If people leave the project, knowledge is often not shared and stored in the organization.</td>
<td>1</td>
</tr>
<tr>
<td>Knowledge-related</td>
<td>Too much explicit knowledge causes information-overload. There should be more initiatives where people are brought together.</td>
<td></td>
</tr>
<tr>
<td>External</td>
<td>Hired parties have a commercial interest to develop new instruments instead of implementing existing knowledge</td>
<td>1</td>
</tr>
<tr>
<td>Organizational</td>
<td>Due to the time-consuming daily operational processes in a project, there is no time left for knowledge sharing and implementation.</td>
<td>1</td>
</tr>
</tbody>
</table>

This overview shows that in the interviews there were 2 barriers identified that can be placed in the social category, 3 in the organizational category, 3 in the project-related category and 1 in the knowledge-related category. One barrier was identified that cannot be placed in one of the four categories. It is placed in the additional ‘external’ category.

#### 5.3.2 ANALYSIS: INTER-PROJECT LEARNING BARRIERS

The analysis of the findings will be based on the analytical framework and on the inter-project learning barriers that are found in the literature review.

### TABLE 11: BARRIERS FOUND IN LITERATURE COMPARED TO BARRIERS FOUND IN THIS STUDY

<table>
<thead>
<tr>
<th>Identified ‘literature’ barriers</th>
<th>Not identified ‘literature’ barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Temporary nature of projects (Scarbrough, 2004; Gieskes and Ten Broeke, 2000)</td>
<td>- Defensive routines (face saving) (Julian, 2008)</td>
</tr>
<tr>
<td>- On-site character of projects (Gieskes and Ten Broeke, 2000)</td>
<td>- Bureaucratic overhead (Von Zedtwitz, 2002)</td>
</tr>
<tr>
<td>- Organizational culture (Gieskes and Ten Broeke, 2000)</td>
<td>- Inability to reflect (Von Zedtwitz, 2002)</td>
</tr>
<tr>
<td>- Uniqueness of projects (Antoni, 2000; Arora and Gambardella, 1994)</td>
<td>- Memory bias (Von Zedtwitz, 2002)</td>
</tr>
<tr>
<td>- Time constraints (Von Zedtwitz, 2002)</td>
<td>- Reluctance to blame (Von Zedtwitz, 2002)</td>
</tr>
<tr>
<td>- Tacitness of knowledge (Von Zedtwitz, 2002)</td>
<td>- Poor internal communication (Von Zedtwitz, 2002)</td>
</tr>
<tr>
<td></td>
<td>- Difficult to generalize (Von Zedtwitz, 2002)</td>
</tr>
<tr>
<td></td>
<td>- Relationships in networks, politics and power positions, (Sense and Antoni, 2003; Fitzek, 2002; Bresnen et al, 2004; Julian, 2008)</td>
</tr>
</tbody>
</table>
First, a list will be made of all barriers found in the literature review (section 2.4) that are identified in the large infrastructure projects and the barriers that are not identified by the respondents. This list gives understanding of which barriers that are found in already existing studies are also present in the world of large infrastructure projects and which are not.

All barriers that are found in literature and grouped into the ‘social’ category of the framework were not identified by the respondents in the interviews. Instead, two new ‘social’ barriers that were not in literature are identified: the barrier that states that in order for project teams to create their own identity and pride they need to develop their own instruments and the barrier that states that job satisfaction is reduced when no ‘complex puzzles’ have to be solved anymore. It is possible that the other barriers found in literature were not recognized because the research of Von Zedtwitz (2002) was focused on R&D projects. Face-saving behaviour, a barrier found in the research of Julian (2008) was never mentioned as possible barrier in the interviews. However, the question is if this barrier would have been mentioned although it was present. It is about people who do not want to admit that they made mistakes and who do not want their reputation to be negatively influenced. If people behave in this way, they also would not identify it as a barrier in the interviews.

From the ‘literature’ barriers that were grouped into the ‘organizational’ category, both the barriers of organizational culture and time constraints were recognized. The culture in the organizations of the projects dominated by engineers. These engineers are by nature more focused on the technical aspects of the project than on the organizational aspects such as learning (Gieskes and Ten Broeke, 2000). They are trained to find solutions for complex problems, and this is where this barrier might be combined with the job satisfaction barrier discussed before. Engineers find job satisfaction in developing instruments for solving complex problems that are encountered in the projects. The time constraints barrier was recognized, because daily operations in the project often consume all available time. Knowledge sharing and implementation gets low priority. This is a barrier that was already recognized in the analysis of the ‘create’ step in the inter-project learning framework. A conclusion might be that this is a barrier that is not only present between the steps of ‘share’ and ‘implement’, but starts already in the ‘create’ step. Time pressure puts a constraint on all activities in the project and could be identified as a general barrier, not only for knowledge implementation. The barrier of ‘bureaucratic overhead’ was not identified by the respondents.

A new barrier in the ‘organizational’ category, that was even identified 5 times, is the lack of a higher level knowledge management system. Higher level means that it is on a level in the functional organizations, above the individual projects. It was already identified in the analysis of the ‘evaluate’ step in the inter-project learning framework, and appears again in this section. The projects indicate that they are not able to know which knowledge is created where and which projects have specific problems that possible could be solved with their created knowledge. The respondents indicated that a solution for this problem would be a structured knowledge management system in the functional organization.

The barrier that was identified most times in the interviews is the barrier of the unique context of projects. According to six of the respondents, it is very difficult to implement knowledge from another project because every project has its own specific context. Since uniqueness is one of the main characteristics of a project (PMI, 2003), it could be expected that this is one of the barriers. The empirical results show that this is also true for the large infrastructure projects in the Netherlands. Antoni et al (2005) state that projects are often a composition of not so unique sub-processes. According to their theory, the uniqueness becomes even more unlikely when a project is part of a larger functional organization. Since this is second most identified barrier in this study, the respondents does not seem to recognize these ‘not so unique sub-processes’.
The other two barriers in the ‘project-related’ category were also identified. The on-site character was mentioned twice and the temporary nature was mentioned once. This temporary nature barrier was only identified in relation to people that leave the project and do not store their knowledge in the organization. In the analysis of the ‘implement’ step (section 5.2.4), a large number of knowledge implantation connections was found between projects that are already completed and running projects. Taking that analysis into account, the temporary nature does not seem to be an important barrier.

In the category of knowledge-related barriers, only the tacitness of knowledge was once identified as a barrier. If knowledge is codified and stored in documents, there is a point where it is not an effective sharing method anymore. If people have to read too many documents with lots of text, they are unable to extract knowledge from it. This is the problem of information-overload.

One barrier that could not be grouped in one of the four categories, is the ‘commercial interest’ barrier. The respondent explained that project organizations work with a large number of hired people from external (commercial) companies. These people and their companies get paid for the hours they spend in the project. Spending more hours results in higher payments, and thereby increase the attractiveness of developing own instruments instead of implementing knowledge that already exists in other projects.

To conclude, the ‘organizational’ and ‘project-related’ barriers are the most important barriers for inter-project learning in large infrastructure projects in the Netherlands. They are identified respectively 5 and 6 times, where the other barriers are all mentioned only once or twice. Interesting is that the respondents at the same time gave suggestions on how to remove the ‘lack of a higher level knowledge management system’ barrier.

Barriers that were found in existing studies do not all play a role in the world of the large infrastructure projects. Barriers found in a study on R&D projects cannot be used in the framework for infrastructure projects, since none of them was recognized by the respondents. Therefore, based on the findings in this research, an improved framework for describing inter-project learning barriers in large infrastructure projects is given below (table 12).

<table>
<thead>
<tr>
<th>Social</th>
<th>Organizational</th>
<th>Project-related</th>
<th>Knowledge-related</th>
<th>External</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Threat of reduced job satisfaction</td>
<td>- Lack of higher level knowledge management system</td>
<td>- Uniqueness of projects</td>
<td>- Information overload</td>
<td>- Commercial interest</td>
</tr>
<tr>
<td>- Importance of own identity and pride gained by developing own instruments</td>
<td>- Organizational culture dominated by engineers</td>
<td>- On-site character of projects</td>
<td>- Time constraints</td>
<td></td>
</tr>
</tbody>
</table>

**TABLE 12: IMPROVED FRAMEWORK FOR IDENTIFYING INTER-PROJECT LEARNING BARRIERS IN LARGE INFRASTRUCTURE PROJECTS**
6. SYNTHESIS

In this chapter, the partial analyses that are made in the previous chapter (chapter 5) are brought together in order to present the general findings of this research. This synthesis will help to come to an answer for the main research question by combining all findings that are presented in chapter 5. The structure of this chapter follows the three research objectives. Every analysis that is made is based on the analytical framework that is developed in chapter 3 for the three research objectives.

![Figure 15: Research Objectives and Main Research Question](image)

**Research objective 1: Developed instruments**

The findings from the research on the development of project management instruments in large infrastructure projects in the Netherlands show the following results:

- **Developed instruments are never completely unique or new**
  This study shows that there are many project management instruments developed by the different projects for the management of time, cost and scope. As indicated by most respondents, a developed instrument is never completely new or unique. Most instruments are improvements of already existing tools, methods or approaches.

- **Innovation can be found in different (unique) interpretations of already existing instruments**
  Development is not only found in the creation of new instruments. Often innovation and renewal can be found in the different (unique) interpretations of already existing instruments. An instrument for project management can be considered as unique if it is approached in a completely different way than all the other projects do.
Developments in past projects are now included in standardizations of the functional organizations
In earlier projects, such as project Betuweroute and project HSL-Zuid, a lot of developments are made. Instruments had to be developed for managing the project in these past situations. The functional organizations Rijkswaterstaat and ProRail implemented these developments in their standardizations. They designed standardized packages that contain all instruments that are considered to be required for the management of a large infrastructure project.

Freedom for the project to develop own instruments or implement from other projects is dependent on connection with the functional organization
The little amount of freedom is perceived by projects that are closely connected to the functional organization. Projects that have the status of independent project organization or projects that have a less direct relation with one of the functional organizations perceived more and sometimes even complete freedom to choose the instruments they want to use. An interesting observation is the fact that the most unique instruments that were identified in this study are developed in the projects that perceived the least amount of freedom. This analysis shows that freedom is not directly influencing the development of instruments and the implementation of knowledge from other projects. There might be other influencing concepts involved, such as creativity and innovativeness. These concepts are outside the scope of this research, but it might be interesting to include these factors in future research on the development of project management instruments.

Research objective 2: Inter-project learning
In order to answer the part of the main research question that wants to find out to what degree knowledge about these developed instruments is shared and implemented, the activities in the process of inter-project learning were studied. The research of these knowledge activities was based on the four inter-project learning steps in the analytical framework: create, evaluate, share and implement.

1. Create

Most projects use internal quality management systems and electronic project archives
However, this can only be considered as knowledge creation when lessons learned are stored in these systems (Van der Spek and Spijkervet, 1996). The systems should contain experiences and information on how and when to use the developed instruments. Only storing documents without additional information cannot be called creation of knowledge.

Knowledge creation is given low priority when there is shortage of time and people
The project organizations consist of a small number of project members and the available time is often fully consumed by the daily operational activities. Knowledge is given low priority when there is scarcity of time.

The ‘time constraints’ barrier (Von Zedtwitz, 2002) can be found in all steps of the inter-project learning framework. It is not only present between the ‘share’ and ‘implement’ steps, but is instead influencing the execution of all knowledge activities in the project.
2. Evaluate

- **Evaluations are used both for intra-project and inter-project learning**
  Most projects conduct evaluations. In these evaluations, they reflect on specific phases or processes in the project. These evaluations or audits are used for intra-project learning, but it appears that most projects also share the outcomes with other projects after they are conducted.

- **Projects want to share knowledge on-demand**
  Projects only want to share knowledge when this is asked by other projects. Sharing knowledge that is never used again and is not picked up by other projects is seen as a waste of time. Multiple respondents indicated that a higher level knowledge management system that contains an overview of which knowledge is required in which project improves the sharing and implementation activities. The projects themselves are not able to see which problems are encountered in other projects.

3. Share

- **Most knowledge sharing activities focus on exchange of tacit knowledge**
  Knowledge about project management instruments can be explicit or tacit. Sometimes documents can be made with descriptions of the instruments, but often knowledge is in experiences, rooted in actions and in the heads of people (Nonaka, 1994). Both explicit and tacit knowledge sharing activities are performed by most projects in this study. However, the focus lies on the transfer of tacit knowledge.

- **Most knowledge is shared between people that are already in each other’s network**
  A finding in this research that constraints the inter-project learning process is that most knowledge is shared between people that already know each other from working together in past projects or from earlier meetings. In this way, projects might not be aware that a solution for their problem is available in other projects, when there are no people of these projects in their personal network.

4. Implement

In the world of large infrastructure projects, there are both sequential and concurrent knowledge transfers. The model for these two knowledge transfer modes by Fitzek (2002) does not take the difference in project phase into account. In the model, a project is labeled as a past project or as a new project. In this study, knowledge transfers between projects that are both running but in a different project phase are considered as sequential. During the interviews, it became clear that there are significant differences between the phases of the projects and it would not be appropriate to consider them as one equal period of time. Therefore, if a project that is in the planning phase implements knowledge from a project that is in the execution phase, this is identified as a sequential knowledge transfer.

- **There are more sequential than concurrent knowledge transfers**
  The findings show that there are more knowledge connections between projects that are in a different phase than between projects that are in the same phase.
  According to literature, knowledge transfers between projects that are in the same phase are more effective because direct interaction is possible, even as sharing of tasks and mutual adjustment (Fitzek, 2002).

- **Knowledge relationships are not established in a structured way**
  There are various knowledge relationships between the projects, but in the analysis no structure could be found in how these connections are established. Connections are based on personal relationships and individual initiatives of the operational project managers.
**Research objective 3: Inter-project learning barriers**

The third research objective identifies barriers that are disturbing the process of inter-project learning about project management instruments. In the analytical framework (section 3.3) these barriers are located between the ‘share’ and the ‘implement’ step. However, an important finding is that the ‘time constraint’ barrier can not only be found between these two steps, but also between ‘create’ and ‘evaluate’ and between ‘evaluate’ and ‘share’. The problem that when there is a lack of time and a lack of people in the organization all time needs to be spent on the daily operational activities in the project has its influence on all knowledge sharing activities. For this reason, the framework could be improved by placing the barriers not only between ‘share’ and ‘implement’ but let them be present between all four steps.

The organizational and project-related barriers are the barriers that are the most disturbing for the process of inter-project learning in the world of the large infrastructure projects. Barriers in this category were the most times identified by the respondents.

Two social barriers are presented in the findings that were not found in already existing studies:

- **The importance of a project organization creating its own identity and pride**
  By developing a new instrument with the project team, the people working in the project can get the feeling that they have created something that is useful and that they are proud of. If it turns out that this new developed instruments works well for managing the project and other projects notice this development, their feeling of pride and identity becomes even stronger. This behaviour increases the tendency to re-invent the wheel instead of learning from other projects.

- **The threat of reduced job satisfaction**
  This barrier might be related with the barrier of the organizational culture that is dominated by engineers. Engineers find job satisfaction in developing solutions for complex problems. They are challenged by developing instruments for managing the project in complex problem situations. If this challenge is removed and solutions have to be developed only once and then it is just a matter of copy and paste into another project, the job satisfaction of project members might be reduced.

In the organizational barriers category, the findings also present a barrier that was not mentioned before in existing literature. In this research, this is the second largest barrier that was identified by the respondents:

- **The lack of a higher level knowledge management system**
  Projects are often isolated from other projects and therefore not able to see which knowledge is available in the other projects. Multiple respondents indicated that there is no knowledge management system in the functional organizations of Rijkswaterstaat and ProRail where knowledge is managed on a higher level, above the individual projects.

The barrier of an organizational culture that is dominated by engineers was indeed confirmed by the respondents in this study. One of the respondents told that in the history of Rijkswaterstaat, one of the functional organizations, a lot of engineers from technical universities work in the projects. Their attitude, that is mainly focused on solving technical problems and the operational activities and less on managing knowledge, has a large influence on knowledge management within Rijkswaterstaat. The other respondent that also identified this barrier is project manager of a ProRail project. This might be an indication that the same organizational culture can be found in the ProRail projects as well.
The project-related barriers are directly related to the characteristics of the project. Uniqueness of projects is the barrier that is identified the most by the respondents in this research. The respondents indicated that it is difficult to implement knowledge about project management instruments that are developed in a project with a specific context into another project with a different context. Since earlier research initiatives were focusing on projects in other sectors, this study shows that this barrier is also present in the large infrastructure projects in the Netherlands. However, Antoni et al (2005) state that most projects often consist of not so unique sub-processes. So the question is if this is really a barrier that cannot be removed because it is part of the nature of projects, or if it is sometimes used ‘too easily’. Projects might have the tendency to consider themselves as unique, but to what extent is this really true when they are compared to other projects?

The knowledge-related barrier of information overload refers to the problem of large documents that contain too much information. Other projects have difficulties implementing this information since the essential knowledge cannot be extracted from the large amount of information anymore. However, the findings in research objective 2 show that the knowledge sharing activities mainly focus on the sharing of tacit knowledge. This implies that most projects already try to reduce this barrier by focusing on the exchange of tacit knowledge instead of explicit knowledge.

The barrier of commercial interest does not belong to any of the four categories in the analytical framework. Hired people in the project organization that belong to commercial organizations might have conflicting interest with the other parties that are involved in the project. Hired people are often paid by the number of hours they spent on the project. Developing new instruments instead of implementing from other projects will lead to more work and thereby to more money for the commercial organization. Since this might be the case in other projects as well, the ‘external’ category can be added to the framework.

In order to provide a complete overview, all inter-project learning barriers are once again presented below in table 13.

<table>
<thead>
<tr>
<th>Social</th>
<th>Organizational</th>
<th>Project-related</th>
<th>Knowledge-related</th>
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<td>- Importance of own identity and pride gained by developing own instruments</td>
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<td>- Organizational culture dominated by engineers</td>
<td>- On-site character of projects</td>
<td>- Temporary nature of projects</td>
<td></td>
</tr>
</tbody>
</table>
7. CONCLUSIONS

The answer to the main research question can be divided into two parts. First, an answer will be given to the question to what degree knowledge about project management instruments is shared and implemented. Second, an overview will be provided of the barriers that disturb the process of inter-project learning about these project management instruments.

The findings in this research show that all kinds of knowledge sharing and implementation activities are performed between the different large infrastructure projects. There is no project found in this study that does not share knowledge about the developed project management instruments. The findings also show that there are many knowledge implementation connections between the studied projects. However, the sharing and implementation of knowledge is not always performed in the most effective way. Much knowledge is transferred from projects in a later phase to projects that are still in an earlier phase. The large infrastructure projects in the Netherlands could learn more effectively from each other if more knowledge sharing initiatives would be undertaken by projects that are in the same phase.

Another conclusion is that all kinds of knowledge sharing and implementation relationships are established between projects, but this is not done in a structured way. Knowledge is only shared and implemented between people that are already in each other’s network. With the lack of a structured way of establishing connections between projects, the individual projects are not able to see in which other projects there is knowledge created that would help them in overcoming specific problems. And vice versa, the projects are willing to share knowledge with other projects that face similar problems, but they don’t have an overview of which knowledge is required in which projects.

This study makes clear that in order to effectively share and implement knowledge, not only the knowledge sharing and the knowledge implementation activities are important. The preceding intra-project learning activities of creating lessons learned and evaluating the value of this knowledge for other projects are important as well. This study shows that there are already barriers present in the first two steps of creating and evaluating knowledge. Lack of time and lack of people in the project organization often results in low priority for knowledge activities, since all available time has to be spent on the daily operational activities. The conclusion that can be drawn is that inter-project learning cannot be effective without intra-project learning activities that are effective as well. Therefore, the analytical framework in this research makes a connection between already existing frameworks for inter-project learning and the Plan-Do-Study-Act cycle that is often used for intra-project learning.

The barriers to the inter-project learning process that are found in this study, contain both barriers that are already identified in existing literature and barriers that were not mentioned before. The following list shows the barriers that might disturb the process of inter-project learning about project management instruments:

- Uniqueness of projects
- Lack of a higher level knowledge management system
- Organizational culture dominated by engineers
- On-site character of projects
- Importance of own identity and pride created by developing own instruments
- Threat of reduced job satisfaction
- Temporary nature of projects
- Information overload
- Commercial interest
- Time constraints

The largest barrier that is identified in this study is closely related to the nature of projects. Each project has its specific context that makes it difficult to implement knowledge from other projects. Despite of the discussion if projects are really unique or that they might be not as unique as they consider themselves, it is a fact that the uniqueness of projects is seen as a major barrier that disturbs the knowledge activities in the inter-project learning process. This means that if projects want to learn more effectively from each other, action is required. Simply ignoring this barrier by saying that projects are not unique will not contribute to the improvement of inter-project learning.

The second largest barrier is the lack of a higher level knowledge management system. Multiple respondents indicated that the functional organization they are connected to should manage the knowledge that is created inside the different projects. They suggested that by having a knowledge management system that is on a higher level, above the individual projects, projects that could possibly learn from each other can be connected. The respondents indicated that this is the responsibility of the functional organization, that should play a facilitating role by establishing knowledge connections between the projects in a structured way.

**Academic implications**

This study makes a contribution to existing literature in the field of inter-project learning by the development of a framework where all knowledge activities in the inter-project learning process can be described. Where existing studies focus mainly on the actual transfer of knowledge between two projects, this framework makes a connection between the intra-project learning and the inter-project learning processes. The added value of this approach can be found in the fact that the intra-project learning activities needs to be performed well first, before inter-project learning can happen effectively. No earlier research initiatives have used a framework that describes both the knowledge activities inside one project as well as the knowledge activities between different projects.

A second contribution to existing literature is that in this framework, the four categories of barriers are included that disturb the inter-project learning processes. There were no previous studies found that explore the learning barriers for large infrastructure projects. In this study it turned out that the barriers that are found in previous research initiatives could not all be applied to projects in the infrastructure sector. Therefore, a new list of identified barriers is presented in this thesis. In addition to the barriers that are found in previous studies, three new barriers are identified that are present in the world of large infrastructure projects.

There were no studies found in the literature review that focus on knowledge management and inter-project learning for projects in the infrastructure sector. Articles that are available mainly focus on cost escalation, planning issues and complexity. This study contributes to both the research areas of knowledge management and infrastructure projects.
This study can be generalized in a sense that inter-project learning activities can be broader than only learning about project management instruments. The identification of developed instruments in this research is a good way to make inter-project learning possible. However, knowledge exchange is often broader than only sharing knowledge about project management instruments. The framework of this research can also be used for studying inter-project learning and possible barriers in other project management areas of the same projects. The barriers that are discovered might also be present in projects in other sectors. This implies that the analytical framework that is used in this research for studying inter-project learning activities and barriers might be used for projects in other sectors as well, and not only for large infrastructure projects.

**Limitations and recommendations for future research**

The first limitation of this research is that interviews are conducted with only one person per project. Although the most representative person of the project was selected, the single informant bias is always present. The interview results might be ‘coloured’ by personal experiences of the respondent and its attitude towards the organization, although subjective information is tried to filtered out as much as possible. A recommendation for future research is to interview more people in the same project organization. This could lead to a broader picture of how the project deals with the different knowledge activities. It is possible that other people in the organization can identify additional activities or other views on possible inter-project learning barriers.

A second limitation is the fact that in this study projects are considered as single ‘atomic’ units of research. The underlying organization, with multiple actors and power positions that influence the decision-making processes inside the project, is left out of the scope of this research. A recommendation for future research is to make a connection between the identified barriers in this study and theories about decision-making. The dynamics of conflicting interests and power positions might contribute to a better understanding of the inter-project learning barriers and possible solutions to remove them.

The third limitation is the focus on only the operational project management factors time, cost and scope. The developed project management instruments that are identified in the first research objective provide a useful understanding for studying the inter-project learning processes and the barriers that are present. However, by including more areas of project management, a broader understanding can be gained. Learning not only takes place in the field of the management of time, cost and scope, but also in all other areas of project management. Interesting areas might be contracting, stakeholder management and dealing with a political environment.

**Managerial implications**

The results of this study give insights in the current development of project management instruments, the way projects can learn from each other and the barriers that disturb the learning between projects. With these understandings, project managers and operational project managers (managers projectbeheersing) are able to recognize how these processes are executed in their own projects. With the understanding of the barriers that might be present in their own project as well, initiatives could be taken to remove them in order to improve the inter-project learning processes and thereby improve the efficiency of project management.

Practical recommendations for the projects on how to remove or deal with specific barriers are presented in chapter 8.
8. Recommendations

This final chapter will present two recommendations that are based on the findings and conclusions of this study. These recommendations can be used to improve inter-project learning activities and to remove barriers that prevent the process of inter-project learning.

1. Higher priority to knowledge creation activities in the project

The findings and conclusions in this study show that the ‘time constraints’ barrier, the problem that lack of time and lack of people in the project organization results in low priority for knowledge activities, is present in all learning processes in and between projects. In the first place, to remove this barrier, an organizational culture is required in the project with a strong attitude towards the creation of knowledge. The people who are working in the project need to be aware of the value of knowledge creation, both for their own project and for other projects. Often, all available time is consumed by the daily operational activities of the project and no time is left for knowledge activities. However, by creating a culture where knowledge gets higher priority because the project members are aware of the value of their knowledge, the ‘time constraints’ barrier can be removed. In this culture, knowledge activities are considered as important as the daily operational activities. Spending time on knowledge management should no longer be an activity that will be done after all other tasks are completed.

The first step that can be made in order to make changes in the existing culture, so that knowledge activities get higher priority, is to make knowledge creation part of the project objectives. This idea comes from studying project Noord/Zuidlijn, where the first project objective is to deliver a working transport system and the second objective is to create knowledge for other infrastructure projects. In this formal way, the project organization is forced to give knowledge management a serious place in the project, besides the operational project management.

A second step can be to oblige the project organization to regularly report about their knowledge management activities. This can be done by giving knowledge management reporting a permanent place in the regular reports that have to be delivered to the client (opdrachtgever) and the functional organization.

Next to this, an organizational culture is required where there is trust and ‘openness’ that makes people feel free to not only express their positive results but also their faults. A culture where people know that mistakes can be discussed, instead of being directly blamed personally, removes the barrier of ‘face-saving behaviour’. This makes it easier to produce useful lessons learned.

2. Higher level knowledge management system that matches supply and demand of knowledge

The most important finding of this study is that all projects are willing to share knowledge about their developed instruments. The organizations are often proud about what they have developed and are also willing to implement knowledge from other projects. However, for the projects it is difficult to find what knowledge is available in which other projects. They often do not know what problems are faced in other projects and what instruments are developed for project management in these complex situations. This makes the search for the right knowledge a time-consuming process. And since another finding of this study is that there is almost always a lack of time, the only option for projects is to continue on their own and develop their own instruments, although solutions might be already available somewhere else.
The solution to this problem is to create a higher level knowledge management system that keeps track of the knowledge that is created in the different projects. If this created knowledge is matched with the problem situations that are faced in other projects, projects that could possible learn from each other can be connected.

This should not be a system in the way that it is just a computer software tool that is available for the projects. It should be managed by a department or by people of the functional organizations, who fulfill the role of ‘knowledge broker’. By having contact with the projects on a regular basis, the knowledge broker knows which problems are faced by the projects and what kind of developments are made to solve these problems. This overview can be used to establish knowledge connections between the right projects in a structured way. With this system, projects no longer have to spend time on searching for useful knowledge themselves and at the same time they know that their own created knowledge is distributed to the projects that really need it.

This recommendation of an individual party that can manage knowledge on a higher level, above the individual projects, removes the second largest barrier that is identified in this study. It stimulates the sharing of knowledge and prevents that project management instruments are developed again that were already available somewhere else. This role can be fulfilled by the functional organizations, but an external party is possible as well.

![FIGURE 16: RECOMMENDATION FOR A HIGHER LEVEL KNOWLEDGE MANAGEMENT SYSTEM](image-url)
REFERENCES


### APPENDIX 1 – FINDINGS: DEVELOPED INSTRUMENTS

<table>
<thead>
<tr>
<th>Location</th>
<th>Time</th>
<th>Cost</th>
<th>Scope</th>
<th>Quality</th>
<th>Reporting</th>
<th>Organizational</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maaswerken</td>
<td>1. Integrated milestone control as main approach and philosophy</td>
<td>1. Actual prognosis for budget and cost</td>
<td>1. Fixed scope, not possible to change scope</td>
<td>1. Quarterly report, including changes in budget and top 4 main risks</td>
<td>1. Small project team, flexible hired staff (1/3 RWS, 2/3 hired)</td>
<td></td>
</tr>
<tr>
<td>Schiphol-Amsterdam-Almere (SAA)</td>
<td>1. PPI: standardized RWS probabilistic planning tool</td>
<td>1. PRI: standardized RWS probabilistic cost estimation tool</td>
<td>1. Strong emphasis on Systems Engineering, use of Relatics software tool (PKN), 2. RWS SAP system</td>
<td>1. Electronic project archive (Hummingbird software tool)</td>
<td></td>
<td>1. Explicit plan for operational project management (projectbeheersing)</td>
</tr>
<tr>
<td>A2 Maastricht</td>
<td>1. Outsourced to contractors</td>
<td>1. Outsourced to contractors</td>
<td>1. Standardized RWS method for scope changes</td>
<td>1. Operational project management to large extent outsourced to contractors, management of quality as main focus 2. Own developed quality management system</td>
<td>1. Yearly project plan 2. Quarterly report on project progress</td>
<td>1. Explicit management model designed for cooperation with four different public parties</td>
</tr>
<tr>
<td>A4 Delft – Schiedam</td>
<td>1. PPI: standardized RWS probabilistic planning tool</td>
<td>1. PRI: standardized RWS probabilistic cost estimation tool</td>
<td>1. SE W-model developed instead of standard V-model, 2. Relatics software tool for integral scope management and</td>
<td>1. Internal quality management system</td>
<td>1. Own developed dashboard, for reporting integral project management information</td>
<td>1. Small project organization, focus on connecting people and competences with use of RWS IPM model</td>
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<tr>
<td>Location</td>
<td>Systems Engineering</td>
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<tr>
<td><strong>Hanzelijn /</strong></td>
<td>1. Probabilistic planning method based on RISMAN method for risk management in planning</td>
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<tr>
<td><strong>OV SAAL</strong></td>
<td>1. ProRail SAP system</td>
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<tr>
<td></td>
<td>1. Scopemangement as used in Betuweroute</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>1. Instruments same as in Betuweroute</td>
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<tr>
<td></td>
<td>1. Instruments same as in Betuweroute</td>
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<tr>
<td><strong>Maasvlakte –</strong></td>
<td>1. Primavera as software tool</td>
<td></td>
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<tr>
<td><strong>Vaanplein</strong></td>
<td>1. Scopemangement as used in Betuweroute</td>
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<tr>
<td></td>
<td>1. RWS SAP system</td>
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<tr>
<td></td>
<td>1. Own developed dashboard, for integral reporting with focus on management of client/contractor relationships</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>1. Management model, where operational project management has independent position in organizational structure</td>
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</tr>
<tr>
<td><strong>Tweede</strong></td>
<td>1. PPI: standardized RWS probabilistic planning tool</td>
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<tr>
<td><strong>Coentunnel</strong></td>
<td>1. RWS SAP system</td>
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<td></td>
<td>1. Own developed VTW (Voorstel tot Wijzigingen) tool to manage scope changes</td>
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<td></td>
<td>1. SCB (Systeemgerichte contractbheersing) for external quality management</td>
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<tr>
<td></td>
<td>1. Electronic project archive (Hummingbird)</td>
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<tr>
<td><strong>Ruimte voor</strong></td>
<td>1. Explicitly chosen to use deterministic planning tool instead of probabilistic</td>
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<tr>
<td><strong>de Rivier</strong></td>
<td>1. RWS SAP system</td>
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<tr>
<td></td>
<td>1. Dashboards per project en one integral dashboard for all projects in RvdR program</td>
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<td></td>
<td>1. Part of larger RvdR program</td>
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<tr>
<td><strong>Noord /</strong></td>
<td>1. Standard planning tools</td>
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<tr>
<td><strong>Zuidlijn</strong></td>
<td>1. Standard financial tools</td>
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<td></td>
<td>1. Standard scope tools</td>
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<td></td>
<td>1. Philosophy in project organization important, copy state-of-the-art</td>
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<tr>
<td>Project</td>
<td>Developed Instruments</td>
<td>Technology from others</td>
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<tr>
<td><strong>HSL-Zuid</strong></td>
<td>1. Developed own procedure for risk management in planning 1. Developed VTW (Voorstel tot wijzigingen) procedure for managing scope changes 1. Developed EKB (Externe Kwaliteitsboring) method for external quality management</td>
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<tr>
<td><strong>Betuweroute</strong></td>
<td>1. Primavera software tool for planning 1. TSV (Transparante Sturing en Verantwoording) method developed for reporting in entire organization</td>
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<tr>
<td><strong>KOSMOS / Spoedaanpak projecten</strong></td>
<td>1. Explicitly chosen for deterministic planning method 1. Standardized RWS instruments 1. Standardized RWS instruments 1. SCB (Systeemgerichte contractbeheersing) for external quality management</td>
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**TABLE 14: OVERVIEW OF DEVELOPED INSTRUMENTS PER PROJECT**
## APPENDIX 2 – FINDINGS: INTER-PROJECT LEARNING ACTIVITIES (CREATE, EVALUATE AND SHARE)

<table>
<thead>
<tr>
<th>Project</th>
<th>Create</th>
<th>Evaluate</th>
<th>Share</th>
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</thead>
</table>
| Maaswerken| 1. Explicit plan for operational project management captures all knowledge about applied instruments  
2. Project plan  
3. Electronic project archive for storing knowledge and lessons learned  
“When there is a continuous shortage of people and time, knowledge receives lowest priority” | 1. Reports  
2. Audits | 1. Presentations about reports and audits:  
Presentations about reports for other projects and project managers  
2. Networks: Participation in Kennis in het Groot and Netlipse |
| SAA       | 1. Explicit plan for operational project management captures all knowledge about applied instruments  
2. Project plan  
3. Electronic project archive for storing knowledge and lessons learned  
“When there is a continuous shortage of people and time, knowledge receives lowest priority” | 1. External audits  
2. Lunchsessions inside the project where lessons learned are discussed | 1. Traineeship for operational project managers:  
Project is developing a traineeship program where other or new operational project managers can follow an internship in project SAA  
2. Workgroup “Leren van de Noord/Zuidlijn”  
3. Presentations about SE for the functional organization |
| A2 Maastricht | “We consider knowledge creation as very important, but due to time pressures and small project organization, it has low priority” | 1. Evaluation of tender (aanbesteding) phase | 1. Presentations about contracting, risk mgmt. and general approach  
2. Networks: participation in knowledge networks  
3. A2 Maastricht conference: Project wants to organize congress where evaluation about tender-phase can be shared with rest of the world. |
| A4 Delft – Schiedam | 1. Internal quality management system for storing knowledge | 1. Evaluation on OTB (*ontwerp tracébesluit*)
“It is not clear which knowledge is needed in which project at this moment. The functional organization should play a facilitating role where an overview is of which projects need which knowledge” | 1. Blog on the internet every two weeks written by project manager
2. Presentations to Rijkswaterstaat organization
3. Meetings with other operational project managers (*managers projectbeheersing*)
4. One-to-one contact with other projects: ‘knowledge on demand’ |
|---------------------|----------------------------------------------------------|---------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| Hanzelijn / OV SAAL | 1. Books that contain experience and lessons learned
“We are careful with created knowledge and try to store it as much as possible, however this is sometimes difficult.” | “We do not structurally think about what the value of our knowledge is for other projects, besides participation in knowledge networks” | 1. Networks: Participation in knowledge networks
2. Connected to Rijksprojecten Academie (RPA)
3. Sharing books that contain experience and lessons learned |
| Maasvlakte – Vaanplein | “We think about it, but the effect is low. There is no step towards storage of knowledge”
“Knowledge management should be a process, but is difficult” | “We are missing a facilitating role of the functional organization, that lets us display our knowledge to other projects connected to Rijkswaterstaat” | 1. To functional organization: Project tries to share knowledge about developed management model with rest of the Rijkswaterstaat organization
2. One-to-one sharing: Sharing on demand with colleagues |
| Tweede Coentunnel | 1. Knowledge management activities integrated in general project report | 1. External audits
2. Auditreport about ‘grondaankopen Westrandweg’
3. Evaluation of ‘financial close’ process
4. Evaluation of processes in project
“We are missing a general database for all RWS” | 1. Contacts with foreign projects about managing DBFM contracting
2. Presentation in Berlin about DBFM
3. Presentation for project ‘Lange Wapper’ in Antwerpen
4. Meetings with project management department |
| Ruimte voor de Rivier | “In Rijkswaterstaat, we are not good in the storage of knowledge” | 1. Evaluation reports | 1. Presentations for Rijkswaterstaat organization  
2. Lunchpresentations  
3. Distribution of evaluation reports. |
|---|---|---|---|
| Noord / Zuidlijn | 1. Knowledge management is explicit objective in project plan  
2. Knowledge Management department within project organization | 1. External audits | 1. Contacts with other projects in Amsterdam |
| HSL-Zuid | “HSL-Zuid is a project where a lot of knowledge is created. Lessons learned can be found now in standardized instruments of RWS” | 1. Evaluation of the contracting together with contractors | 1. Series of presentations about operational project management (*projectbeheersing*)  
2. Knowledge exchange sessions with foreign projects (New Orleans, Indonesia)  
3. Document created about the evaluation sessions and shared with other projects  
4. Audit of Noord/Zuidlijn project |
| Betuweroute | 1. Knowledge capturing project as part of Betuweroute project | 1. Presentations | 2. Website (kennis.betuweroute.nl) with documents, procedures and descriptions used during the project |
1. Teambuilding meetings to discuss created knowledge and produce lessons learned.

“Talking with other project members in an ‘open’ organizational culture where faults can be discussed is most important form of capturing knowledge”

1. Meetings with project managers of other projects in Spoedaanpak program

| TABLE 15: INTER-PROJECT LEARNING ACTIVITIES CREATE, EVALUATE AND SHARE PER PROJECT |
# Appendix 3 – Findings: Inter-Project Learning Barriers

<table>
<thead>
<tr>
<th>Project</th>
<th>Identified barriers</th>
<th>Barrier category</th>
</tr>
</thead>
</table>
| Maaswerken               | 1. The organization of Rijkswaterstaat was always dominated by engineers, although this is changing the last years  
2. Developing own instruments instead of implementing from others results in an own identity and pride for the creators  
3. The context of the project makes it impossible to copy an instrument of another project for the full 100 percent. | 1. Organizational (culture)  
2. Social (psychological)  
3. Project-related (uniqueness) |
| SAA                      | There are no barriers. There are lots of knowledge sharing and implementation initiatives that prove that projects learn from each other.                                                                           | No barriers                                         |
| A2 Maastricht            | 1. It is not possible to just implement an instrument from another project with another context  
2. It takes more time to implement an instrument from another project with another context than developing it yourself.                                           | 1. Project-related (uniqueness)  
2. Project-related (uniqueness) / Organizational (time constraints) |
| A4 Delft – Schiedam      | 1. Projects are not able to see which knowledge is available in other projects. There is no overall system in the functional organization that connects projects that could possibly learn from each other. | 1. Organizational (knowledge management processes)   |
| Hanzelijn / OV SAAL      | 1. The ‘engineering’ culture in projects stimulates to develop own instruments instead of learning from each other.  
2. Hired parties sometimes have a commercial interest to develop new instruments instead of implementing existing knowledge.  
3. Finding solutions for complex problems results in job satisfaction for project members. Taking away the ‘puzzling’ part by implementing solutions from other projects results in lower job satisfaction. | 1. Organizational (culture)  
2. External (commercial interest)  
3. Social (job satisfaction) |
| Maasvlakte – Vaanplein   | 1. The context of a project makes it difficult to implement instruments from other projects.  
2. The sharing and implementation of knowledge that is created in projects should be performed by the functional organization. They have a higher level overview of which knowledge is required for which project. | 1. Project-related (uniqueness)  
2. Organizational (knowledge management processes) |
<table>
<thead>
<tr>
<th>Location</th>
<th>Barriers</th>
<th>Identified by</th>
</tr>
</thead>
</table>
| Tweede Coentunnel       | 1. Due to the time-consuming daily operational processes in a project, there is no time left for knowledge sharing and implementation.  
2. Projects are not located next to each other. This makes it difficult to directly interact and exchange knowledge.  
3. If people leave the project, knowledge is often not shared and stored in the organization.  
4. Supply and demand of knowledge should be managed by the functional organization. Projects do not know where to find knowledge for specific problems. | 1. Organizational (time constraints)  
2. Project-related (on-site character)  
3. Project-related (temporary nature)  
4. Organizational (knowledge management structure) |
| Ruimte voor de Rivier   | 1. Too much explicit knowledge causes information-overload. There should be more initiatives where people are brought together.  
2. Projects are too isolated from other projects too effectively share knowledge.  
3. Rijkswaterstaat should manage knowledge exchange and connect projects in order to learn from each other. | 1. Knowledge-related (tacitness of knowledge)  
2. Project-related (on-site character)  
3. Organizational (knowledge management structure) |
| Noord / Zuidlijn        | There are no barriers. Knowledge is transferred by the people who move from project to project. They do not reinvent the wheel, but use their experience from previous projects. | No barriers |
| HSL-Zuid                | 1. Knowledge can only be shared and implemented effectively if there is a receiving and demanding party available.  
2. It is difficult to implement knowledge from previous projects into new projects with a different context. Much effort is required to let this work. | 1. Organizational (knowledge management structure)  
2. Project-related (uniqueness) |
| Betuweroute             | 1. Copy-and-paste of knowledge from one project into another is not difficult if you have to know how to do that. The context of the project is very important. | 1. Project-related (uniqueness) |
| KOSMOS / Spoedaanpak projecten | 1. You have to think about the reasons for implementing knowledge from other projects. It is not possible to simply copy knowledge from another project. | 1. Project-related (uniqueness) |

**TABLE 16: INTER-PROJECT LEARNING BARRIERS IDENTIFIED BY THE RESPONDENTS**