UNIVERSITEIT TWENTE.

AALBORG UNIVERSITY

Grisnich

Master Thesis at Machinefabriek Grisnich

How to Create and Transfer Knowledge for the Development of Standard and Custom Products?

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S0069191

Master of Science Business Administration

Specialization: ECIU Joint Master's Innovation & Entrepreneurship degree programme

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Preface

In front of you lies a Master Thesis about knowledge creation and knowledge transfer for the development of different product types. The particular research is done at a machine manufacturer that develops machines for the potato industry, loading and unloading of goods, and book sorting industry. The research focused on how the early stage of product development differs for either standard or custom products and had a focus on maximising the use of the available knowledge in the company.

I would like to thank a number of people, starting with Eric in den Bosch who made it possible for me to perform this research. Sikke Born, Jacob van Maanen, Jan Brouwer and Erik van Wijngaarden provided me with feedback on my thesis and helped me to develop a useful end product. On top of that I would like to thank the engineering department, Herman Baltus and Pieter Kaat for giving me a nice place to work and a good atmosphere. From the university I would like to thank Birgitte Gregersen for her support, my fellow students for their support and comments, especially my girlfriend Marije who has supported me throughout the entire thesis. Last, but definitely not least, I would like to give a special thanks to Jeroen Kraaijenbrink who has provided superb feedback and helped me to push myself to achieving the final result that lies in front of you. Without the support of all these people this would not have been the thesis it is today.

Simon Zomerdijk

Enschede, June 2010

Executive Summary

This research is performed for Grisnich. Grisnich is a machine manufacturer that has been active on the market for almost 50 years. During this period several markets have been explored and different products were developed. During the last decade, however, product development has decreased and new products have barely emerged. In 2008 Tolsma Beheer B.V. acquired the company and a new management is appointed at Grisnich. Change needs to occur and developments need to be made according to the new management and that is why this research is done.

Many of the employees working at Grisnich have been working there for over ten years, meaning that there is a lot of knowledge on how the current products are made and about the industry. That is why knowledge is chosen as a starting point for this thesis. Further questioning showed that there are two main forms of products at Grisnich: standard products and custom products. Basically, these are standardised products and custom products that need to be designed completely according to customer specifications. Since the development of both of these product types has come to a standstill this research will focus on using knowledge creation and transfer for the development of different product types. This has resulted in the following central question:

> *How should knowledge for the development of standard and custom products be created and transferred at the engineering department of Grisnich to optimise the development process?*

Knowledge creation and knowledge transfer are the main concepts of this research. Looking further into these concepts revealed six important elements of knowledge creation and transfer: (1) knowledge stock, (2) knowledge network, (3) organisational routines and processes, (4) learning factors, (5) motivation factors, and (6) communication factors. This results in a total of seventeen factors that are important for creating and transferring knowledge. Not all factors are evenly important throughout the development process that is why they were linked to a process. A problem solving process with a creativity phase where ideas need to be generated, the second phase a rough selection of the ideas needs to be made and further research on the ideas in the form of a business model needs to be done, the final phase is about selecting ideas that need to go through for further development and prototyping. Linking the factors to a particular phase allows concentrating on particular factors at a particular point in time.

Results on research on the current situation showed that no distinction is made between the sales process and the development process, making it impossible to relate it to the three-phase process of the ideal situation. Looking at the individual factors of knowledge management shows that also no distinction is made between the different product types or high priority is given to the creation and sharing of knowledge. Main problems lie in the communication, network and understanding of the bigger picture. There are problems with the acquisition of new knowledge, determining proper solutions, two-way communication between departments, redesigning of products, and quickly understanding new products. The current situation lies closer to the ideal situation for the development of standard products than it does to the development of custom products, with the current situation scored ideal on eight out of seventeen factors of knowledge creation and transfer for the development of standard products, while it scored ideal on only four for the development of custom products. Positive, however, was that there is knowledge available and changing the current methods can close the gap.

Based on the factors that need to be improved in order to close the gap between the current and ideal situation a method for the development for standard and custom methods is created. Knowing that with the attraction of a new head of engineering knowledge about prototyping and later stages of product development is available the developed method focuses on the early stages of product development. This five-step method ensures that first the goal or problem for the development of products is determined. Not only does this provide direction, it also shows when the process can be ended and the development of other products can start. Second it provides guidelines to organise (group) creativity sessions that allow

the generation of ideas. For the development of standard products this needs to be done individually, while for the development of custom products it is done in groups. This allows optimal idea generation. Third, the ideas are reduced to a number so a maximum of two ideas can be appointed to the group members. Each group member, or individual in the case of standard products, makes a business model in the fourth step of the method. This business model forces the ideas to become concrete and allows to compare them to current products in the case of standard products and to see the potential in the case of custom products. It also makes it possible to compare the ideas to each other and see which one has the most potential. Comparing and selecting is done in the last step. Here the ideas that have enough potential or are a significant improvement can go through for further development.

An additional benefit of this model is that it can be seen as a type of stage-gate model. This allows evaluating different stages of the development of products, but also deadlines can be given for individual stages making sure that progress is made. Currently no deadlines are given; with as result that often development gets overruled by the daily routines.

Concluding remarks of this research are that although the current situation is far from ideal, products can be developed with the current knowledge available and the suggested methods provided. This means that Grisnich should be able to create and transfer knowledge better in order to develop products more efficiently.

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1. Introduction

Knowledge plays an important role in today's competitive environment (Grant, 1996). It is created and exchanged to develop new products and services. Not all products and services are the same so the need for creation and transfer of knowledge differs. Grisnich, the company for which this research is done, is a machine manufacturer and has standard products and custom products. Standard products are products that have been made before and only need a few adjustments before they can be produced. It are products with just a single purpose. For example, in the potato sorting chain, the unloading of the boxes in which the potatoes arrive. Custom products on the other hand are made according to customer specifications and require a lot of engineering before production can start. Both of these product types are placed in (new) installations that require the development of (a part of) the logistics of the potato sorting chain as well as redesigning some standard products within the whole layout. To be able to develop these different product types knowledge creation and knowledge transfer are needed. The question is do these two types of products require the same creation and exchange of knowledge? In other words how should knowledge be created and transferred for different product types? This thesis will try to answer this question.

1.1 Company Description

Grisnich is a machine manufacturer founded in 1963. The first products where silo storages for the cattle and poultry industry, soon followed by transport belts for the onion and potato industry. In 1989 Berend Grisnich became the successor of his father by becoming the new CEO of the company. Under his supervision telescopic transport belts and book sorting systems where developed. In 2008 Tolsma Beheer B.V. acquires Grisnich and the activities are reorganized in three core activities. These activities concern the making of machinery and installations for: sorting potatoes, loading and unloading of goods and book sorting. Developing machinery and installations for sorting potatoes still is the main activity of Grisnich.

Currently, 53 people are working at Grisnich and an organisational change is taking place. Since 2008 Grisnich is no longer a family owned business, a management team leads the company. The desire of the management team is to focus more on product development and innovation. The engineering department provides the ideas for product development, or designs them according to customer specifications (given by the sales department). According to the management team there is a lack of structure for the development of new products; ideas are available but not communicated enough through the company.

Grisnich's main activities lie in the food-processing sector, which is often categorized as a low-tech industry (Tunzelmann & Acha, 2005). In the current situation no state-of-the-art technology is used, potatoes are sorted using sieves. On the contrary, the competition uses optical technology for sorting potatoes. All products manufactured at Grisnich at the moment are custom build; the industry however experiences a development towards standardized products. The products can be categorized into 'standard' products and new installations.

- Standard products; are products which are designed for a single purpose. They consist of a single machine designed to do a single task, for example sorting potatoes. This does not mean that it can be mass, or even batch produced. In the case of the potato-sorting machine, for example, the customer has the choice of determining the sorting size (this means that the customer can actually say: I would like a sorting size of x mm). The standard machines almost always have to be placed in an existing location, meaning they have to be adapted to the available space. Not only are the physical dimensions concerned with this, also the place of the operation panel can change with every single machine. This means that even though it are standard products they still require engineering work. At the moment the designs of the standard machinery are becoming more modular so the engineering work can be minimized, but this is far from completion. Because standard products are adapted almost every time they are sold they have experienced continues improvements, and are expected to be flawless.

- New installations; are products that involve more of the entire chain of potato processing, for example from the delivery truck to the cutting machine for making French fries. During this process the potatoes have to be unloaded, sometimes stored, washed, sorted, and transported to the cutting machine. This means that installations have to be designed to serve several purposes, as well as efficient logistics. New installations, like standard products, often have to be fitted into the available space or be connected to existing lines of production. This means that the machinery used is never the same. Not only do these kinds of products require the engineering of the individual machinery, but also the creation of the logistics. This brings constraints to the use of transport belts that often have to be redesigned as well. Since these installations cover several purposes and are connected to other parts of the production process, cooperation with other suppliers is no exception with this kind of products. The time span for the development of this kind of products is obviously longer than of standard products.

To sum up, standard products are parts of installations and need only minor modifications before they can be produced. New installations require designing a new installation or the expansion of a current installation. Apart from the individual standard products designing a new installation also requires designing the logistics. Both product types can be made according to customer specifications. This means that Grisnich manufactures a range of standard and custom products that can be applied in an installation.

1.2 Problem Analysis

According to the management, the main problem lies in the development of new products. For the development of a product, one person is assigned to a project, which varies from a standard product to a complete installation. Deliberation takes place but mainly persons are working individually on a project. No master drawings are available, so each time a new project starts an old drawing is used as a starting point. A file system of photos of previous (completed) projects is available, but engineers are free to design solutions on their own. Working with this method and having to redesign products causes problems as indicated by the three examples below.

Before a new installation can be sold it has to be sketched. The development of a sketch involves the designing of the logistics and creation of an overview of the work involved in the total project. This together with an estimation of the price is called an offer. A lot of work is involved in making these offers and this consumes time of the engineering department. Since this is part of the development of a new installation the making of an offer is included in the development of a new installation. The downfall of making an offer is that it requires time of the engineering department and no money is made during the making of an offer.

Having one person assigned to a project and not making money while sketching the offer is not only time consuming, it also can lead to other problems. For example, having only one person making the offer has led to situations where obvious solutions are overlooked. At one particular project the aim was to minimize the number mobile transport belts needed in different setups. When the fourteenth version of the concept was presented to the customer he suggested why the mobile transport belts were not re-used in different situations this reduced the total amount of belts needed by one (at a cost of €50,000 per belt).

Currently, all products have to be redesigned even if they are seen as standard products, or the product is produced several times in the past. It seems that all products require a lot of work even if it is a standard product. Drawings have to be redesigned each time a product is sold. This means that standard products are not standard at all. A consequence of having to redesign everything is that products are often more expensive than the competitors. Customers have mentioned this several times.

From these three examples it seems that the classification of standard products and custom products seems difficult to maintain in practice. Basically all products require engineering so there are no real standard products. Currently the development of new products has come to a standstill, because engineers are busy designing existing products or are making offers.

Knowledge is the most important resource for the development of products (Kogut & Zander, 1992; Grant, 1996). So, knowledge should be used for activities where it can contribute the most. This means that the engineering department should use their knowledge for the development of new products. The problem, that becomes clear from the examples above, is that there is not enough time available for the development of new products because all the time is consumed for redesigning existing products or making offers. This leads to the question is knowledge not available, or is it used incorrect?

In the engineering department a lot of experience is present, with employees working there for over 15 years. They possess a lot of knowledge, but communicate very little to each other about it. Individuals' knowledge is seen as important, but also as something that makes an individual irreplaceable. As a consequence interaction only takes place when direct questions are asked. Having so much knowledge also temps to look in the past for solutions thereby slowing down the development of new knowledge. But, since knowledge is available there has to be a way in which this can be exploited. Therefore, a solution for the problem needs to be sought in the field of knowledge management. Knowledge management is concerned with the recognition, creation, transformation and distribution of knowledge (Gold, Malhotra, & Segars, 2001). Looking at the examples given above, especially knowledge creation and distribution are important. They can support the development of new products by making knowledge available to all the employees and support the creation of new knowledge by making it easier to combine existing knowledge (Smith, Collins, & Clark, 2005). Therefore knowledge creation and knowledge transfer are the focus areas in which the solutions are sought.

1.3 Research Objective

A solution for the problem should result in less time spent on the development of new products and thereby a more efficient development process. A lot of time is lost in the beginning of the development process (with making orders or redesigning products). By looking into the fields of knowledge creation and knowledge transfer an answer to this problem is sought.

1.3.1 Research Goal

The goal of this research is:

> *To provide recommendations on the creation and transfer of knowledge between individuals and departments to reduce the time required in the development process of different product types.*

With these recommendations Grisnich should be able to develop products faster and introduce a method for the creation and transfer of knowledge. The research will also result in recommendations of how to deal with the different product types and the amount of knowledge creation and transfer they require.

1.3.2 Relevance of the Research

This study is relevant because it provides the management of Grisnich more insight into the fields of knowledge creation and knowledge transfer that is currently not present. Findings of this study contribute to the understanding of the development process of Grisnich because they provide guidelines for integrating knowledge creation and knowledge transfer methods into the current development process. It also tries to add to the understanding of knowledge creation and knowledge transfer theory by performing empirical research on the topic. Currently knowledge creation and knowledge transfer are often seen as two separate theories (e.g. Ko, Kirsch, & King, 2005; Smith et al., 2005), are often explained according to important factors (Smith et al., 2005; Szulanski, 1996), and are seen as separate business processes (that often require IT support). On top of that the distinction between standard and custom products and their relation to the creation and transfer of knowledge has also not been explored extensively in the scientific literature. This research combines the fields of knowledge creation and knowledge transfer for the development of different product types and tries to fill the gap currently present by linking theories of the development of standard and custom products to knowledge creation and knowledge transfer. The goal is to incorporate knowledge creation and knowledge transfer theories into the current business processes. The novelty factor lies in the combination of insights from different

knowledge management fields and the practically applicable framework that results from the analysis. This is currently not present in the literature. This makes this thesis interesting from a scientific point of view.

1.4 Research Questions

The goal of this research is to provide recommendations about the creation and transfer of knowledge for different product types, in particular at the engineering department of Grisnich. This results in the central question:

> *How should knowledge for the development of standard and custom products be created and transferred at the engineering department of Grisnich to optimise the development process?*

Definitions:

- Different product types; refers to the different products that Grisnich produces, these products are categorised as standard products or custom products.
- Knowledge creation; '[the extent to which individuals within the company] are capable of combining information and knowledge into new knowledge, and perceive value from the exchange and combination process' (Smith et al., 2005, p. 347). For this thesis knowledge creation is the generation of new ideas and ability to solve problems by creating new solutions.
- Knowledge transfer; the exchange of useful knowledge between individuals (Levin & Cross, 2004). For this thesis knowledge transfer is the exchange of knowledge from previous projects into new ones. This can be interpersonal or from existing knowledge bases.
- Optimization; given the nature of the problem optimization is consuming the least amount of time and finding a balance between the development of the different product types.
- Development process; process of designing a new solution for the customer.

Additional insight in how creation and transfer of knowledge for the development of different product types can be done is needed to provide recommendations. This central question helps to gain this insight.

Key terms of the central question are knowledge creation, knowledge transfer and (perhaps less explicitly) finding a balance in the development of different product types. The central question is concerned with how knowledge should be created and transferred (an ideal situation). This implies that the current situation and how to get from the current situation to the ideal situation also should be researched. Also the classification of the product types is important. Currently no distinction is made during the development of the product types. The first research question is concerned with determining the ideal situation for each of the product types:

1. *How should, from a theoretical perspective, knowledge be created and transferred for standard and custom products to optimise the development process?*

Theory can provide insight in how to create and transfer knowledge ideally. Therefore, the ideal situation is determined according to criteria derived from theory. These criteria are then used to analyse the current situation. Resulting in the research question:

2. *How is knowledge currently created and transferred for standard and custom products at the engineering department of Grisnich?*

The differences between the current and the ideal situation provide a base for the recommendations of how to create and transfer knowledge at the engineering department of Grisnich. To provide good

recommendations one must know how to get from the current to the ideal situation. Resulting in the last research question:

3. *What is needed to go from the current situation of knowledge creation and transfer for standard and custom products to the ideal situation of knowledge creation and transfer for standard and custom products?*

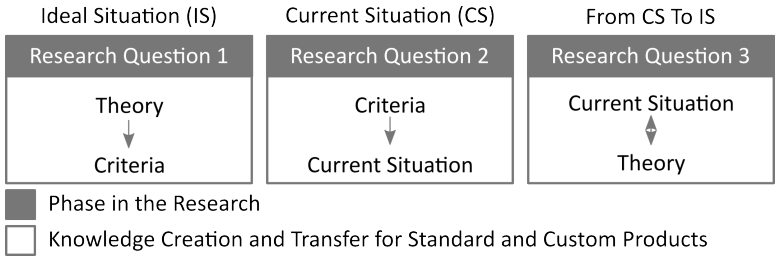


Figure 1 - Research Questions and Outline

In Figure 1 the three-phase process of this research is displayed. Each of the three phases is concerned with a research question indicated by the grey rectangle. The adjacent white rectangles display the step that is taken to answer the research question of that phase. All research questions take into consideration standard and custom products and are concerned with the creation and transfer of knowledge.

1.5 Research Strategy

As said, Figure 1 displays the steps taken in this research. First, the ideal situation is determined by deriving criteria from theory. Second, the criteria from the theory of knowledge creation and transfer are used to analyse the current situation. Finally, the comparison of the current situation and the theory is made to provide recommendations about the creation and transfer of knowledge for standard and custom products.

1.5.1 Type of research

This thesis is a formal, descriptive study (Cooper & Schindler, 2006); its goal is to answer the central question stated earlier. Because a model for the development of different product types is made this study also has design characteristics (Verschuren & Doorewaard, 2005). It tries to find out how knowledge creation and transfer differ between standard and custom products at Grisnich to make the development of products less time consuming. In doing so it is a cross-sectional study in order to provide a snapshot in time (Cooper & Schindler, 2006). Execution of the research will take place at the location of Grisnich and researches a practical question using empirical data (see section 1.5.2 for data collection methods). The research can be categorised as a single case study (Verschuren & Doorewaard, 2005). It tries to do an in-depth analysis on the particular situation of Grisnich and combines theory with practical data.

1.5.2 Data collection and results

The research can be divided into three phases (see Figure 1). For the first phase a theoretical framework is needed to look at knowledge creation and transfer. This framework has to explain how to create and transfer knowledge and has to consist of criteria that can be used to analyse the current situation in the second phase of the research. The theoretical framework is constructed from the analysis of relevant literature concerning knowledge creation and transfer, knowledge management, and problem solving.

The second phase of the research determines the current situation. By doing in-depth interviews, conducting a questionnaire and analysing previously completed projects data is gathered. Combining and analysing these three forms of data allows creating a complete understanding of the current situation of knowledge creation and transfer. The result of this phase of the research is an overview of the current situation of knowledge creation and transfer based on the criteria established earlier.

The last phase of the research is an analysis of the differences between the current situation and the theoretical ideal situation. The goal of this analysis is to determine the differences and provide recommendations on how to solve the differences. By minimizing the differences the current situation will come closer to the ideal situation improving the knowledge creation and transfer practices of the engineering department of Grisnich. This phase should result in a practical method for the creation and transfer of knowledge for the development of standard and custom products.

1.6 Outline of this Thesis

Throughout this chapter the research objectives, questions and methods are introduced. The next chapter provides the theoretical framework to explore the research questions. It forms the perspective of how to look at the problem at hand. Chapter 3 elaborates on the methodology of the research. This chapter explains the method for data collection, data analysis, and structure and methods of the research. Chapter 4 displays the results of the research based upon the theoretical framework and the data collection. Chapter 5 contains the analysis of the differences between the current and ideal situation and a method for minimizing these differences. Finally, chapter 6 is the conclusion of this thesis, which will consist of the concluding remarks of the research and the limitations of it.

2 Theoretical Framework

This chapter forms the theoretical framework that will function as the perspective to look at the research questions of this thesis. The theoretical framework consists of criteria and a process description for the creation and transfer of knowledge for different product types. Before these criteria can be established the fields of knowledge creation and knowledge transfer are explored. Important for the theoretical framework is the difference of knowledge creation and transfer of standard and custom products and the setting in which they have to be managed.

2.1 Introduction of Key Concepts

Creation and transfer of knowledge for different product types is the focus point of this thesis. Different product types are standard and custom products in this case. They seem contradicting to each other at this point, introducing them should provide a better understanding why this is the case. First, the concept of knowledge is introduced.

- Knowledge; and information are often used interchangeably, but are not the same. Knowledge is created and organized by the flow of information (Nonaka, 1994), in other words: information becomes knowledge when it is processed in the minds of individuals (Alavi & Leidner, 2001). Knowledge exists in two different forms, tacit and explicit knowledge (e.g. Nonaka, 1994). Explicit knowledge is characterized by the way it is expressed. It is knowledge in written form, meaning hard data, scientific formulas, patents, documents, manuals, etc. On the contrary tacit knowledge is mainly people-bound (e.g. know-how) and difficult to formalize (Nonaka, 1994; uit Beijerse, 2000). The conversion of these two kinds of knowledge is believed to be the core of knowledge creation (Nonaka, 1994; Nonaka & Takeuchi, 1995). Knowledge creation is further explored in section 2.2. The distinction between tacit and explicit knowledge is important because of the transferability of the two. Tacit knowledge is embedded into the minds of individuals and cannot be transferred as a separate entity. Explicit knowledge, on the other hand, has the character of a public good (Osterloh & Frey, 2000). The transfer of knowledge is explored in section 2.3.

- Standard products; are already introduced (see section 1.1), but not from a theoretical perspective. Standard products are related to the term standardisation. Standardisation refers to the homogeneity of products, components or processes (Ulrich, 1995). Standard products are seen as being homogeneous, in the sense that they can be produced multiple times for different customers. Scholars claim (e.g. Farrell & Saloner, 1985) that benefits from standardisation come from economies of scale. This indicates that standard products have to be mass, or at least batch produced to be beneficial. Standard products are also related to routine based work (Kelly & Littman, 2004). This means that the development of standard products often is done with routines known to the company. Focus points are often efficiency and low costs (Ulrich, 1995). Standardisation begins with the standardisation of the design (Lampel & Mintzberg, 1996).

- Custom products; customization refers to the early involvement of the wishes of the client in the development of the product (Duray, 2002). This means that products are adapted and manufactured according to the wishes of individual customers. Batch or mass production for this type of product is relatively rare. The development of custom products often involves more knowledge creation since a product has to be created according to the wishes of the customers (Lampel & Mintzberg, 1996). Wishes are often not specific enough to directly develop a product, so knowledge has to be created.

Basically standard and custom products can be seen as opposite products, where one is focused on efficiency and low costs, while the other focuses on transforming the wishes of the customer into a product. Often modularity is seen as a way to combine the two.

2.2 Knowledge Creation

The creation of new knowledge is essential for companies in a competitive environment (Kogut & Zander, 1992). The capability of a company to create knowledge is defined by Smith et al. (2005) as the extent to which individuals have access to one another, are capable of combining information and knowledge into new knowledge, and perceive value from that process. In this sense combining refers 'to the process of bringing together elements previously unconnected or by developing new way of combining elements previously associated' (Smith et al., 2005, p. 347). And new knowledge refers to 'discoveries about phenomena that were not known previously' (McFadyen & Cannella, Jr., 2004, p. 735). Thus knowledge creation is the development of new knowledge by the process of combining previously known knowledge.

Smith et al. (2005) suggest three categories of organisational resources that impact the capability to create knowledge, (1) stocks of individual knowledge, (2) networks of key employees, and (3) organisational routines and processes. These three resources combined define how well a company can create knowledge.

2.2.1 Knowledge Stock

The ability to create knowledge depends on the existing knowledge (Cohen & Levinthal, 1990; Smith et al., 2005). Existing knowledge can also be used by the management to determine a strategy (Nonaka, Toyama, & Konno, 2000). Therefore insight into the available knowledge is needed. The existing knowledge can be seen as a knowledge stock. This stock of knowledge is determined by using three factors: (1) experience, (2) formal education, and (3) knowledge diversity (Smith et al., 2005). The factors create an overview of the existing knowledge.

Experience

Experience is important, because new skills are more quickly learned if they share elements with the already acquired knowledge (Kogut & Zander, 1995). If one has extensive experience in an industry one will possess high amounts of tacit knowledge that can be brought in for the creation of new knowledge (Nonaka et al., 2000). So, the higher the experience the more an individual has to bring to the creation of knowledge (Smith et al., 2005). Studies in other fields have also highlighted the importance of industry experience (Wright & Wright, 2008). They stated the importance of industry experience by identifying frequently occurring error types and contributions to decisions. People with more experience tend to make fewer errors. Experience can also work against one, when one is so confident and only looks insight for new knowledge. The phenomenon is known as myopia (Wuyts, Colombo, Dutta, & Nooteboom, 2005).

Relating this to the different product types of Grisnich means that experience is beneficial for the development of standard products. Experience of an individual can be used to fast remember previous projects and solutions from them. Since standard products are made more often the room for error is less. Experience can be beneficial in this case (Wright & Wright, 2008), because it results in an efficient determination of a new solution. On top of that standard products are often created using organisational routines, which means that experience also has benefits. For the development of custom products the point of Wuyts et al. (2005) has to be considered as well. It is true that experience makes sure that a lot of tacit knowledge can be brought in for the creation of new knowledge (Smith et al, 2005), but it can also mean that solutions are sought in the same direction. This can be good, but sometimes it is not. So for the development of custom products having a lot of experience can be positive as well as negative.

Formal Education

Education helps to improve one's understanding, it provides new explicit information and knowledge (Smith et al., 2005). Education also gives an indication about the cognitive capabilities of individuals (Wuyts et al., 2005). These cognitive capabilities refer to the amount of information or knowledge a person is able to understand and has an influence on the ability of that person to create knowledge (Smith et al., 2005). The more a person knows, or is able to absorb the more (s)he is able to share, thereby creating knowledge for others.

Having high cognitive capabilities is also good when having to absorb a lot of new knowledge (Wuyts et al., 2005). When developing custom products a lot of new knowledge needs to be absorbed, for example, the constraints of the location, previous installations, and cooperation with other suppliers of the production chain. On top of that the custom product has to be designed, so having a high level of formal education (and thereby a high ability to understand) helps to encounter these problems. Of course education is also important for the development of standard products, but it is less crucial. Since a lot of knowledge can be gathered from previous projects education does not add that much as it does when developing a new installation. Routines, for example, can also be learned by doing, meaning theoretical knowledge is less vital (Nonaka & Takeuchi, 1995). So, formal education is beneficial for the development of custom products, but not necessarily required for the development of standard products.

Knowledge Diversity

Although the knowledge of organisational members can be expressed in the two factors above, the diversity of knowledge within a group (e.g. a company) can influence the capability to create knowledge (Smith et al., 2005). A group of people with similar backgrounds is less likely to think of a solution not related to their individual background. But, a group of people with different backgrounds is more likely to come up with a solution not similar to their individual background thereby creating knowledge. Other scholars support this statement indicating the importance of multidisciplinary teams (e.g. Cohen & Levinthal, 1990; Nonaka et al., 2000). There has to be an overlap in knowledge however, because otherwise time is wasted trying to understand each other. A theoretical optimum can be achieved between understanding and novelty of knowledge indicated by the optimal cognitive distance (Wuyts et al., 2005).

Relating this to the product types of Grisnich means that for the development of standard products knowledge diversity is not necessarily needed. Because the products are relatively standard solutions can be sought within that knowledge domain. If, however, custom products need to be developed knowledge diversity is desirable. Because of this knowledge diversity the possibility to create a novel solution are higher due to the different knowledge backgrounds of the individuals (Smith et al., 2005). This means that custom products require knowledge diversity, while for standard products it is not necessarily needed.

2.2.2 Knowledge Networks

Networks can be looked upon from multiple perspectives, from an organisational perspective or an individual perspective for example. For this thesis networks are looked upon from the perspective of the individual. This is done, because knowledge originates in the minds of individuals (Nonaka, 1994). Nobody's knowledge is the same, one person knows more than the other. This means that key knowledge employees (the ones that have a high knowledge stock) can be identified. These employees are valuable for the creation of knowledge (Chen & Edgington, 2005; Smith et al., 2005). Not only the identification of the key persons within a company is important, but also the business relations they possess (McFadyen & Cannella Jr., 2004). Key persons need to be highlighted, because they can provide insight into the knowledge of the company and can provide more information about the possibilities of knowledge creation (Smith et al., 2005). On top of that the networks these individuals possess have a major impact on the knowledge creation capabilities of a company (Smith et al., 2005).

Networks play an important role, because networks allow combining and sharing of knowledge and through networks knowledge becomes 'official'. Knowledge creation requires that network members engage in discussions (McFadyen & Cannella, Jr., 2004). Looking at the network itself, there are three factors that determine the 'strength' of the network; (1) number of direct contacts, (2) network range, and (3) strength of the network ties (Smith et al., 2005).

Number of Direct Contacts

Social capital includes the relationships between individuals and the resources embedded in these relationships (McFadyen & Cannella, Jr., 2004). A common measurement for measuring ones social relations is the number of directs contacts to which one is connected (Smith et al., 2005). This number of

direct contacts is relevant, because the creation of knowledge benefits from having a large number of contacts. However, a nuance is in place, if the number of contacts rises the amount of time available to spend on each relation becomes less. McFadyen and Cannella Jr. (2004) argue that the number of relations and the effect on knowledge creation is not strictly linear, but has an optimal at some point. It is key to manage the number of direct contacts so that knowledge creation can be optimal.

Relating the benefit of number of direct contacts to the different product types of Grisnich is difficult, because the benefit often comes from the network range (Smith et al., 2005). Network range is concerned with knowledge diversity, while the number of direct contacts is not. Having said this means that the number of direct contacts has a positive effect for the development of standard products. The diversity of knowledge is not important for the development of these products (see section 2.2.1); therefore having a large pool of knowledge available has a positive effect. For custom products a large number of direct contacts also means a large knowledge pool to receive knowledge from. But this does not have to be positive, since the effect on the creation of knowledge is not linear (McFadyen & Cannella, Jr., 2004). It is therefore acceptable to state that a large number of direct contacts has no positive or negative effect for the development of custom products.

Network Range

Smith et al. (2005) define the network range as the scope of different types of contacts contained in a person's network. It is comparable with the diversity of knowledge at individual level. Diversity of knowledge is beneficial for knowledge creation (Nonaka & Takeuchi, 1995), so is the network range. Organisations should avoid the risk of myopia, meaning that they only look inside for new knowledge (Wuyts et al., 2005). To compensate for this, inter-organisational contacts are necessary.

In section 2.2.1 knowledge diversity showed to have a positive effect on the creation of new ideas and thereby on the development of custom products. A broad network range can be seen as having a large diversity of knowledge available, meaning a positive effect on the development of custom products. On top of that it also ensures that myopia is avoided. For the development of standard products the main resource is the previous projects completed. The risk of myopia there is high. Having a broad network range means that one has a large knowledge pool to derive a solution from. In the case of custom products this is important, but for standard products this does not have to be. The knowledge about standard products is high internally. If one is aware of the consequences of myopia the network range has no positive or negative effect on the development of standard products.

Strength of Network Ties

A Relationship between individuals takes time to develop, as wells as the creation of knowledge from that relationship. The strength of a tie refers to the nature of the relationship, with closeness, long duration, and frequent contact characteristics of a strong tie (Smith et al., 2005). Strong ties are more likely to share valuable information and cooperate for mutual benefits (Smith et al., 2005). But that is not the only benefit of strong ties; they also provide more efficient exchanges of knowledge (McFadyen & Cannella, Jr., 2004). There is a downfall to this, because when ties become stronger and knowledge is exchanged more often the cognitive distance becomes smaller so as the novelty value of knowledge, allowing less exchange (Wuyts et al., 2005). McFadyen and Cannella Jr. (2004) argue an optimal strength for the creation of knowledge.

Standard products require fast development. As stated earlier, knowledge diversity is not necessarily needed; efficient exchange of knowledge is needed though. Strong ties are said to provide efficient exchanges of knowledge (McFadyen & Cannella, Jr., 2004). Efficient exchange of knowledge contributes to getting fast development. Therefore, strong ties are beneficial for standard products. For custom products, strong ties can be beneficial as well. The development of a custom product requires a lot of engineering and often cooperation with other suppliers. Since strong ties are more likely to share valuable information (Smith et al., 2005) they are more likely to contribute to finding a valuable solution. Having strong ties will

also help to seek for new knowledge, since one is also more likely to share valuable information to others. Thus, strong ties are also beneficial for the development of custom products.

Position in the network

The network can be looked upon from different perspectives (Zaheer & Bell, 2005). Since this research focuses on internal knowledge creation and transfer practices the perspective to look at the network will be at the individual level. The position of a company in a network is related to the innovation capacity of that company (Ahuja, 2000). The same logic can be applied on individuals. A network consists of three aspects, direct ties, indirect ties and structural holes. Figure 2 and the explanatory example afterwards are adapted from Ahuja (2000). Ahuja's (2000) original example was based on organisational level, while the example shown below is on individual level. The principle behind the direct ties, indirect ties and structural holes is the same on both levels of analysis.

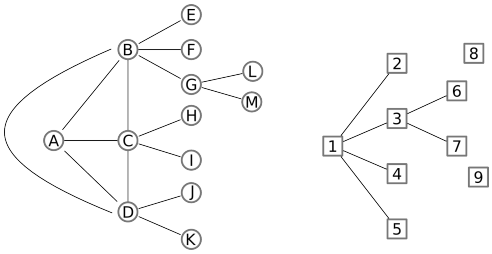


Figure 2 - Network Structures (Ahuja, 2000)

Direct ties are direct contacts between partners; in Figure 2 Actor A is directly connected to B, C, and D so Actor A has three direct ties. Actor A also has nine (E though M) indirect ties. These are ties connected to the direct ties of Actor A. Although not directly connected to Actor A, Actor A can extract knowledge from actors E through M via their direct contacts. Gulati and Garguilo (1999) explain this as the power of indirect ties in a network (in: Ahuja, 2000). Actors A through D form a closed network, because they are all linked to each other. Actor 1 has more direct ties (four) but less indirect ties (two). Actors 1 through 5 are not all linked to each other and therefore defined as an open network. The missing links between companies 2 and 3, or 3 and 4 are called structural holes.

Relating this to different product types and what is said earlier (the number of direct contacts is already explored as well as the range and strength of ties) it is interesting to know what kind of network is beneficial for a particular product type. In the paragraph above the distinction is made between closed and open networks, with one having structural holes and the other not. So basically structural holes are the discriminating factor to relate the possible benefits for the development of different products too. The literature on structural holes is divided on the benefits they have on the innovation process. Some scholars claim that they are beneficial (e.g. Burt, 1992), while others claim they do not show direct beneficial effects (e.g. Walker, Kogut, & Shan, 1997). Ahuja (2000) provides an interesting conclusion for clarifying this matter. His findings on structural holes suggest that the impact of structural holes can only be understood relative to a particular context. When developing a collaborative environment and overcoming opportunism are essential, closed networks are likely to be more beneficial, while if speedy access to diverse information is essential, structural holes (open networks) are likely to be advantageous. This is supported by a later study of Zaheer and Bell (2005) who state that individual actors bridging structural holes have shown to improve organisational performance.

For the development of standard products it is beneficial to have a large number of direct contacts, as well as strong ties. Although speedy access to information is needed, it does not necessarily need to be diverse knowledge. Structural holes are likely to provide access to novel knowledge (Zaheer & Bell, 2005) this is not necessarily needed for the development of standard products (Smith et al., 2005). Having this in mind structural holes will be less beneficial for the development of standard products. For the development of custom products on the other hand, structural holes are important, because they allow accessing novel

knowledge. This would mean that an open network is important for the development of custom products, meaning that structural holes are needed for the development of custom products. So, taking together the development of both product types this means that no single network is best for the development, but structural holes are important for the development of custom products and can be beneficial for the development of standard products.

2.2.3 Organisational Routines and Processes

Organisational routines and processes define how a company develops and uses knowledge. It also provides insight in what processes the company currently uses to create knowledge. Knowledge is embedded in organisational routines and processes (Nonaka & Takeuchi, 1995). Determining the priority of projects or methods for solving problems are examples of organisational routines and processes where knowledge is embedded in. Two aspects of these organisational routines and processes are the climate for risk taking and the climate for teamwork (Smith et al., 2005).

Climate for Teamwork

Norms for cooperation, combination and exchange of knowledge are important for knowledge creation. The atmosphere of cooperation opens access among group members and creates motivation for knowledge exchange (Smith et al., 2005). Motivation plays a role in the creation (Smith et al., 2005), but also for the transfer (see section 2.3.2) of knowledge (Osterloh & Frey, 2000). On top of that many scholars indicate the benefits of multi-disciplinary teams (e.g. Cohen & Levinthal, 1990), were persons with different backgrounds (thereby different kinds of knowledge) together solve problems.

Teams are more likely to create a virtuous circle (Kelley & Littman, 2004). These circles can be permanent or semi-permanent (Anderson & West, 1998). When working in a team people get motivated from each other and so are capable of getting the best out of themselves. On top of that having teams working on different projects can create some kind of competition (Kelley & Littman, 2004). While there are scholars indicating the positive and negative effects of competition on the development of products (e.g. Tsai, 2002), it is commonly accepted that one would like to belong to the team that wins (Kelley & Littman, 2004).

Teamwork can have advantages for the development of complex products (Kelly & Littman, 2004). Individual team members can motivate others and as said before having a greater knowledge diversity and knowledge pool to start with is beneficial for the creation of knowledge, especially for the development of custom products. Therefore, a climate for teamwork is positive for the creation of custom products. For the development of standard products, teamwork does not necessarily have to be beneficial. When cooperating in a team, a consensus has to be reached (Stasson, Kameda, Parks, Zimmerman, & Davis, 1991). Since standard products have been developed in the past, this consensus about the optimal design has been reached in the past, there does not have to be a team to efficiently find a solution. Therefore, a climate for teamwork is not necessarily positive for developing standard products.

Climate for Risk Taking

The willingness to experiment and develop new ideas is needed for knowledge creation to occur. A climate that supports these factors will encourage the sharing of knowledge (Smith et al., 2005). Risk taking can be seen as the tolerance of uncertainty in an organisation (Millar & Friesen, 1982). Allowing risk taking also stimulates the creativity of individuals (Kelley & Littman, 2004). Creativity is important to develop new things, but also helps to be efficient (Soo, Midgley, & Devinney, 2002).

Risk taking is needed when developing new things, because not everything is known upfront. When developing custom products not everything is known upfront, so a climate that supports risk taking is beneficial (Kelley & Littman, 2004). Standard products are based on best practices from the past and often have a long history of continues improvement. This means that risk taking plays a smaller role and is not necessary required. So for the development of standard products a risk-taking environment is not needed.

Looking at the creation and transfer of knowledge, not only the climate is important, the knowledge processes in an organisation also influences the development of products (Nonaka & Takeuchi, 1995). Since a lot of knowledge is embedded in these processes it is interesting to look at what the effect of the past is on these processes and how knowledge from the past is used in today's processes. Looking into the concept of organisational memory will do this.

Organisational Memory

As said before knowledge originates in the minds of individuals. This means that individuals acquire knowledge by themselves and are able to use this in problem-solving or decision-making activities (Walsh & Ungson, 1991). The knowledge that they use can be either codified (explicit) or tacit. Going deeper into these forms of knowledge four (complementary) types of knowledge can be distinguished. First, know-what knowledge that refers to facts, this type of knowledge lies close to information. Second, know-why knowledge that refers to scientific knowledge of principles and laws, useful for technological development in certain areas. Third, know-how (i.e. the capability to do something) refers to skills or procedures, useful for production activities. Fourth, know-who refers to information about who knows what and social skills (Lundvall & Nielsen, 2007). All these types of knowledge are included into the organisational memory.

When individuals engage in problem-solving or decision-making activities knowledge gets interchanged (see section 2.3 for an elaboration on the exchange of knowledge) and thereby transcends the individual. This is true for all four types of knowledge and it allows knowledge to stay in the company when employees leave. Organisational memory consists of three main factors, (1) acquisition of knowledge, (2) retention, and (3) retrieval (Walsh & Ungson, 1991).

- Acquisition of knowledge; before knowledge can become organisational memory is has to be acquired first. The acquisition of knowledge is mainly done for and during two activities, the making of decisions and the solving of problems. During these activities two things happen, individuals get triggered by and response to the problem or decision at hand. Because it is the individuals that get triggered knowledge does not necessarily gets stored centrally in the organisation, this means that organisational memory also is not stored centrally. But how does organisational memory differs from memory of individual and how does it stay in the organisation when employees leave? This is done during the second activity and that is the response. During the response so called cognitive heuristics are created (i.e. methods for dealing with a particular situation are developed). Because of the creation of these methods knowledge becomes part of the organisation and surpasses the individual memory (Walsh & Ungson, 1991).

- Retention; building on what is said earlier, organisational memory is not stored in one single location. Walsh and Ungson (1991) have made a literature review on the 'storage bins' of organisational memory (i.e. places where knowledge gets stored) and found six places of knowledge storage. The first one is (obviously) the individual, they store knowledge based on their direct experience and observations. Second, the culture of the organisation determines how and what kind of knowledge gets stored. This can happen, for example, through the telling of stories, use of symbols or in the language used. The third place where knowledge can get stored is in transformations. Through transformations (the processing of raw materials to finished products, or a new recruit that becomes a veteran over the years) knowledge is embodied. Some scholars (e.g. Perrow, 1976) argue that these kinds of transformations determine, for example, the technology used by the company (in: Walsh & Ungson, 1991). Fourth, the organisational structure determines how individuals behave and what they expect. The structure reflects the organisational rules and thereby influences the organisational memory. Fifth, the ecology (i.e. the physical setting) influences the experience the individuals have and thereby influences the organisational memory. Scholars have indicated that the physical design of, for example, the office interior influences the reaction of, for example, visitors (e.g. Kelley & Littman, 2004). This can in its turn influence the organisational memory. Sixth and last, external archives influence the organisational memory. Sometimes it is not possible for individuals to track all the events that took place within the company, but a customer or partner could mention actions from

the past and thereby contribute to the organisational memory. This means that external archives also need to be included as a storage bin for organisational memory (Walsh & Ungson, 1991).

- Retrieval; of knowledge can automatically take place or be controlled. These are the two extremes that from a continuum of knowledge retrieval. On top of that knowledge retrieval can take place at two levels, the individual level and the organisational level. On the individual level knowledge can be automatically retrieved by following procedures and practices based on previous experiences. In other words, knowledge becomes embedded in the procedures executed. Theses practices are often based on the storage bins explained earlier. On an organisational level the methods for knowledge retrieval work more or less the same as at the individual level. The main difference lies with the controlled or automatic situations. If knowledge is automatically retrieved it is done by applying standard methods or procedures. While if it is controlled knowledge systems are used to retrieve, but also store data. The advantage of these kinds of knowledge systems is that knowledge can be stored without previous decisions made on the matter (Walsh & Ungson, 1991).

Organisational memory plays several roles within organisations. First it plays an informational role, by the ability to contribute to the decision-making process. Second it fulfils a control function, by reducing the transaction costs often associated with an implementation of a new decision. Third it can play a political role, because control of sources of knowledge creates dependence with which individuals in power are able to influence the actions of others. Organisational memory can also be misused in three contexts: (1) automatic retrieval can lead to a routine response where a non-routine response is desirable, (2) controlled retrieval can contribute to a non-routine response where a routine decision would have been appropriate, and (3) a controlled retrieval process may be initiated while a non-routine decision needs to be made (Walsh & Ungson, 1991).

Relating this to knowledge creation and transfer for standard and custom products is useful, because the memory of an organisation is closely linked to its ability to use knowledge. For the development of standard products organisational memory can be beneficial. It helps to speed up the development process by having standardized routines and methods for development (know-how). These methods based on best practices from the past (know-what) can contain a lot of knowledge of previously solved problems (Walsh & Ungson, 1991). Not having to 'reinvent the wheel' can be of great benefit and can be captured in organisational memory. For the development of custom products, organisational memory can have negative effects. If a decision is always made in the same way or using only experience from the past it will be difficult to develop radical new things (Kelley & Littman, 2004). It can, however, also have positive effects similar as to the development of standard products, for example with understanding principles behind products (know-why) or which people to contact for collaboration (know-who). This means that it is very important to be aware of the existents of organisational memory and the possible negative effects that it can have, but use it to prevent embarrassing situations to occur. For the development of custom products it has positive as well as negative effects.

With insight in how different factors influence the creation of knowledge for different product types, the first hurdle is overcome. But to create a complete overview of how to manage knowledge for the development of different product types the same has to be done for the transfer of knowledge.

2.3 Knowledge transfer

One can look at the knowledge possessed by individuals as a knowledge reservoir. By doing so, knowledge transfer takes place when knowledge reservoirs are interchanged. This means that individuals are affected by the experience of others. Knowledge transfer can occur, for example, when a person communicates with another person about a practice that (s)he has found to improve performance (Argote & Ingram, 2000). Three factors can be highlighted, a social network (i.e. communication between persons), motivation (one person has to be motivated to learn the other person something), and learning (one person learns something to the other person about improving performance). Ko et al. (2005) have

addressed these factors as being the ones that influence knowledge transfer and will serve as a frame for the analysis of knowledge transfer.

2.3.1 Learning Factors

Learning is an important aspect of knowledge transfer. Three learning factors (earlier identified by Szulanski, 1996) influence the transfer of knowledge. These factors are, (1) the relationship between the source and the recipient of the knowledge, (2) the shared understanding, and (3) the absorptive capacity of the source and recipient of the knowledge (Ko et al., 2005).

Ease of the Relationship

Mostly the creation of knowledge will come from the exchange of knowledge (McFadyen & Cannella, Jr., 2004). The relationship between source and recipient is important for the transfer of knowledge (e.g. Levin & Cross, 2004; Ko et al., 2005). The 'ease of a relationship influences the success of knowledge transfer (Szulanski, 1996). If, for example, the relationship is very distant, knowledge transfer is more difficult than with a very close relationship. People prefer to turn to other people rather than to documents for information, even if they have access to well-populated sources of electronic information. Literature is divided about the role of strong and weak ties play in knowledge transfer. Levin and Cross (2004) state that strong ties are of more benefit to receive useful knowledge, while weak ties are more likely to provide novel information. Others state that the strong ties will have more efficient knowledge transfer due to the fact that their cognitive distance is shorter (Wuyts et al., 2005).

Since tacit knowledge is difficult to transfer (Nonaka, 1994) and trust within a relationship improves the sharing of valuable knowledge (Smith et al., 2005), intimate relationships with persons holding tacit knowledge is important. People holding a lot of tacit knowledge often have high amounts of experience in a certain field. Having said this, intimate relationships are important for the development of standard products. Although weak ties are said to benefit the most novel knowledge, this does not mean that intimate relationships are less important for the development of custom products. This development requires cooperation with different organisations for the completion of the project. Relationships with the organisations involved in this development are thus vital. On top of that strong ties are more likely to share valuable information (Smith et al., 2005), which is helpful for the development of a custom product. So, intimate relationships are important for the development of standard products as well as for the development of custom products.

Shared Understanding

Shared understanding is concerned with work values, norms, problem-solving approaches and prior work experience. Without this shared understanding there can be a tendency for people to disagree about what should be done and why can emerge (Ko et al., 2005). Shared understanding is needed when firms cooperate in projects (Kogut & Zander, 1995) and is concerned with the cognitive distance of one another (Wuyts et al., 2005). There is, as said before, an optimum in the learning curve when the novelty value of knowledge and the shared understanding curves meet each other. In other words, maximum learning is achieved when new knowledge is involved, but it has to be connected to what people know, because otherwise one is not able to understand it or learn from it.

Relating this to the development of custom products is relatively simple. Multiple organisations are involved in the development of a custom product, meaning that shared understanding is vital. For the development of standard products the need to understand different people is not that high. But work values, norms and prior work experience are important for the development of standard products. This means that one has to understand why these aspects are important. On top of that one has to understand the purpose of the machine and the constraints of the place it will work. Not much knowledge needs to be transferred, but a shared understanding of why choices are made in the past is needed for the development of standard products, making a shared understanding also important.

Absorptive Capacity

Absorptive capacity is the ability of an organisation or of people to recognize the importance and value of knowledge and know what to do with it (Cohen and Levinthal, 1990). Absorptive capacity depends largely on the recipient's existing stock of knowledge prior to the transfer (Ko et al., 2005). Being able to understand and know what to do with knowledge is vital in the transfer of knowledge. The higher ones absorptive capacity the more likely one is to understand the received knowledge and be able to do something with it.

For standard products the scope of knowledge that goes into them is relatively limited. This implies that the need of a high absorptive capacity is also limited (Smith et al., 2005). For custom products on the other hand absorptive capacity plays a much bigger role. Knowledge needs to be combined from different fields of knowledge, being able to understand and use this knowledge is needed for a custom product to be developed.

2.3.2 Motivational Factors

Motivational factors influence the transfer of knowledge. Osterloh and Frey (2000) argue even that knowledge transfer is closely connected to motivation. Motivation comes in different types, intrinsic and extrinsic. Intrinsic motivation is needed for tasks that require creativity, while extrinsic motivation is best when repetition tasks need to be performed (Osterloh & Frey, 2000). The lack of sufficient extrinsic and/or intrinsic rewards to compensate individuals for the cost of sharing knowledge is a common barrier to knowledge sharing (Bock, Zmud, & Kim, 2005).

Extrinsic Motivation

People are extrinsically motivated when satisfaction does not lie in the content of the work (Ko et al., 2005). Money often is involved in extrinsic motivation; this is done by linking monetary motives to the goals of the people (Osterloh & Frey, 2000).

For the development of standard products extrinsic motivation is important. Motivation from these products is hard to get from fulfilling a project, because it has been done before. Therefore extrinsic motivation can be a solution to the efficient completion of the development of standard products. Custom products on the other hand should not have to be motivated by monetary means. Satisfaction should arise from the completion of the project itself (Osterloh & Frey, 2000) in the ideal situation. In practice it turns out extrinsic motivation is important as well, but not as much as with repetition tasks.

Intrinsic Motivation

People are intrinsically motivated if their needs are satisfied directly through their work (Ko et al., 2005). Ideally, the incentive system is in the work content itself, which must be satisfactory and fulfilling for the people (Osterloh & Frey, 2000). There are, of course, advantages and disadvantages of intrinsic motivation. Disadvantages of intrinsic motivation are the ability to change the motivation and undesirable content. Changing intrinsic motivation is difficult, and the outcome is more uncertain, in comparison with extrinsic motivation. Envy, vengeance, and the desire to dominate are not less intrinsically motivated than altruism, conscientiousness, and love (Osterloh & Frey, 2000).

There are not only disadvantages of intrinsic motivation; under specific conditions it can be superior to extrinsic motivation. First, as said before, intrinsic motivation is needed for tasks that require creativity. Second, if tasks involve relevant aspects that cannot be covered completely by contracts, intrinsic motivation is needed. Finally, intrinsic motivation enables the generation and transfer of knowledge in conditions where extrinsic motivation fails (Osterloh & Frey, 2000).

Since the development of custom products requires creativity, intrinsic motivation plays an important role. Sometimes the development of a custom product requires trust and cannot be covered by contracts, in this situation intrinsic motivation is also important. Having this in mind intrinsic motivation is important for the development of custom products. The opposite is expected to be true for the

development of standard products. But although extrinsic motivation is important for the development of standard products, intrinsic motivation is important as well. The development of standard products does require some creativity, since the products are adapted to the specifications of the customer. Motivation (extrinsic as well as intrinsic) has to exist in order to want to start a project again. Therefore intrinsic motivation is important for the development of standard products as well.

2.3.3 Communication Factors

Two communication factors influence the transfer of knowledge. These factors are, (1) source credibility, and (2) communication competence (Ko et al., 2005).

Source Credibility

Source credibility is the extent to which a person perceives another person to be trustworthy and an expert (Ko et al., 2005). When source credibility is high, the knowledge presented by the source is perceived to be useful; the impact is higher, thereby facilitating the transfer of knowledge. If the source credibility is low on the other hand, the source's knowledge is perceived as less persuasive and will be discounted (Ko et al., 2005).

Trust plays an important role in the transfer of knowledge (Levin & Cross, 2004). In their study Levin and Cross (2004) tried to create a holistic view of the influence of trust on knowledge transfer. This resulted in three characteristics determining knowledge transfer, structural, relational, and knowledge characteristics. Structural characteristics refer to the configuration of knowledge transfer, meaning the method or strength of the knowledge transfer.

Relational characteristics refer to the level of trust between the individuals that exchange knowledge. Trust is defined as the willingness to be vulnerable. Trusting relationships are proven to lead to greater knowledge exchange, because people are more willing to share insightful information. On top of that, trust makes knowledge transfer less costly. These effects are shown in the individual as well as the organisational level of analysis (Levin & Cross, 2004). This does not mean, however, that trust and tie strength are the same. For example, one can trust someone even when they do not know him or her well.

Knowledge characteristics are concerned with the type and complexity of knowledge that has to be transferred. The types of knowledge where introduced in section 2.1. Tacit knowledge turns out to be quite difficult to transfer (Zander & Kogut, 1995), and tends to slow down the product development process (Hansen, Mors, & Løvås, 2005).

Source credibility is very important in the development of standard products. This is because these products rely mostly on previous developed products. If these come from a non credible source the product will not be as good as if it would come from a credible source. For the development of custom products creativity plays a large role, although knowledge from other sources is important it is not as important as it is with standard products because knowledge is mainly used in the creativity process. Quantity plays a larger role there than quality (Kelley & Littman, 2004), which means the source credibility can be less. So, source credibility is important for the development of custom products, but not as vital as it is for standard products.

Communication Competence

The speed of knowledge transfer is concerned with the possibility to codify and teach the knowledge that needs to be transferred (Kogut & Zander, 1995). Communication competence is the ability to demonstrate knowledge of the appropriate communication behaviour to effectively achieve one's goals. Communication-decoding competence refers to a recipient's ability to listen, be attentive and respond quickly. Communication encoding competence refers to a source's ability to express one's ideas clearly, have a good command of the language, and be easily understood (Ko et al., 2005).

For the development of standard products it is important to have a fast knowledge transfer. Standard products do not require a lot of engineering, so they should be developed quickly. Communication competence is important in this case, because time is money. Custom products also benefit from having efficient communication, but in this case it is mainly about efficient communication between all the parties involved. Thus communication competence is important for the development of custom products as well as for the development of standard products.

2.3.4 Summary

In the previous two sections the concepts of knowledge creation and knowledge transfer where explored. Three resources determine the knowledge creation capability, knowledge stock, knowledge networks and organisational routines and processes. Knowledge stock is the reservoir of knowledge available to the company. Knowledge networks are the networks of individuals and they used to obtain insights and information from different fields. Organisational routines and processes enable the creation of knowledge. For each of these resources the influence they have on the development of different products is determined.

Knowledge transfer is influenced by three factors, leaning, motivation, and communication. Learning factors of knowledge transfer are concerned with the relationship, understanding and absorptive capacity. Motivational factors are concerned with the satisfaction of the work. Communication factors are concerned with the credibility of the knowledge source and the competence of communication. The influence all of these resources have on the development of new products is summarized in Table 1.

	Knowledge Creation										**Knowledge Transfer**						
	Knowledge Stock			Knowledge Networks				Org. Routines and Processes			Learning Factors			Motiva-tional Factors		Commu-nication Factors	
	Experience	Formal Education	Knowledge Diversity	Number of Direct Contacts	Network Range	Strength of Network Ties	Structural Holes	Climate for Teamwork	Climate for Risk Taking	Organisational Memory	Ease of the Relationship	Shared Understanding	Absorptive Capacity	Extrinsic Motivation	Intrinsic Motivation	Source Credibility	Communication Competence
SP	+	±	-	+	±	+	±	-	-	+	+	+	-	+	+	+	+
CP	±	+	+	±	+	+	+	+	+	±	+	+	+	±	+	±	+

Table 1 - Factors to Emphasise for Standard and Custom Products

In Table 1 SP means standard products and CP custom products. If a resource is seen as being important it is rated with a plus, if it is not important it is rated with a minus, if it is in-between it is rated with a plus-minus sign. The method for gathering the plusses and minuses in the table above is not without its limitations, but it does provide an indication of where the focus should be for each product type. For example, it is obvious that there are differences in the amounts of knowledge creation and knowledge transfer between the different individual products. But looking at the plusses and minuses shows that there is also a difference between the product types.

Factors affecting knowledge creation and knowledge transfer are important, but they do not explain how these concepts can be used in a development process. Grisnich's products have to be fitted into the factory layout of the customer, so they require modifications and thereby development. Basically each new order requires a problem to be solved. Problems can be solved according to an enlarge-reduce-pick principle. Where first ideas are generated, reduced to possible solutions and finally a solution is picked. Problem solving capability is concerned with this principle, which can be used as a process for the creation and transfer of knowledge.

2.4 Problem Solving Capability

The capability to solve problems depends on cognitive (e.g. learning) and social (e.g. conflicts) factors. This means that knowledge creation (cognitive) as wells as knowledge transfer (social) are involved in the problem solving process. If one understands and masters the cognitive and social factors related to problem solving it creates an advantage for solving problems (Ginsberg, 1994, p. 154; Soo, et al., 2002). The capability to solve problems is defined by three socio-cognitive advantages (1) creativity, (2) comprehensiveness, and (3) consensus (Soo et al., 2002).

2.4.1 Creativity

The first advantage is creativity. "[Creativity is] the ability to be innovative and efficient in devising solutions and choosing options" (Soo et al., 2002, p. 15). Sternberg and Lubart (1993) identify six resources for creativity:

- Intelligence; the ability to redefine problems and to think insightfully. The capability to think insightfully can contribute to redefining problems, for example: recognizing that old information is useful for solving a new problem. Insight can also contribute to redefine the problem.

- Knowledge; in order to be creative one must have knowledge about the field. The opinions about having knowledge are divided, on the one hand scholars state that having knowledge creates a tunnel vision (Sternberg & Lubart, 1993), but on the other hand people without knowledge of the subject are more likely to provide novel information (Levin et al., 2002). Even so, having some knowledge about the subject is important for understanding (Cohen & Levinthal, 1990) and making sure that one does not invent the wheel again (Sternberg & Lubart, 1993).

- Thinking styles; the ways in which people choose to use or exploit their intelligences as well as their knowledge. In other words, it is about the abilities, but about how these abilities and knowledge are acquired in the day-to-day life (Sternberg & Lubart, 1993).

- Personality; Sternberg & Lubart (1993) state that creative people are likely to have certain personality attributes. People can be creative if they are short of these attributes, but they are more likely to be creative if they possess the following personal attributes: (a) tolerance of ambiguity – this is concerned with the willingness to tolerate the period of anxiety when developing a solution, (b) willingness to surmount obstacles and to persevere – one has to be willing to confront obstacles in order to make contributions over the long term, (c) willingness to grow – a person has to want to move on when an idea is accepted and not remain with the rewards given for the solution, (d) sensible risk-taking – for this aspect finance and creativity are the same: to gain major returns one needs to take risks, and (e) belief in oneself – due to the fact that ideas often change current situations people are against them. Therefore it is important that people believe in their own ideas (Sternberg & Lubart, 1993).

- Motivation; intrinsic motivation is one key to creative contributions. Some studies even state that it is needed for tasks that require creativity (Osterloh & Frey, 2000). Sternberg & Lubart (1993) emphasize that it has to be task focussed instead of goal focussed.

- Environment; people will be more creative if they are in a place that fosters, accepts and actively rewards creative ideas. Creative ideas are often not inline with the current status of the company and are suppressed by the environment. If the environment is compatible with creativity, it is more likely that creative ideas will occur (Kelley & Littman, 2004). People need an environment that values what one has to offer (Sternberg & Lubart, 1993).

Creativity can be seen as a process (Torrance, 1993), in which two steps need to be taken in during this process: (1) the formulation of the problem and/or goal of the process, and (2) the generation of ideas that could help to solve the problem and/or reach the goal (Byttebier, 2002).

Formulation of the Goal/Problem

According to Litchfield (2008) the formulation of the goal determines the direction in which solutions are sought. If the goal is presented with a number of categories into which solutions need to fit, the solutions will be more focussing on a category. If, on the other hand, goals for individual categories are given and a single category at the time is questioned solutions will be more novel (Litchfield, 2008). Ward, Patterson, Sifonis, Dodds, and Saunders (2002) have shown that if individuals are given different goals they access different knowledge (i.e. they use a different part of their memory). This paves the pad for a (sequential) brainstorm session to focus on either developing ideas for standard products or custom products. Litchfield (2008) provides a model for goals for creativity that can be used to determine the formulation of goals (see Figure 3).

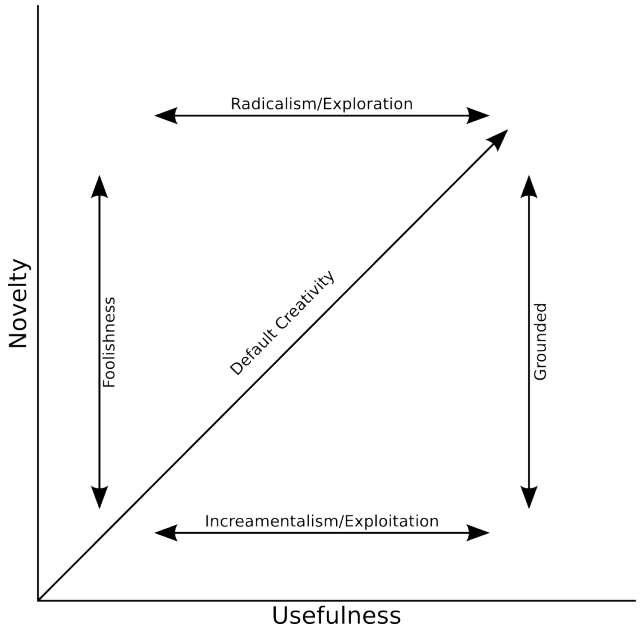


Figure 3 - Disaggregating Goals for Creativity (Litchfield, 2008)

In Figure 3 two main criteria, novelty and usefulness are stated along the vertical and horizontal axes. On the diagonal axes the amount of creativity for the ideas is given split into novelty ideas in the upper triangle and usefulness in the lower triangle. Novel ideas are determined by the degree of foolishness and radicalism/exploration, while useful ideas are determined by the degree of incrementalism/exploitation and grounded (see Figure 3). As mentioned earlier making a distinction between useful and novel ideas is useful for the development of standard or custom products. Standard products need to be useful and are often incremental innovations of previous versions, while custom products require a novelty factor and can be seen as more radical innovations.

Generation of Ideas

The second step of the creativity process is the generation of ideas. The main method for the generation of ideas is the brainstorm method (e.g. Byttebier, 2002; Kelley & Littman, 2004; Litchfield, 2008). A lot of research has been done on the effectiveness of brainstorming for the generation of ideas in laboratory settings (e.g. Litchfield) as well as practical settings (e.g. Kelley & Littman, 2005). Two main thinking methods have emerged from this research (Byttebier, 2002), associate and feedback. The former technique is based on the linkages that people can make with the current thing they have in mind (i.e. the ability to relate different items to each other). Via this relation new insight is gained and additional thinking steps (the grey clouds in Figure 4) can be made. The latter method is also aimed to gain new insight for additional thinking steps, but has its roots in completely new information not related to the topic or thinking done before. This causes complete new insight and could result in additional thinking steps to be made (see Figure 4).

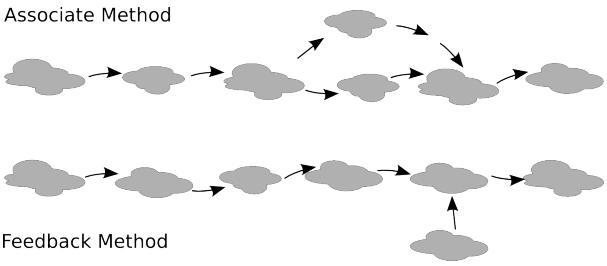


Figure 4 - Thinking Methods (Byttebier, 2002)

Although results vary among the believe of effectiveness of individual or team brainstorming is higher and whether or not writing down ideas is the best, rules (whether or not formulated as a goal (Litchfield, 2008)) for an effective brainstorm can be determined.

Four rules of brainstorming are (1) to generate as much ideas a possible, (2) to avoid criticizing any of the ideas, (3) to attempt to combine and improve on previously articulated ideas, and (4) to encourage the generation of "wild" ideas (Litchfield, 2008). Having in mind these rules techniques for the generation of ideas are developed. These techniques take into account, for example, the available time, level of experience of the brainstorm participants, or required depth of the solution (Byttebier, 2002). This implies that although there are rules for holding a brainstorm, it can be adapted to the development of different products by using different techniques during that brainstorm.

With a clear formulation of the goal/problem and ideas generated during a brainstorm session the next step is to analyse and categorise the ideas generated, which is explained in the next section.

2.4.2 Comprehensiveness

"[Comprehensiveness is] the ability to be exhaustive and coherent in judging situations and assessing problems" (Soo et al., 2002, p. 15). This means that in order to make a good judgement one should be able to limit the number of alternatives/criteria so synoptic is remained. Comprehensiveness is critical for mastering cognitive obstacles, i.e. difficulties in the learning process (Ginsberg, 1994). Not only limiting the number of ideas to hold an overview, but also the capability to generate multiple ideas is important for solving problems (Soo et al., 2002). Strategic management literature has put emphasis on the concept of comprehensiveness naming it an important aspect of the strategic decision-making process (Frederickson & Mitchell, 1984). This implies that it is also important in the development process of new products.

Comprehensiveness Process

Several studies have composed a comprehensiveness process (e.g. Frederickson & Mitchell, 1984). In general the following steps are taken in that process: (1) making explicit of the range of alternatives, (2) weighting and evaluating different aspects of the range of alternatives, (3) examining the consequences of the individual alternatives, and (4) making plans about the implementation of the different alternatives. A good method to do this is via is the formulation of a business model (Van Wulfen, 2006). A business model forces one to appoint all the aspects of the idea, thereby making it explicit. On each element of the business model a weight can be given, so individual alternatives can be compared on each element. Since a business model includes all elements of the product (including costs, revenues, and potential markets) the consequences can be determined (Chesbrough, 2006), it allows making plans about implementation of it. This makes is easier to make a final decision later in the process.

Elements of a Business Model

Osterwalder, Pigneur and Tucci (2005) state nine aspects of a business model that can be used for making explicit the ideas from the creativity process. These nine aspects are: (1) value proposition – gives an overall view of the company's bundle of products and services, (2) target customer – describes the segments of customers a company wants to offer value to, (3) distribution channel – describes the various means of the company to get in touch with its customers, (4) relationship – explains the kind of links a

company establishes between itself and its different customer segments, (5) value configuration – describes the arrangement of activities and resources, (6) core competency – outlines the competencies necessary to execute the company's business model, (7) partner network – portrays the network of cooperative agreements with other companies necessary to efficiently offer and commercialize value, (8) cost structure – sums up the monetary consequences of the means employed in the business model, (9) revenue model – describes the way a company makes money through a variety of revenue flows.

To sum up, during the comprehensiveness process more research is done on the alternatives created in the creativity process to be able to make a grounded decision that is done by forming a consensus.

2.4.3 Consensus

Many companies assign groups to solve problems because it is believed they are more capable to solve problems than individuals (Stasson, Kameda, Parks, Zimmerman, & Davis, 1991). "[Consensus is the] harmony and shared commitment to goals and decisions" (Soo et al., 2002, p. 15). People tend to have more confidence in group-judgements than in individual ones. Consensus, however, does mean that members of a group have to be in same direction thereby creating the possibility of loosing effectiveness (Stasson et al., 1991). Even so, consensus, as well as comprehensiveness, is critical for mastering cognitive obstacles (Ginsberg, 1994).

In general two forms of consensus can be determined, unanimity and majority. Unanimity meaning everybody agrees with the suggested solution, and majority meaning the larger part of the group agrees with the solution. These forms of consensus have their influence on the effectiveness of the problem solving process and amount of knowledge transfer that takes place. Unanimous decisions tend to consume more time compared to majority decisions, but unanimous decisions tend to have correct solutions more often compared to majority decisions (Stasson et al., 1991).

2.4.4 Tacit and Explicit Knowledge

Throughout this chapter the importance of tacit and explicit knowledge has been touched upon. The factors described above all use or require one of the types of knowledge, but how do these types of knowledge relate to each other? Although explicit knowledge can be transferred more easily because it is in written form (uit Beijerse, 2000), tacit knowledge also plays a very important role in the creation and transfer of knowledge (Nonaka, 1994). According to some scholars one type of knowledge is better than the other, but others have shown that both are needed (Alavi & Leidner, 2001). Polyani (1975) states: 'the two are not dichotomous states of knowledge, but mutually dependent and reinforcing qualities of knowledge: tacit knowledge forms the background necessary for assigning the structure to develop and interpret explicit knowledge' (in: Alavi & Leidner, 2001). Nonaka (1994) states a process of knowledge conversion in order to create knowledge. This process converts tacit and explicit knowledge into each other in order to create organisational knowledge out of knowledge of individuals. This process consists of four constructs; (1) socialization, (2) externalization, (3) combination, and (4) internalization (Nonaka, 1994; Nonaka & Takeuchi, 1995; Nonaka et al., 2000).

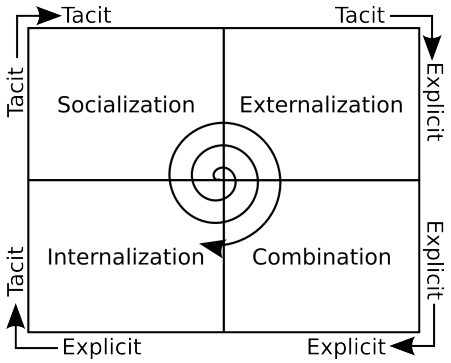


Figure 5 - SECI model (Nonaka, 1994)

Nonaka (1994) describes the process of sharing tacit knowledge as socialization. Important to realize is that acquiring of tacit information can take place without the use of language (e.g. the transfer of craftsmanship). Socialization in a business context consists of four parts, the gathering of information from other departments, the gathering of information from outside the company (e.g. from the daily life), the gathering of information from suppliers, and the ability to adopt tacit skills from a master (Nonaka et al., 2000). By sharing knowledge in the form of socialization, one gets familiar with asking questions to other individuals. Socialization consists of the factors: (1) tacit knowledge accumulation – the gathering of information from sales, production sites and the sharing of experience with customers, and (2) extra-firm social information collection – the gathering of information from outside the company, for example, from the daily life (Nonaka et al., 2000).

Ones capacity is explained through certain skills (uit Beijerse, 2000). These skills, however, can differ from what is stated in ones job description. They are known within the minds of the individuals. By asking somebody what their knowledge is one can get an understanding of what the skills are that one possesses. This process is closely related to externalization, which consists of the factor abductive thinking – meaning the use of metaphors in dialogue for concept creation (Nonaka et al., 2000).

Combination refers to the use of social processes to combine pieces of information held by individuals. For example, reconfiguring of existing information to create a financial report. Combination consists of the factors: (1) acquisition and integration – the engagement in planning strategies and operations, (2) synthesis and processing – the building and creation of manuals, documents and databases, i.e. codification of knowledge, and (3) dissemination – the engagement in the planning and implementation of newly created concepts.

Since knowledge is strategically seen the most valuable resource (Grant 1996), ones attitude towards knowledge is important for the company. Explicit knowledge has to be used to make it ones own; this process is called internalization (Nonaka, 1994). An example of internalization is reading a manual and reflecting on it (Nonaka et al., 2000). Factors of internalization are: (1) personal experience – the engagement in 'enactive liasing' activities with functional departments (e.g. engagement in the search and share of new values and thoughts, or the engagement in trying to understand the management vision), and (2) simulation and experimentation – the engagement in facilitating prototyping and benchmarking and the facilitation of a challenging spirit within the organization.

2.5 Constructing a Framework for Knowledge Creation and Transfer

To gain an overview of how knowledge can be created and transferred for the development of different product types the factors of knowledge creation, knowledge transfer and de process of problem solving have to be incorporated into a framework. For answering the central question, however, more insight is needed. To manage the factors of knowledge creation and transfer correctly insight into the importance of each factor during the problem solving process is desirable. This is, because it allows the management of Grisnich to see on which points the focus needs to be in order to develop products efficiently. Because these elements are complex the construction of the framework will be done in phases, with first the combination of the knowledge creation and transfer factors, second the indication of importance of each factor and finally the search for a balance between the product types.

2.5.1 Elements of the Framework

The development of a product (standard, or custom) can be seen as a project, because each product is only produced if a customer places an order. The first element for the framework is the time span. Standard products will generally require less time than custom products, but obviously every project has a beginning and an end. This means that the first element of the framework has to be the time span of the project, with variation included for different product types (see Figure 6).

The second element to add in the model is the problem solving process. This process is similar for each product type and thereby for each project. From section 2.4 three phases of the problem solving process became clear. The first phase, creativity, is the phase where a lot of ideas are generated. The second phase, comprehensives, reduces the number of ideas, because not all ideas generated are useful. This reduction has two purposes, eliminating all the ideas that are not useful or too outrageous and limiting the number of ideas so an overview is easily created. In the third phase the final solution for solving the problem is chosen. Figure 6 displays how the problem solving process is integrated into the framework of knowledge creation and knowledge transfer.

All these phases have to be completed for the development of a product, meaning they will fall within the time span of a project. Given the nature of the product types of Grisnich the three phases described above not necessarily have to be even to each other. Variation per project of course exists, but also by product type. Why this also differs per product type is explained later in this thesis.

Finally, the concepts of knowledge creation and transfer have to be added to the framework. This is done by linking the different factors of knowledge creation and knowledge transfer to each phase of the problem solving process. Doing this will not only provide insight in how to manage the creation and transfer of knowledge throughout the problem solving process, but also gives an indication of where the focus lies in each phase of the process per product type.

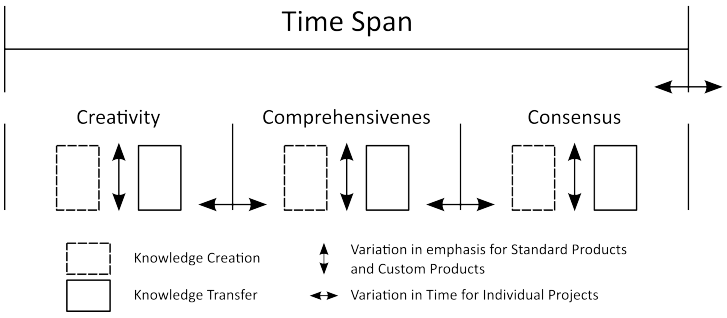


Figure 6 - Theoretical Framework for Knowledge Creation and Knowledge Transfer

Figure 6 shows the concepts of knowledge creation and knowledge transfer incorporated into the framework. What can be seen is that knowledge creation and transfer takes place in each of the phases of the problem solving process. The amounts of knowledge creation and knowledge transfer, however, vary throughout the different product types as well as throughout the different projects. By relating the factors of knowledge creation and knowledge transfer to the phases in the process one can get an indication of the importance of knowledge creation and knowledge transfer within the phases and the importance of the phases themselves.

2.5.2 Importance of the Factors during the Problem Solving Process

Throughout this chapter the importance of knowledge creation and knowledge transfer for the development of different product types has been emphasized. In the summary of section 2.3.4 the importance of the factors of knowledge creation and knowledge transfer has been indicated by the use of plusses and minuses. It showed that the importance of knowledge creation and transfer factors for product types differs. The concepts of knowledge creation and knowledge transfer have been incorporated in the framework, but the importance of these factors for different product types not. To get an overview of how knowledge has to be created and transferred this importance for the different product types is needed. Because the framework is structured in three phases the factors will be linked to each of these phases. Linking the factors to each of the phases does not mean that the factor is only needed in the indicated phase. It only provides an indication of the most relevant factors in a specific phase of the problem solving process. It can help to provide recommendations about how to create and transfer

knowledge at a specific point in time and it provides on indication on which factors to focus and how to organise the development of different products.

Creativity

Given the name of this phase one would expect only knowledge creation factors to be present, but this is not the case. Knowledge transfer factors also have an influence on the creativity (Smith et al., 2005). This means that the resources for creativity can contain aspects of knowledge creation and knowledge transfer. Since the only interest is to link the factors of knowledge creation and transfer to a specific phase the individual creativity resources of Sternberg and Lubart (1993) will not be taken into account.

- Important factors; intelligence has to do with the education of a person; often a highly educated person will have a high intelligence (Sternberg & Lubart, 1993). People with a high intelligence will also be more likely to have a high absorptive capacity, because this is dependent on the stock of knowledge a person possesses prior to the transfer of knowledge (Ko et al., 2005). Experience in a field is related to the possession of knowledge, as well as the range of the network. People with a lot of years of experience are more likely to have more knowledge about a certain field (Nonaka et al., 2000). Range of the network indicates the scope of the network, meaning the different kinds of knowledge available in the network. This contributes to the knowledge creation capability (Smith et al., 2005). A broad network range will result in a high amount of available knowledge and structural holes within a network result in the availability of novel knowledge. Having a diverse stock of knowledge enables a person to look at matters from a different perspective (Nonaka & Takeuchi, 1995). Possessing knowledge from different fields will result in a greater creative capability. For knowledge transfer the competence to communicate is important. Communication competence is related to the ability to demonstrate knowledge and communicate is appropriately. Having a high communication competence means that one is able to demonstrate knowledge and communicate knowledge in an appropriate way. For creativity intrinsic motivation is important. The position of the network determines the amount and type of external knowledge that can be attracted (Ahuja, 2000). Since the amount and type of knowledge are important in the creativity phase the network position is most important for the creativity phase.

- Neutral factors; as said earlier the availability of knowledge is important for the creation of knowledge. But to have knowledge available and be able to understand it several factors are of relative (mediocre) importance. Factors concerning the network and communication are of mediocre importance (number of direct contacts, strength of network ties, shared understanding). These factors are important to creativity, but more important in later phases, because during the creativity phase the focus lies on the gathering of quantitative numbers of knowledge instead of qualitative numbers of knowledge these factors are classified as neutral factors in this phase. Another factor of neutral importance is extrinsic motivation. Intrinsic motivation is seen as important during the creativity phase, but this does not exclude the importance of extrinsic motivation. Therefore it is classified as a neutral factor.

- Non-important factors; creativity requires a lot of (novel) knowledge. It is relatively unimportant where the input of the knowledge comes from, as long as there is plenty of knowledge input (Kelley & Littman, 2004). Later phases will filter out irrelevant knowledge, but for now (the creativity phase) all knowledge is welcome. This implies that source credibility and ease of the relationship are not important factors for this phase. They are therefore classified as non-important factors.

Comprehensiveness

Comprehensiveness is the ability to reduce the number of ideas generated earlier to a limited number preparing for the next phase of making a selection (Soo et al., 2002). One could say that during this phase a rough selection is made. Knowledge transfer obviously plays a role in this phase, but to make a good selection and develop plans for the implementation of them, knowledge creation also is involved.

- Important factors; Strong relationships with ties enable persons to evaluate different ideas with others and ask them about their opinion. This means that the network of employees can play an important role. Strong ties are more likely to share valuable information (Smith et al., 2005) and do it in an efficient way (McFadyen & Cannella, Jr., 2004), so strong network ties are important. Having a large number of contacts is also important, because it creates a large pool of knowledge to base a decision on. Having more persons to ask potentially makes the decision better funded. These persons, however, need to be trustworthy. Since the comprehensiveness phase is concerned with planning the possibilities of implementation and examining consequences of alternatives one could say that this is the phase where the basis of a possible implemented solution is found. One should be able to process and understand the information provided at that time, so absorptive capacity is important. Source credibility refers to this trustworthiness and is very important in this phase. Credible sources help to reduce uncertainty in the decision process (Ko et al., 2005). Having a large number of (preferably trustworthy) persons to get knowledge from to make a decision is nice, but one has to be able to understand them. Shared understanding is especially important in the first to steps taken in the comprehensiveness phase where the alternatives are made explicit and evaluated on different aspects, because shared understanding helps to create a good base for further analysis and helps in being efficient in this process (Frederickson & Mitchell, 1984). This is why shared understanding also plays an important role in this phase. Communication is also important during this phase since not only a rough selection needs to be made, but also plans for implementation are developed. This requires proper communication (Soo et al., 2002).

- Neutral factors; the knowledge stock of individuals (experience, formal education, knowledge diversity) are less important during this phase than that they are during the creativity phase. They are needed, however, when it comes to making plans about the implementation of ideas. The knowledge stock of employees can be very useful when it comes to remember events and best practices from the past (Nonaka & Takeuchi, 1995; Smith et al., 2005). Because they are still of relative importance during this phase knowledge stock factors are classified as neutral factors. The network range and position are also less important in this phase, because they have their effect mostly on the gaining of novel knowledge that is not as important in this phase as it is in the creativity phase. Novel knowledge acquired in the creativity phase is used in this phase, making them of relative importance at this phase. One can imagine that knowledge management plays an important role during this phase, because the ideas generated in the previous phase need to be explained and understood by everybody in order to make proper choices. Therefore, all factors that are not mentioned as important in the previous point (ease of relationship, intrinsic motivation, and extrinsic motivation) are seen as of relative importance.

- Non-important factors; all factors are already treated, which means that there are no non-important factors in this phase of the decision making process.

Consensus

Consensus is concerned with the final selection of a solution to a problem. In the ideal situation there it is not the intention to create addition knowledge during this phase. This is why the emphasis in this phase lies on the transfer of knowledge.

- Important factors; to reach a consensus one has to be able to speak freely to one another. This means that the ease of a relationship is important. Having a good relation means that one can say more to each other. On top of that the view that money is rewarded for a good decision helps for reaching a good consensus. Of course the competence to communicate properly is important since collaboration is required during this phase (Soo et al., 2002).

- Neutral factors; as said earlier, experience and knowledge diversity are important to remember events from the past and being able to see aspects from different perspectives. For selecting the final solution these factors are important, because they can prevent mistakes or flaws from the past (Kelley

& Littman, 2005). Because they can also slow down exiting or new ideas they are not classified as important factors, but as neutral factors. During the consensus phase the final solution is made. This means that a lot can be learned about the process prior to the solution made. Learning factors play an important role for that reason. Shared understanding and absorptive capacity are important, because they can guarantee that the alternative solutions are understood and there is the possibility to work towards a good consensus. Since everybody is able to understand and process the information included in the alternatives.

- Non-important factors; the ego-network of individuals is not seen as important (from a knowledge management perspective) during the consensus phase. This is, because the decision is made based on well thought alternatives in previous sections. The influence of the network is of non-importance during this phase. What also is of non-importance is the education of the individual. During the previous phases all the knowledge is created and integrated into different ideas. Education has had its input during these phases and therefore is not as important at this point. Source credibility is emphasised as important in the comprehensiveness phase, therefore it is not seen as important during this phase.

Process Factors

There are three factors that have not been treated jet. These are the factors of organisational routines and processes. Obviously these factors influence the entire process. It would not be right to link them to a single phase or state that they should be emphasised in a particular on.

Summary

Linking the factors of knowledge creation and knowledge transfer to the framework creates more insight in how they fit into the development process. An overview of factors that are linked to a phase in the problem solving process can be seen in Table 2. The phases are indicated on the left side, with creativity is indicated with CR, comprehensiveness is with CM and consensus with CN. The plusses and minuses indicate the importance of each factor during a particular phase. A plus sign indicates an important factor, a minus sign indicates a non-important factor, and a plus-minus sign indicates a neutral factor.

	Knowledge Creation										**Knowledge Transfer**						
	Knowledge Stock			Knowledge Networks				Org. Routines and Processes			Learning Factors			Motiva-tional Factors		Commu-nication Factors	
	Experience	Formal Education	Knowledge Diversity	Number of Direct Contacts	Network Range	Strength of Network Ties	Structural Holes	Climate for Teamwork	Climate for Risk Taking	Organisational Memory	Ease of Relationship	Shared Understanding	Absorptive Capacity	Extrinsic Motivation	Intrinsic Motivation	Source Credibility	Communication Competence
CR	+	+	+	±	+	±	+	+	+	+	-	±	+	±	+	-	+
CM	±	±	±	+	±	+	±	+	+	+	±	+	+	±	±	+	+
CN	±	-	±	-	-	-	-	+	+	+	+	±	±	+	±	-	+

Table 2 - Importance of the Knowledge Creation and Knowledge Transfer Factors

Table 2 displays which factors should be emphasised during which phase of the problem solving process, while Table 1 displays the importance of the individual factors for different product types. One can imagine that emphasising factors for the development of standard products can affect the development of custom products. A challenge for the management is balancing the tension between these two product types and the balance of managing the knowledge creation and transfer concerned with them. In order to provide sufficient recommendations additional insight into the balance is needed.

2.5.3 A Balance for the Development of Different Product Types

The factors of knowledge creation and knowledge transfer for the development of standard products or custom products can have contradicting values. From Table 1 this already became clear. At several factors the values for these factors are opposites of each other. This implies that focusing on the development of standard products can have negative effects on the development of custom products and vice versa. Therefore, a balance has to be found to warrant the development of both product types.

Before a theoretical balance can be sought first the contradicting areas have to be determined. These are the areas with the largest difference in values between the product types. Looking at Table 1 four potential problem areas can be noted: (1) knowledge diversity, (2) climate for teamwork, (3) climate for risk taking, and (4) absorptive capacity. The problem solving process at Grisnich starts with a very basic question: Have we done this before? Although this question seems very simple, it makes a very interesting decision for the further development of products. Because if the answer is yes, projects from the past will be used for the development, but if the answer is no the project is designed from scratch. This implies that there is a difference between the development of new products and standard products. Another thing that becomes clear from this aspect is that organisational memory is used for the development of standard products. The question is whether or not it is used correctly.

On the organisational level concepts are developed for the development of different product types. These concepts, however, are not concerned with how knowledge should be managed; they rather focus on innovation theories. Gupta, Smith, & Shalley (2006) have studied the interplay between exploration and exploitation. According to them, exploration refers to learning and innovation, while exploitation refers to the use of past knowledge. This is similar to the question asked at the beginning of the current development process at Grisnich. Basically they question: Do we need to explore or exploit for the development of this project?

Although focusing on innovation, the search for a balance between exploration and exploitation shows similarities with the balance needed in this study. Both need to find a balance between the use of past knowledge and the creation of new. Results form the study of Gupta et al. (2006) show that it depends on the unit of analysis whether or not a solution is possible. For example, on the individual level it is inefficient to force people to explore and exploit at the same time. While at an organisational level this is easier (individuals can perform different tasks). The solution provided by Gupta et al. (2006) for finding a balance is twofold. First an ambidextrous organisation is proposed, where the organisation is split into two organisations one optimized for exploration and one optimized for exploitation. Second, a theory about a punctuated equilibrium is proposed where specialization of an organisation is possible only if another company specializes in the opposite.

Before the search for a balance can continue the concepts of ambidextrous organisation and punctuated equilibrium have to be brought back to the field of knowledge management. The former concept, ambidextrous organisation, describes that exploration and exploitation will happen at the same time within an optimized organisational subunit (Gupta et al., 2006). This means that knowledge has to be created and transferred to support the development of both types of products. Individuals need, however, to focus on exploration or exploitation. While the concept of punctuated equilibrium states that a choice has to be made between exploration and exploitation.

Standard products more often require exploitation (the use of past knowledge), while custom products require more often exploration (learning, creating new knowledge). This means that making a choice between exploration and exploitation cannot be made. Both need to be done, because otherwise the development of one of the product types would come to a standstill. No only is this undesirable from a practical point of view, it would also make this study unnecessary. The balance for knowledge creation and transfer is therefore sought with insights from the theory of ambidextrous organisations.

As stated above, the concept of ambidextrous organisation is developed using the organisation as unit of analysis. Striving for ambidextrous individuals is less likely to be successful. This statement is supported by Amabile (1996), who states that individuals who focus on creativity and experimentation are often quite different from those who emphasize on acting according to routines (in: Gupta et al., 2006). Looking at a team level, however, Gilson, Mathieu, Shalley, & Ruddy (2005) have shown that teams that felt empowered to use creative problem solving as well as standardized routines and procedures had the highest levels of team effectiveness.

Knowledge diversity and absorptive capacity depend on the individual. This means that tasks have to be assigned to the individual on which these two factors have a positive effect on the development of the product. In other words, if a product requires exploration it should be assigned to a person with high absorptive capacity and knowledge diversity. On the other hand if a product requires more exploitation high knowledge diversity and absorptive capacity are not needed. Letting people develop different kinds of product types simultaneously is less effective as stated above.

Climate for teamwork and climate for risk taking are not dependent on the individual, they affect the entire engineering department. This means striving for an ambidextrous department is more likely to be successful. Teams can strive for exploration and exploitation simultaneously by dividing tasks in a team. Taken into account what is said earlier this does not mean that individuals have to be assigned to both explore and exploit, but one task at the time to be more efficient. But how does this relate to the factors of organisational climate? For the development of custom products a climate for teamwork is desirable. Most important phase for the development of custom products is the creation phase (see section 2.5.2). This means that during this phase teamwork is desired. Since people will have to be assigned to explore or exploit it will mean that they will be developing a standard product or a custom product. This implies that the people working on custom products will be performing in a team and need to take risks, while the people working on standard products are working individual and risk-taking is less required.

A Balance by using Organisational Memory

Organisational memory can help to find the balance needed. As said earlier, organisational memory is important in all the phases of the problem solving process and is closely linked to the question asked at the beginning of the project. Organisational memory can fulfil several functions within a company, but also can be misused (see section 2.2.3).

The method for using organisational memory for the development of different products is to use it during each phase, but only one purpose during each phase. In the first phase creativity is important, the information function of organisational memory is important here. It can determine whether or not a routine process is started and point out where information in the organisation is available. In the second phase (comprehensiveness) the political power of organisational memory is important. Due to this political power people can be influenced to perform certain tasks and actions. This will help to reduce the number of alternatives to a small number and makes sure that people will actually perform their tasks (e.g. by confronting them with a planning of a previous project that was completed in a certain time span). In the last phase (consensus) the control function of organisational memory plays an important role. Controlling decisions made can reduce transaction costs involved in implementation (Walsh & Ungson, 1991), this can help maintain efficiency during and after the development process.

2.6 A Framework for the Creation and Transfer of Knowledge

This section forms the conclusion of the theoretical perspective of this study. It is a summary of what is said earlier in the chapter.

A framework for the creation and transfer of knowledge is constructed by linking two elements of knowledge management (knowledge creation and knowledge transfer) to a problem solving process. By doing so focus points for the creation and transfer in different phases of the problem solving process where identified. This framework is made visually in Figure 6. After this basic framework was established,

the link with multiple product types was made. As can be seen in Table 1, different product types require different emphasis of knowledge creation and transfer factors. A balance for simultaneous development of different product types is sought later in the chapter.

A balance for the development of different products can be achieved by assigning tasks to persons who like to perform the tasks and are qualified to perform the tasks assigned to them. It is not efficient to expect people to develop different products simultaneously, but sequentially is possible. On top of that people with a high knowledge diversity and absorptive capacity are better in developing custom products, while people with a low diversity of knowledge and absorptive capacity are better in developing standard products. Organisational memory can help during the process of assigning people to perform tasks and using knowledge from the past for the development of products. It can also help to control or influence the development process by retrieving knowledge from the past. The final model for the creation and transfer of knowledge can be seen in Figure 7.

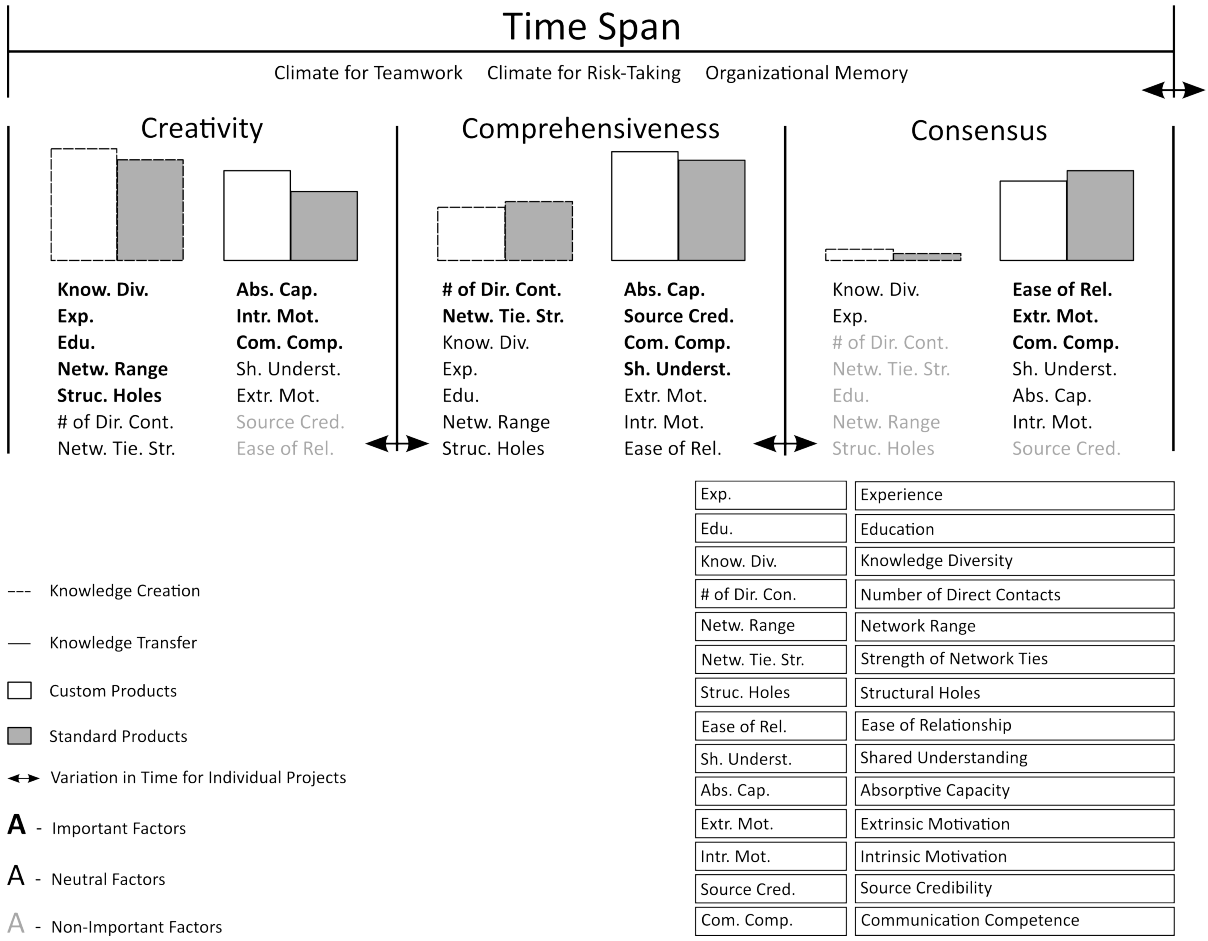


Figure 7 - Final Framework for the Creation and Transfer of Knowledge

Figure 7 displays the elements of Figure 6 with the boxes for knowledge creation and knowledge transfer replaced for standard and custom products. Note that the factors displayed in a phase are categorised according to their importance; with bold, normal and grey representing important, neutral, and non-important factors. The three process factors that are important during and influence the entire process are displayed under the time span. A list of abbreviations is included to understand the figure correctly. Figure 7 basically summarises what is explored in the theoretical framework. What can be seen from the model is that although the importance of the knowledge creation and transfer factors follows the same pattern for both standard and custom products there is a difference between the two looking at the phases individually. This model will be used for the analysis of the current situation of Grisnich. How the current situation is analysed using the model of Figure 7 is explained in the next chapter.

3 Methodology

The theoretical situation sketched in the previous chapter is seen as the ideal situation. This chapter will focus on the empirical part of the research, it will explain how to measure and analyse the current situation. To do so, the factors described in the previous chapter have to be made measurable and methods for collecting data have to be developed. But first, the type of research is introduced.

3.1 Type of Research

This research is concerned with providing recommendations on how to create and transfer knowledge for the development of standard and custom products to the management of Grisnich. To do so, the current situation has to be analysed and an in-depth understanding has to be gained. Recommendations will be provided based on the theoretical framework of the previous chapter and the in-depth understanding of the current situation. Before these recommendations can be given a method for analysis of the current situation is needed. Recommendations need to be based on an understanding of how and why things happen. Quantitative methods measure the frequency of events occurring, while qualitative research has the focus on the how and why of events occurring, this makes qualitative research methods the best option for this research. Recommendations will explain how to get from the current situation to the ideal situation, it is therefore important to understand how the employees perceive the current situation. How this perception can be extracted from individuals is explained in the methods for data collection in section 3.3. Qualitative research has several advantages given the goal of this research:

- Sample size; since the purpose of doing qualitative research is to provide a detailed description of events, situations, and interaction between people and things (Cooper & Schindler, 2006) a large sample size is not necessary. The engineering department of Grisnich currently has six employees, doing qualitative research will allow making a better analysis than when doing quantitative research with the same sample size.

- Research purpose; the purpose of this research is to gain an in-depth understanding of the current situation. This is in line with qualitative research; quantitative research on the other hand, is more often concerned with describing or predicting of a situation (Cooper & Schindler, 2006).

- Data type; for qualitative research data will often consist of verbal descriptions (Cooper & Schindler, 2006). This allows capturing more detail than with, for example, survey answers. Since the goal is to gain an in-depth understanding, capturing more detail is desirable.

- Data collection; due to a smaller sample size, data is obtained more quickly and can be analysed faster. This shortens the overall time span of the research (Cooper & Schindler, 2006). It also allows doing in-depth interviews with a relatively large proportion of employees resulting in a better understanding of the current situation.

- Data analysis; because data often consists of verbal descriptions it forces the researcher to see the contextual framework of the situation analysed (Cooper & Schindler, 2006). This makes sure that the researcher can ground the recommendations provided.

With the choice made to perform qualitative research the next step is to create a perspective of how is looked at the research (methodological view). This perspective helps to select methods for data collection and analysis later in the research.

3.2 Methodological View

To relate the theoretical foundations described in the previous chapter to the real world a perspective of the method used for this is needed (Arbnor & Bjerke, 2009). According to Arbnor and Bjerke (2009) the results of the study are dependent on the methodology chosen. This makes the choice of methods important for the research. Figure 8 displays how the theory of the previous chapter and the methodology

of this chapter relate to each other. One can see from the figure that the presumptions and theory of science determine the methodological view. Together with the methodology chosen the operative paradigm is determined. This is then applied to the study area.

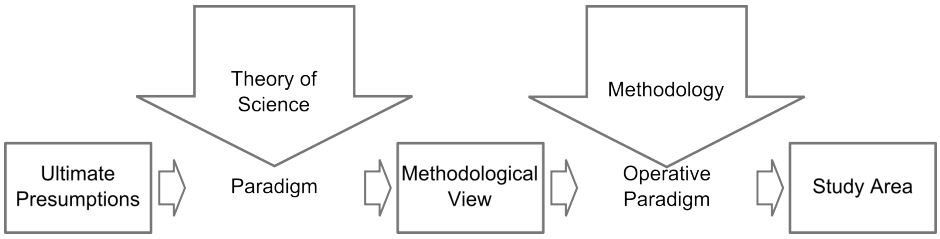


Figure 8 - Paradigm and Operative Paradigm (Arbnor & Bjerke, 2009)

Following the figure, first the methodological view has to be chosen before the methodology can be chosen and operationalisation of the criteria (operative paradigm) can be done.

Arbnor and Bjerke (2009) describe three perspectives to look at the reality; the analytical approach, systems approach, and actors approach. In the first the reality consists of facts and facts can be summated to find the truth. In the second approach the reality consists of systems interacting with each other. In order to find any results the whole reality has to be found in order to create a good understanding of it and see how everything interacts with each other. The last approach described by Arbnor and Bjerke (2009), the actors approach, states that each individual has its own reality. In order to create results one has to understand the reality of the individuals involved in the research and be able to speak their language when searching for and explaining results. This last approach suits the type of research (qualitative) chosen, because it allows searching for an in-depth understanding and acknowledges that different individuals have different realities.

In the actors approach the individual persons are the centres of analysis. Each individual has a presumption of reality, through interaction with the environment an understanding is created, after which an after understanding can be formulated. The reason for choosing this approach is that the employees of Grisnich are the ones that hold the knowledge about the areas of improvement whereas the researcher can only contribute towards the problem areas with external insights. This methodological view allows making use of historical data for the creation of an understanding (Arbnor & Bjerke, 2009). On top of that it also allows using what the authors call traditional techniques for data collection, which are for example, conducting interviews, or using questionnaires. This allows combining quantitative as well as qualitative methods, which is common when doing a case study (Cooper & Schindler, 2006).

The operative paradigm consists of two elements (Arbnor & Bjerke, 2009): (1) methodical procedures – which covers theories, techniques and previous results that will be used in the analysis of the project (see section 3.4), and (2) methodics – which describe how the methodical procedures are used in order to answer the research questions of this study (see section 3.3).

3.3 Method for Data Collection

For the collection of data the distinction can be made between primary and secondary sources. Primary data sources will function as the main source of data for the understanding of the current situation. Where additional information is needed secondary data sources will be addressed.

3.3.1 Primary data collection

The primary sources of data collection are interviews with key employees and a small questionnaire for additional information about the background of the employees of the engineering department.

Interviews

Interviews are conducted to gain an in-depth understanding of the current situation. This in-depth understanding will form the basis for the recommendations that will be provided. Interviewing people from different departments within the company helps to gain this understanding of the current situation.

- Structure; each interview is conducted with people all having specific knowledge. Although this needs to be exploited the best, the topics will mostly remain the same for each interview so results can be compared between interviewees. A general hierarchy of questions will be used during the interview. This interview hierarchy makes sure that the topics that need to be covered are asked, but also makes the interviewee feel that (s)he has a lot to contribute. Making the interviewee feel at ease and allowing him/her to speak openly is needed in order to have a useful interview (Cooper & Schindler, 2006). All of this is achieved by starting the interview with some broader questions followed by going more into the topic. The interview scheme will have four types of questions: (1) broad questions – to make the interviewee feel at ease and introduce the topic, (2) narrowed down to one topic – for example the exchange of knowledge, (3) narrowing the topic – how is knowledge currently exchanged between the sales and engineering department, and (4) are the sources of your information credible enough to provide information to the engineering department for the development of standard products (Cooper & Schindler, 2006). Each interview is planned to last for approximately one hour to one and a half hours and will be recorded so it can be codified later and the interviewee can control statements made. This is done to make sure that the data obtained is correct.

- Interview type; the type of interview chosen is semi-structured interviews, because it opens up for the possibility to go into a dialogue with the interviewee (Cooper & Schindler, 2006). This is important for the actors approach since it also creates a common language between interviewer and interviewee, which is needed to understand the perception of the interviewee (Arbnor & Bjerke, 2009). Bias of an interviewee trying to answer the question the way the interviewer wishes is also reduced using this method (Shadish, Cook, & Campbell, 2002). Room for additional questions or information is reserved for each interview. This is done so the interviewee can share all the knowledge they have on the subject even if it is not (directly) asked during the interview. It also allows providing recommendations that are more appropriate for the management of Grisnich. By conducting interviews an understanding of the current situation is obtained. Important for gaining this understanding is the sample and order of the interviews done.

- Interview sample; the first interview will be conducted with the head of engineering. This is done, because the head of engineering has the overview of the activities of the engineering department and will possess knowledge of possible improvement areas. Interviewing the head of engineering will result in a quick global understanding of current situation. After interviewing the head of engineering the other interviews will be planned with key persons that possess valuable information. The second interview will be held with someone outside the engineering department. This is done to see how knowledge is exchanged with the other departments. The key person for this interview is the head of production from the management team. This person is constantly involved in the projects that take place within the organisation. On top of that he possesses knowledge about the relationships between departments and possible shortcomings.

  After two persons with an overview of the whole process four persons with a specific function will be interviewed. First, an engineer will be interviewed to understand his perspective; because the recommendations are provided will affect this department most. Second, the head of production floor will be interviewed. He is daily involved in the communication between construction and design. Therefore, he has insights into the knowledge flows from engineering to construction and vice versa. Third, the purchaser will be interviewed. He is involved in the orders and materials being purchased and functions as an intermediary between suppliers and engineers. He advises about the construction methods available. Fourth, a sales manager will be interviewed to see what influence the sales have on the development of products via the knowledge they can extract from customers.

Interviews are not the only source of primary data collection. The other source of primary data collection is a questionnaire.

Questionnaire

The goal of the questionnaire is to gain additional insight into the knowledge available within the company. Interviews are conducted with key individuals, but since all the employees hold knowledge it is needed to gain an understanding of their capabilities as well. The focus of the questionnaire will be on individual knowledge and the perception individuals have on the development of different products.

- Structure; before this questionnaire can be conducted several preparations have to be made. Following the method described by Smith et al. (2005) a list of different contact categories and technological fields will be established with the head of the engineering department. During this dialogue with the head of the engineering department a better insight in the type of technologies that are used in the previous projects, but also to see what kind of contacts are used during a project or by a person in general can be obtained. This type of interaction is encouraged when using the actors approach (Arbnor & Bjerke, 2009). The questionnaire will be constructed in such way that questions concerning a factor of knowledge creation or knowledge transfer are grouped together (Cooper & Schindler, 2006). Questions will be (where possible) derived from existing questionnaires. This is done to ensure that the questions measure what needs to be known.

- Type of questions; the questionnaire will consist of closed questions for the contact categories and technology types (see section 3.4) and open and closed questions concerned with factors of knowledge creation and transfer that are not crystal clear after the interviews or are focused on individuals. The questions are all formulated in such a way that they can be filled out by checking boxes. Some questions will ask individuals about the skills and competencies they posses (mainly for the contact categories and technology types), while other questions are concerned with the perception that people have about factors of knowledge creation and knowledge transfer (e.g. a question about the level of mutual agreement on important aspects of a project). The latter type of questions will be formulated in such a way that they can be answered by using a 5-point Likert scale. For the development of the questionnaire mainly existing questions are used from the theory of the theoretical framework.

- Questionnaire sample; the questionnaire will be digitally sent to all the employees of the engineering, finance, purchasing and sales departments, plus the head of production, assembly and the warehouse. The employees of production are excluded, because the head of production is interviewed, as well as given a questionnaire. On top of that the head of assembly and head of the warehouse are also given a questionnaire. These are the persons who have the most frequent contact with the engineering department. This should provide enough information on how knowledge flows from the engineering department to production. To achieve maximum understanding of the questionnaire it will be formulated in Dutch. Anonymity is off course guaranteed. A total of 18 people are approached for answering the questionnaire (for an example of the questionnaire see Appendix D).

In addition to the interviews and questionnaire secondary data sources will be used. This is mainly done to see if the projects are executed the way the questioned people indicate. This data is used to support the statements made in the interviews and questionnaire.

3.3.2 Secondary data collection

Secondary data sources will consist of the analysis of previous projects according to production documents and the ERP system. Production documents consist of the hours of production per employee, technical drawings, parts lists and financial data. The ERP system registers all the activities that take place within the organisation. This system will also be used to gather data since the overall planning is included into this system. Previous projects are chosen as a subject of analysis, because they can provide an objective overview of the process of a project. They can show which people worked on the engineering of

a project and how long it took them. On top of that it can show if teamwork has taken place and how knowledge is used (this is done by looking at which people worked on which aspects).

The goal of collecting data from previously completed projects is to gain insight in the current situation on the knowledge creation and transfer practices that are not depended on employee perception. Main focus of the analysis will lie on the analysis of current organisational processes and routines, for example which people (knowledge) are assigned to which type of project. Although the analysis of the previous projects is perfect for the use of quantitative methods this will not be done. It is not the intention to perform quantitative analysis on the previous projects, because the analysis of the previous projects is done to gain additional insight into the statements made by the interviewees it does not serve as the main source of information, and second, the overall analysis is concerned with understanding why and how events occur, not how frequent. This means that no statistical analysis will be made on the previous projects. Analysis can, however, show whether or not an event occurs as indicated by the interviewee. Given this kind of goal and method, the analysis of previous projects will more or less have a control function.

With all the data collection methods introduced the next section provides an overview of the total research sample of this study.

3.3.3 Research Sample

The sources for data collection show three events for data collection, interviews, a questionnaire, and the analysis of previous projects. The central objective of this study is to provide recommendations to the management of Grisnich on how to create and transfer knowledge for different product types. With the three events for data collection an understanding of the current situation can be obtained. This understanding functions as the base for the recommendations provided at the end of the study. But how do the three events of data collection relate to each other?

The interviews are chosen so that they cover most of the departments of Grisnich. The departments that are not covered are the financial and administration department. The financial department is excluded, because it does not have any influence in the development of products at the moment and the administrative department consists of only two part-time working people and does not influence the development process of products either. Therefore, it is chosen not to interview them.

A questionnaire is chosen besides the interviews, because it allows analysing the knowledge available within the company. On top of that it creates the possibility to ask questions to all the departments of Grisnich in a relative easy way. This not only fills in the gap in the analysis with the financial and administrative department, it also adds to gaining a holistic view of the company at an individual level. The results from the questionnaire can be used to develop a knowledge map of the company and can provide an overview of the information flows.

With this understanding of the qualities of individuals at Grisnich the previous projects will be analysed to gain understanding in the organisational processes or the engineering, sales and production departments. These departments are chosen, because they form the core of the development process of new products and the available data concerns these departments. The main goal is to see what kind of knowledge is put into the process and how it is used. This analysis can function as a check to what is being said at the interviews and in the questionnaire. Table 3 summarizes the research sample of this study. In the columns the different departments are listed, while in the rows the different analysis tools are displayed. In the table itself the sample size is shown.

	Engineering	Sales	Production	Finance	Total per Method
Interview	N = 2	N = 1	N = 3	-	N = 6
Questionnaire	N = 6	N = 4	N = 5	N = 3	N = 18
Projects	N = 213	-	-	-	N = 213

Table 3 - Overview of Sample Size per Collection Method

As said earlier, the goals of the analysis are to objectively and subjectively determine how knowledge is currently created and transferred and to see what kind of (technological) knowledge is put into each project. But how can knowledge creation and knowledge transfer factors be measured?

3.4 Determination of Measurements

Knowledge creation and transfer are concerned with the network and knowledge of the individual. Following the method described by other scholars (e.g. Kogut & Zander, 1995; Smith et al. 2005) a list of possible answer categories can be beneficial for analysing a particular situation. A list of different contact categories (see Appendix B) has to be made before the factors concerning the network can be measured accurately. Contact categories are types of contacts an individual can have, for example, material suppliers, technology suppliers or customers. On top of that a list of technologies has to be made in order to accurately measure the factors concerning the knowledge of an individual (see Appendix C). With these lists in mind the factors of knowledge creation and knowledge transfer can be operationalised.

3.4.1 Measurements for Knowledge Creation

Knowledge creation capability is determined by ten different factors. Each of these factors has to be made measurable in such a way that they can provide insight into the current situation of knowledge creation and transfer practices. It is therefore important to determine what is to be asked for each of the factors. Scores of individual employees are not compared in the analysis. This is not needed, because the goal is to provide recommendations about the creation and transfer knowledge. Difference between product types, on the other hand, needs to be highlighted. This section will only summarize the measurements for the three categories of knowledge creation factors Appendix A provides a detailed overview of the measurement for each item.

- Knowledge stock; the aim of measuring the knowledge stock is to see what kind of knowledge is available within Grisnich. This knowledge can come in the form of experience – by measuring amongst others the years active in the industry, formal education – by measuring the highest degree of a person, or diversity – by measuring for example the known technologies of an individual. What also can be determined from the knowledge stock of individuals is what kind of products they have been working on and what their capabilities are.

- Knowledge network; by measuring the knowledge network the different relationships need to be determined. In other words, how the people of Grisnich are related to each other and who contacts whom for what kind of information. On top of that it can also provide an indication of the possibilities of expanding the knowledge stock or range of the network. This is measured by, for example, the number of direct contacts of a person, or the persons they search contact with to achieve their goals, but also the types of contacts an individual possesses.

- Organisational routines and processes; measurements for this are concerned with the attitude against risk-taking and teamwork, but also how processes are currently done. Is there a system for the storage and creation of knowledge, and if so, who does this system works? These are questions that will be answered by measuring the three factors concerned with the organisational routines and processes. Goal is to determine which processes are currently used for the development of products and how knowledge from these processes is created and transferred.

As said in section 3.3 most of the factors will be asked during in-depth interviews. The measurement for which this is not possible, or for the ones where additional insight is desirable a questionnaire will be held to gain this information or previous projects will be analysed. Appendix A provides a more detailed overview of what is measured per measurement of knowledge creation. Table 4 provides an overview of which factors are included in which data collection method.

3.4.2 Measurements for Knowledge Transfer

Following the same procedure as for the factors of knowledge creation, knowledge transfer is to be made measurable. As a guide for measuring knowledge transfer, items from the questionnaire by Ko et al. (2005) will be used. This questionnaire is based on the factors of knowledge transfer identified earlier by Szulanski (1996). For each factor the goal behind asking questions about the factor and the collection method will also be stated. Again, Appendix A provides a more detailed overview of what is measured per measurement of knowledge transfer.

- Learning factors; questioning the learning factors results in an understanding about the willingness of people to learn new things, but also about whether or not they understand each other when communicating. On top of that it also tries to determine whether or not people understand the complete picture and if there are people with which some find it difficult to communicate. Not only does this provide an indication of the willingness and ability of employees to learn new things it also gives an understanding of how new things are currently received.

- Motivational factors; these factors try to determine what motivates people to do their daily job, but also what they feel is the best thing about doing what they do currently. This is questioned in order to determine if monetary means or other incentives need to be used to stimulate the development of products and get the employees involved in the process.

- Communication factors; these factors need to make measurable how good people are in communicating (i.e. the encoding and decoding of information) by questioning the preferred communication methods and the current quality of the communication. On top of that they need to determine whether or not the people or Grisnich trust each other.

Appendix A provides a more detailed overview of the measurements of knowledge transfer. As said earlier all factors will be asked during in-depth interviews. The factor for which this is not possible, or for the ones where additional insight is desirable a questionnaire will be held to gain this information. Table 4 provides an overview of the measurements and the data collection methods in which they are used.

3.4.3 Measurements used in each Data Collection Method

In the previous sections an indication of the measurements for each factor of knowledge creation and transfer was introduced. Appendix A provides a more detailed description of each measurement and states the collection methods for each measure. Often this is at two different collection points, because it creates the opportunity to crosscheck important statements made or can be viewed from a different perspective (see Appendix A). Table 4 provides an overview of the factors questioned during each method for data collection thereby displaying the link between the measurements and data collection.

	Knowledge Creation										**Knowledge Transfer**						
	Knowledge Stock			Knowledge Networks				Org. Routines and Processes			Learning Factors			Motiva-tional Factors		Commu-nication Factors	
	Experience	Formal Education	Knowledge Diversity	Number of Direct Contacts	Network Range	Strength of Network Ties	Structural Holes	Climate for Teamwork	Climate for Risk Taking	Organisational Memory	Ease of Relationship	Shared Understanding	Absorptive Capacity	Extrinsic Motivation	Intrinsic Motivation	Source Credibility	Communication Competence
I				x	x	x	x	x	x	x	x	x	x	x	x	x	x
Q	x	x	x	x	x	x	x					x	x	x	x		x
P	x		x					x	x	x							

Table 4 - Overview of Measurements for Different Data Collection Methods

The interview measures all the factors from knowledge creation and transfer apart from 'knowledge diversity'. This is done to gain an understanding of the current situation as possible. Knowledge diversity is not questioned, because this can be measured during the questionnaire and project analysis sufficiently. The focus of the interviews will lie on the perception the individuals have on the different factors and how they feel that their department experiences the factors.

The questionnaire measures all the factors concerned with individual knowledge stocks, individual knowledge networks, motivation, and communication competencies. These factors are not questioned to the employees as indicated in Table 3. The focus of the questionnaire will lie on the perception the individual has about the current situation of knowledge creation and transfer.

The analysis of previous projects will mainly focus on the organisational routines and processes and the knowledge that is put into these processes. Since this is an important aspect of knowledge creation and transfer the factors will be questioned during the interviews to gain detailed explanations of each factor. The previous projects are then analysed to see whether or not these explanations are correct in practice. Previous projects are chosen because they provide objective data about the current situation.

Difficulties for Data Collection

In the theory a distinction is made between standard and custom products. In the introduction and problem analysis (see chapter 1) it already became clear that this distinction is difficult to have in practice. When collecting data this needs to be taken into account, to do so several precautions are taken: (1) during the interviews questions will be introduced by an example of a specific product type if relevant, (2) every relevant question in the questionnaire will be asked for a specific product type, and (3) in the project analysis a differentiation will be made between standard and custom products.

With the methods and measurements determined the only thing missing is the method for data analysis. Not only will that section focus on how data is analysed, it will also explain why it is necessary to measure factors at different levels and state how the analysis relates to the central question of this study.

3.5 Method for Data Analysis

To perform a proper analysis a method for data analysis is needed. Key is to use a method that allows the formulation of recommendations later in the research. The goal of the data analysis is to determine the current situation of knowledge creation and transfer practices within Grisnich and the current balance there is between the development of different products. This is done by analysing the primary as well as the secondary data gathered. First the conducted interviews will be analysed, after which the questionnaire and the previous projects will be analysed to create a complete understanding of the current situation. Combining insights from all analyses allows creating a complete understanding (Arbnor & Bjerke, 2009).

3.5.1 Primary Data Analysis

The two sources of primary data (interviews and questionnaire) are analysed separately. The method of analysis differs and will be discussed below.

Interviews

Interviews are the main source of primary data collection. All planned interviews were executed with individuals from different departments. Due to the fact that one of the sales persons left the company the interview was executed with another person from sales. Although this was different from the original plan, this had no influence on the expected expertise present in the interviewee. The interviews lasted between 58 and 73 minutes and where recorded as planned. The interviews will be recorded and codified in the form of extended summaries. This is done to find out what the answers actually mean and later be able to compare answers from different interviewees.

The method used for codifying the interviews is based on the method described by McLellan, MacQueen and Neidig (2003). The method contains of seven points: (1) preserve the morphologic naturalness of transcription - the word forms and sentences should be kept as close to what is said as possible, (2) preserve the naturalness of the transcript structure - the text should be clearly structured so that the interviewee can easily read the interview back and understand it quickly, (3) the transcript should be an exact reproduction - text should not be reduced where this is not possible. It is key not to delete explanations, because this causes misinterpretations (Arbnor & Bjerke, 2009), (4) the transcription rules should be universal - transcriptions should be made for both human and computer use, (5) The transcription rules should be complete - no statements made by the interviewee can be left out, because they do not suit the researchers believes, (6) The transcription rules should be independent - they should be understandable to everybody and be usable by other interested researchers, and (7) The transcription rules should be intellectually elegant - rules should be kept limited in number (no long transcriptions), simple and easy to learn.

By laying the codified interviews side by side an understanding of the current situation from different perspectives of the organisation should be gained. For each of the factors of knowledge creation and transfer questions are asked and by comparing the answers given to these questions an overview of the current situation for that factor should be gained. Combining the factors should provide a detailed description of the current situation of knowledge creation and transfer within Grisnich, which is also the goal of this process. To support this description data from the questionnaire (for example on the factor of knowledge diversity) is used. How this data is analysed is explained in the next section.

Questionnaire

Fifteen out of 18 people answered the questionnaire, meaning an 83% response rate. This can be clarified, because the majority of the individuals that did not answered or handed in the questionnaire are part-time employees, or do not work at the company any more. All people who did not answer the questionnaire before the deadline where personally contacted and this resulted in 4 more questionnaires handed in. During the questionnaire the factors concerning individuals' knowledge stock, network, motivation and communication are asked in the questionnaire. Looking at these factors one can see that there can be done more analysing these figures than just quantitative statistics.

The factors concerning individuals' knowledge stock (experience, formal education and knowledge diversity) are analysed to see who knows what. By simply listing the experiences, educational levels and known technological fields of the respected individuals an overview of the current knowledge stock is gained. The factors related to an individual's network (number of direct contacts, network range, strength of network ties, and network position) are analysed to see how the internal knowledge network currently is situated. This is done using the network analysis method described by Stein (1992). He developed a method for analysing network and determining the key knowledge individuals and information sources. The method is appropriate for sample sizes between the 15 and 100 respondents, which make it perfect for this study. Goal of this analysis is to see how the employees of Grisnich are linked together, retrieve knowledge, and how the communication flows are. Motivational factors (extrinsic and intrinsic) are analysed to see how people currently are motivated, which is done by summating the answers of individuals. The last factors from the questionnaire are about the communication within Grisnich (shared understanding, absorptive capacity, and communication competence) the answers to these questions are used to check and where possible support the statements made during the interview. The answers provide an indication of the correctness of the perception of the interviewee (e.g. if the head of engineering says communication is easy and everybody has the same goal to work for, but the engineers themselves all state that communication is very difficult, the perception of the interviewee is not corresponding with the perception of the employees).

By laying the analyses of the questionnaires side-by-side a more detailed overview of the current situation of knowledge creation and transfer is provided. A knowledge map of the employees, as well as their communication linkages are gained from the analysis. On top of that, this overview differs from the one

gained by conducting interviews on the level of detail. The interviews describe the current situation more from a department view, while this analysis goes to an individual level. How knowledge is used during organisational processes is analysis during the analysis of previous projects.

3.5.2 Secondary Data Analysis

Secondary data comes from the project analysis. Factors that are analysed are mainly concerned with organisational routines and processes and the knowledge input into these processes (experience, knowledge diversity, climate for teamwork, climate for risk-taking, and organisational memory). For the project analysis data was used from the year 2002 till 2010. In these seven and a half years 213 projects where executed and they are all included in the analysis. The main goal of the project analysis was to find out how the engineering department spends their time.

Experience and knowledge diversity are analysed by how diverse they are put into a project. In other words, how heterogeneous the group that works on a project is. Heterogeneity is depended on a number of groups and the population's distribution among them. Using a so-called heterogeneity index allows to compare different groups to each other by their diversity (Blau, Blum, & Schwartz, 1982). Such an index will be used to see how diverse the knowledge put into different groups was.

Organisational processes are analysed using the ERP system to see which people are performing which tasks. Having in mind the knowledge and contacts individuals' possess and seeing which tasks they perform can create a picture of the organisational processes. For example, how many people are working on a project simultaneous and which knowledge do they have, or do employees are often assigned to develop similar products? Results of this analysis will be in the form of an overview of how knowledge is put into the development process. But also how knowledge is used during the process and when knowledge from the past is used. The next section provides an overview of the total analysis.

3.5.3 Analysis Overview

The analysis of the current situation is done in three steps. The first step is done by conducting interviews. This step provides the most information and is done in collaboration with key individuals within Grisnich. On itself this step is able to provide an overview of the current situation of knowledge creation and transfer. To provide accurate recommendations some aspects require more detailed information, for example on individuals' knowledge stocks, this information is gained in the next two steps. The second step is completed by holding a questionnaire and asking individuals information about themselves on the fields of knowledge stocks, knowledge networks, motivation, and communication. This results in a better understanding of the available knowledge and a detailed overview of the business network and knowledge within this network, for example, an overview of who contacts whom on a daily basis. The final step is the project analysis in which the input of knowledge and the use of it during the development process is analysed. This provides additional insight in how knowledge is currently. The results from the three steps combined provide a detailed overview of the current situation of knowledge creation and transfer at Grisnich, thereby answering the second research question.

3.6 Summary of Methodology

This chapter elaborated on the methodology of this research. First the type of research was determined, after which the methodological perspective and the methods for data collection where chosen. The sample presented in the methods for data collection was chosen in relation to the central goal. Next, measurement for each knowledge creation and transfer factor where constructed and the goal of measuring each factor was stated. Finally the methods for analysis of the data were introduced. Together with the introduction of these methods an indication of the expected results was provided. The results of the analysis should provide a detailed description of the current situation, thereby answering the second research question.

With the ideal situation and methods for determining the current situation completed the first results can be created. Results will be in the form of a description of the current situation. This is done in the next chapter.

4 The Current Situation of Knowledge Creation and Knowledge Transfer

The results of this study are a description of the current situation on knowledge creation and transfer at the engineering department of Grisnich. Since the theoretical framework consists of six categories of factors of knowledge creation (knowledge stock, knowledge network, organisational routines and processes) and transfer (learning factors, motivation, and communication competence) the results will follow the same structure. As expected no distinction is currently made for the development of the different products, which is why the results describe only one scenario, that of the current development practices and it is not split out into different product types.

4.1 Knowledge Stock

From the theoretical framework it became clear that for the development of different product types, the discriminating factor is knowledge diversity. For standard products knowledge diversity is not important, while for custom products this factor is important. Experience plays an important role as well, meaning that for standard products it is needed, while for custom products it can be beneficial as well. The inverse applies for education, meaning it is important for the development of custom products and it can be beneficial for the development of standard products.

4.1.1 Results from Data Collection on Knowledge Stock

The first factor to analyse is the experience that the individuals at Grisnich have. Either in the industry or within the company itself, one can conclude that on average the individuals working at Grisnich are experienced. Industry experience (measured in the questionnaire) scored either 11-15 or 15+ years (the two highest categories) of experience in 73% of the cases, while company experience scored 60% of the respondents' answers in these categories. Looking at experience on the job, the score is still high with 46% scoring in the 11+ year of experience range.

But not only the years of experience are of importance, also the activities performed during these years determine ones experience (Kelley & Littman, 2004). Activities done by the engineering department are captured in the ERP system where a distinction is made between four types of hours; (1) engineering on a new order, (2) making documentation, for example CE-documentation, (3) engineering of a layout, this is mainly done for the sales department, and (4) engineering of repairs, meaning correcting the errors made during the design (see Figure 9).

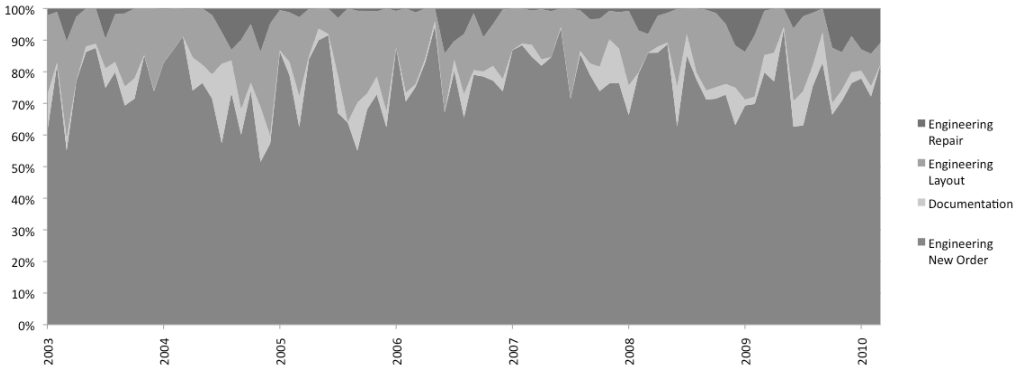


Figure 9 - Hours spend by the Engineering Department

From Figure 9, it can be seen that by far the most time is spend on engineering new orders, followed by engineering layouts, engineering repairs, and the least time is spend on documentation. Although this provides an indication of the time that engineers are working on new orders, it does not provide information on what these new orders are. It is therefore needed to specify the hours spend on working

on a new order into the machines produced by Grisnich, because it can provide a better insight in what amount of time is currently spend on developing the different product types.

From interviews with sales persons and engineers a list of products was determined. This list was then compared with the descriptions from the ERP system. Filtering the data of the ERP system allowed specifying the hours into nine categories (sorting machines, bins, box tipper, development, transport belts, specials, fall breaker, steps/platform, 3M). These categories and their distribution over time can be seen in Figure 10.

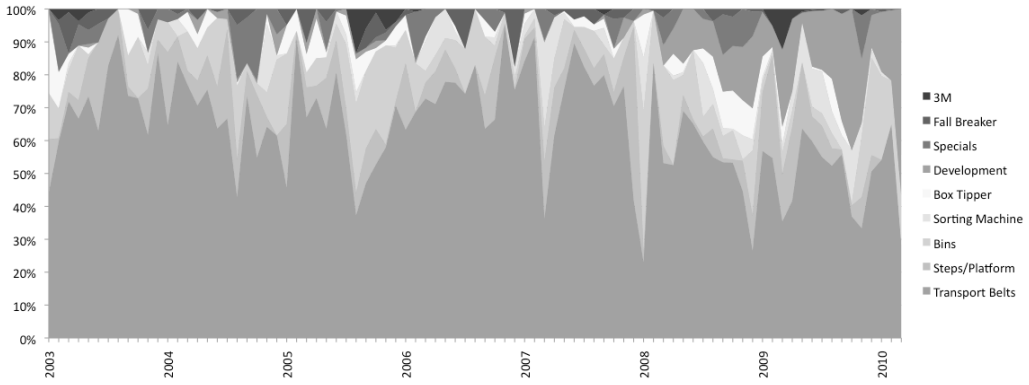


Figure 10 – Time Spend on Different Product

This distribution displays the product that consumes the largest part of the hours spend, which are the transport belts. Apart from that the graph is difficult to interpret. This changes when only the last three years are included (see Figure 11).

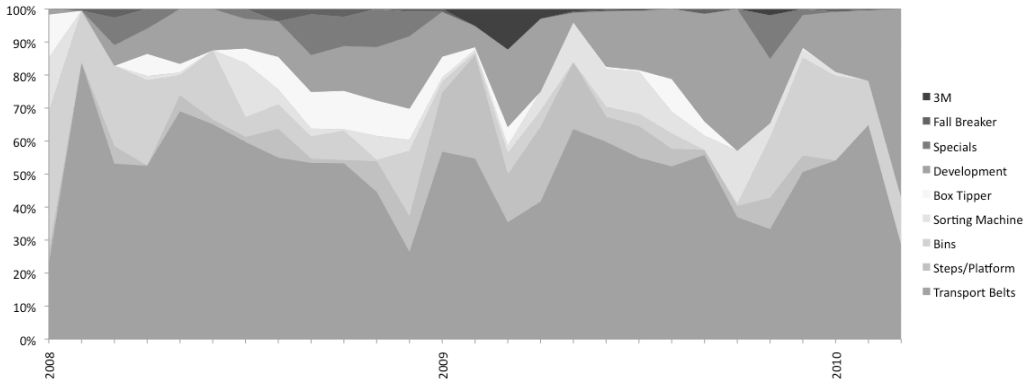


Figure 11 - Time Spend on Different Products (Last Two Years)

What becomes clear from Figure 11 is that in the last couple of years there has been a shift in activities, like the 3M decrease that can be explained by the 3M-productrange being (almost) discontinued. The most interesting one from the perspective of this thesis is the increase in development. This is because new employees have been hired and others started to focus more on the development of new products under the new management.

The second factor to analyse is the education level of the individuals. From the questionnaire it became clear that the average education level of the individuals questioned is at MBO level (10% a VMBO education, 66% a MBO education, and 24% a HBO education), indicating a low level of education. More than half of the employees (60%) have followed courses in the last years. These courses where mainly about leadership or other business related knowledge fields and very practically aimed, usually followed because of the start of a new function or because the job required additional skills of the employee.

The third factor to analyse is the knowledge diversity. The majority of the employees questioned have a technical background (93%), with more than half of the employees (56%) a background in mechanical engineering. This includes not only people from engineering, but also from sales and planning. Since the majority of the individuals working at Grisnich have a technical background they should be able to understand the technologies that go into the products. From the interviews it became clear that this is the case (all interviewees indicated that the technologies are understood by the employees). Taking a closer look at the technologies present in the products, 6 out of 25 where not indicated by the employees as being an expert on these technologies, nor anybody indicating they would like to follow a course on this field. No heterogeneity index is performed, because if a large project comes in all the engineers work on that particular project, meaning the same knowledge diversity is present. Taken into account what is said before, how can these results of the knowledge stock be interpreted?

4.1.2 Interpretation of the Knowledge Stock Results

Looking at the period of time the employees have been working in the industry and the company. One can obviously say that they are working there (on average) for a long time. Although looking at the function of the individual employees this is in general not as long as they have been working for the company, they still can be categorised as experienced. Therefore experience in the current situation is given a plus sign.

The average formal education level is low. But people are willing to learn and have shown to do so. This can offer perspective when needing additional knowledge in the future. Since the courses followed in the past years by the employees where all aimed at improving day-to-day activities and where not of a high level. Formal education is given a minus sign.

Since 93% of the employees have a technical background and more than half (53%) has an education in mechanical engineering the knowledge diversity of the employees of Grisnich is low. Add to that the fact that 6 out of 25 technologies that go into the products are not believed as having an expert on, classifies the current knowledge diversity as low, thereby it is given a minus sign (see Table 5).

	Ideal Situation Standard Products	Ideal Situation Custom Products	Current Situation
Experience	+	±	+
Formal Education	±	+	-
Knowledge Diversity	-	+	-

Table 5 - Results Knowledge Stock

With the results of the knowledge stock determined, the same needs to be done for the knowledge network.

4.2 Knowledge Network

The optimal knowledge network differs for the development of different product types as became clear from the theoretical framework. For standard products an open or closed network with a high number of direct contacts and strong relationships with those contacts is needed. While for the development of custom products an open network is needed with a divers range of contacts and strong relationships with network contacts. The knowledge network of Grisnich is explained next.

4.2.1 Results from Data Collection on Knowledge Network

The first factor to analyse is the number of direct contacts. The number of direct contacts differs highly between the different employees of Grisnich. Although the employees know each other well, some of them appear not to have other business relationships. This limits the total number of direct contacts. Others do not have a small network, but a relative large. Looking at the engineering department one can say that with an average of 9 different contact groups and an average of 4-6 people in that network, the individuals from the engineering department have a smaller knowledge network than that of, for example, the sales department with an average of 17 different contact groups and an average of 7-10 people in these groups.

The second factor is the range of the network. As can be seen from what is said above the network range differs between the employees of Grisnich, some only indicating four different contact groups, while others indicating up to 20. The same can be said internally, with people indicating they only need one single person to reach their goal, or people indicating they need five people to do so. From these lists of needed contacts it became clear that there is limited contact with suppliers about possibilities to incorporate new technologies into the current designs. It was confirmed during the interviews (2 out of 6 interviews confirmed this). The only contact currently present is via the purchase department.

The third factor to analyse is the strength of network ties. From the interviews it became clear (all interviewees confirmed the question) that the industry in which Grisnich is operating is characterized as a "like-knows-like" network, meaning that all actors in the network know each other, thus a closed network. Partially this is due to the small size of the Dutch part of the industry, but also there is a rumour circuit. This implies that the actors often meet each other, for example on exhibitions or other industry related events. Even though this is the case there is not a good overview of the market and especially not of the market needs. There are a lot of potential markets and customers as well as opportunities in related customer segments (e.g. small packaging industry or light "farmer" industry). Currently, however, these are not explored extensively. Internally the strength of the network ties can be interpreted as strong with 27 out of 32 indicated tie relationships as strong (4+ ranging on a scale of 1-5).

The fourth factor to analyse is the network position. Internally everybody knows each other. This became clear from the questionnaire, where all employees indicated to know all the departments, became clear during the interviews where interviewees named people when they gave examples assuming that the names are familiar to everybody and it this is seen in the daily activities as well. There is, however, not much communication between Tolsma and Grisnich (all interviews confirmed this). The sales departments of both companies, for example, are starting to work together increasing the capacity of the sales department by 18 people (Grisnich currently has 3 people working in this department). The goal of most interviewees is to go and cooperate more intensively with people from Tolsma. Overall, this means that the internal knowledge network of Grisnich can be considered as a closed network. Figure 12 displays the current knowledge network of Grisnich.

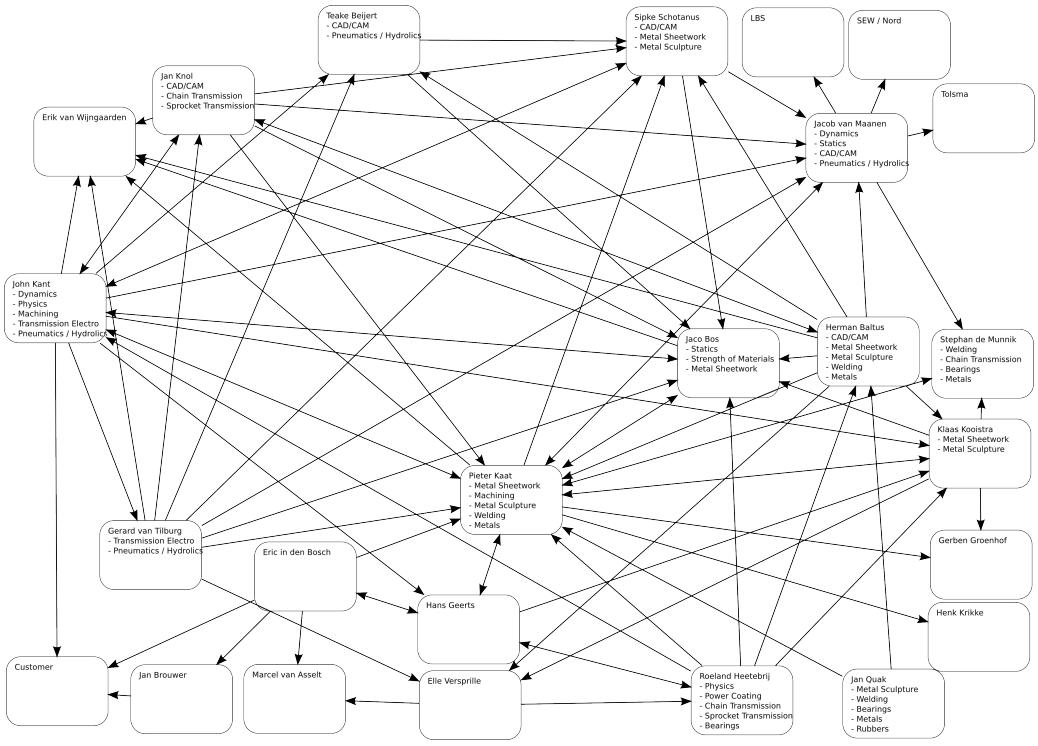


Figure 12 - Knowledge Network of Grisnich

The knowledge network is established by letting people answer questions concerned with which persons they searched contact to achieve their goals, or in need of expertise. On top of that the technologies included in the products where displayed and individuals where questioned on which technologies they felt like they where an expert. This is combined with the name of the person in the rounded rectangle in Figure 12, the arrows indicates which person contacts whom.

4.2.2 Interpretation of the Knowledge Network Results

The number of direct contacts needs to be high for the development of standard products and could be high for the development of custom products. This is, however, not the case. Internally everybody knows each other, but that is not enough to classify each ego network to consist of a high number of direct contacts. This is because the company is a small company and it is difficult not to know each other. The discriminating factor is the other types of direct contacts an individual has, for example, with suppliers or research institutes (i.e. external contacts). Some individuals score high on these types of direct contacts, for example, the CEO and the sales department, but that are in total only four people. That is not enough to score the current situation with a high mark. Because of the low number of direct external contacts, the number of direct contacts is given a minus sign.

Looking at the network range and thereby sources of new knowledge, one of the first aspects that became clear from the interviews was the source of new knowledge for the company. New knowledge is only gained from experience (reports) from the sales department. Sales persons have contact with (potential) customers and determine their needs; this is then translated into technical specifications for engineering. Due to this process it becomes clear that the sales department is dependent on their experience and knowledge in the field since they determine for a large the knowledge stock of the engineers. The company is not subscribed to any kind of technical magazines or journals. With the attraction of a new head of engineering and an extension of the sales department there are efforts made to increase the network range. Therefore the network range is given a plus-minus sign.

With the high number of individuals rating their relationships as strong and all interviews confirming the tight relationship people have with each other. The frequent contact that employees have with each other and the long lasting relationships they have allows giving network tie strength a plus sign.

What can be concluded from Figure 12 is that there are a lot of people contacting each other. The person who is contacted the most is the head of the production floor. The only persons who have contact with the customer are in a sales or sales related function. From the filled out questionnaires it also became clear that there is no distinction made by the employees of Grisnich between the engineers, since a lot of people just filled out “engineering department” at the question who they contacted the most. This results in the engineering being contacted by the same persons in the knowledge network displayed above. What can be said from the knowledge network is that there are some individuals that have a lot of arrows leaving them and some individuals have a lot of arrows pointing to them. One example of an individual having a lot of arrows leaving him is the internal sales person (Gerard van Tilburg). One can conclude from this that the current network position of Grisnich is a closed network (internally) and given the fact that it is a small industry the external network position is also closed, meaning few structural holes (see Table 6).

	Ideal Situation Standard Products	Ideal Situation Custom Products	Current Situation
Number of Direct Contacts	+	±	-
Network Range	±	+	±
Strength of Network Ties	+	+	+
Structural Holes	±	+	-

Table 6 - Results Knowledge Network

With the knowledge network of Grisnich analysed the last category of factors of knowledge creation is left, the organisational routines and processes.

4.3 Organisational Routines and Processes

As can be seen in the theoretical framework, organisational routines and processes play an important role in the development of different product types, but also provide two of the four discriminating factors when developing standard products or custom products.

The development of a standard product requires a high use of organisational memory, but apart from that it does not require a climate for teamwork or a climate for risk taking. On the other hand, organisational memory is not required that extensively for the development of custom products, but a climate for teamwork and risk taking is required though. Since these two descriptions are quite distinct from each other it is interesting to see what the current organisational routines and processes are.

4.3.1 Results from Data Collection on Organisational Routines and Processes

Before going deeper into the aspects of the organisational routines and processes, it is important to know is the current development process. Remarkable is the fact that there is no distinction made between the current sales process and the development process. It is grown from the past that products are made according to customer specifications (interview sales manager) and therefore engineered according to their needs (interview engineer). From the interviews the following process from sales until assembly can be determined (see Figure 13).

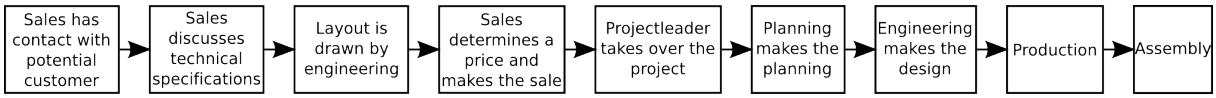


Figure 13 - Process Flow

With the process flow known the aspects of the organisational routines and processes can be further elaborated. The first factor is the climate for teamwork. From the interviews no clear preference was stated. Production, engineering and sales currently all work individual and apart from engineering they have a clear preference for working this way. Reasons for working this way are for the sales department that when working in teams information can get lost during transition (interview sales manager) and for the production because it has grown from the past. Another aspect for working individually is the quality of the products. Since it is, for example, not indicated where the welding should be done exactly the construction workers are free to welt at any place. This differs per construction worker, so if multiple people are working on a single product quality issues could arise (interview head of production floor). Speed was also provided as a reason for working individually (interview sales manager). It is believed that when working individually tasks can be completed faster, especially tasks with urgency (interview head engineering). For the head of production working in teams is the preferred method, because greater successes can be achieved this way (interview head of production).

Looking at the project analysis teamwork cannot be made explicit. From the almost 21.000 records in the ERP system only 107 indicated the same date, customer, order number and different engineer, indicating that there was teamwork on the same order going. It can be the case that people are working on projects or helping each other without assigning their hours to it. On top of that there is deliberation within and between the departments of Grisnich. For example, a worker together with the head of the production floor formulates a method for the construction of a product. This is determined before the actual production starts. During this deliberation the best method for construction are discussed, together with possible difficulties indicated by the engineering department on the drawing (interview head of production floor). On top of that every Monday there is a deliberation of the current projects with the planning, work preparation, purchasing, production and engineering departments. In this deliberation the current projects and their issues are discussed. This has been introduced lately in order to stay on top of things and create an overview of the activities. During these deliberations the input of the team members can be described as equal. Everybody is motivated and there is a healthy curiosity, although it does differ

per project. At the time of the interview this working method has been in use for about three months (interview head of production).

As said before the engineering department does not have a clear preference for working individually. In the last three months the engineering department has functioned without a head of the engineering department, due to the leave of the former head of engineering. In this period the collaboration between engineers has increased significantly (interview head of engineering; interview engineer). The main advantage seen of working together is the increase in responsibility for each individual (interview head of engineering).

The second factor to analyse is climate for risk taking. When questions are found in the market they are not asked directly to engineers. Reports of visits are made and spread throughout the company. The sales department is willing to take responsibility for new products (often "invented" by the sales department). It is desirable that this is the other way around though (interview sales manager).

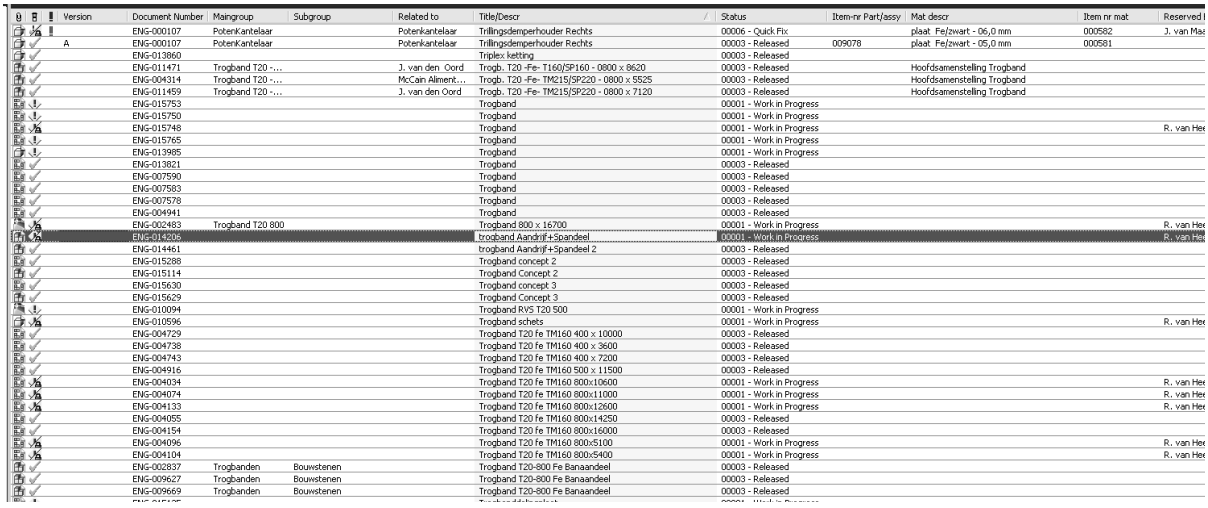
Risk in the form of time challenges are most liked by the head of production floor. But also the construction of new products is something he likes. On top of that the construction workers also like the construction of new products. Looking at the ratio of how conservative the construction workers are it is about 50-50 on conservative and non-conservative (like to take challenges). Major decisions on the other hand are always taken on the conservative side. This is, because quality and robustness are important to Grisnich. Challenges are good, but within the limits of what is possible. Products often get turned down, because there is no believe in them (interview head of production floor).

Size as well as technical complexity and time pressure are seen as challenges and require the will to take risks (head of production). When looking at major decisions taken in the last years, departments can be described as conservative (all interviewees confirmed this statement). Reasons provided for this range from concerns about the current financial situation of the company (interview purchaser) to statements saying that no risk full decision have to be taken if you do not search for them (interview engineer), or we had always done it this way (even though it is not true)(interview head of engineering). Currently decisions are made with the thought in mind that there is no project after the current one. This implies that work gets done slower or jobs are sought for people, for example, not outsourcing simple activities but doing them intern (interview head of production).

The last factor is organisational memory. Organisational memory consists of three phases: (1) acquisition of information, (2) retention, (3) retrieval (Walsh & Ungson, 1991). The sales department mainly does the acquisition of information from outside the company, while the internal acquisition of information (e.g. improvements in assembly or production processes) is mainly done in a practical sense or through verbal communication (all interviewees confirmed this). During the development process with 3M there was more contact between the different development partners to determine an optimal strategy for using everybody's competences. This is currently not done (interview purchaser; interview head of engineering). Also internally it is hard to get the knowledge from the production floor to the engineering department. During projects problems are solved, but no structural solution is found during these problem solving activities (interview head of production floor).

Retention of information is lacking currently, often discussions about making explicit the positive and negative aspects of a project have been made. There is a need to know what went good and what went wrong, but no actions are taken to realise this. It is often seen as a task of engineering to remember the positive and negative aspects (interview sales manager). Currently the calculations of a project are not a priority, this means that it basically does not happen at all. If it does happen, however, it is not as accurate as it should been (interview head of production). Another way for the retention of information is trough the processes or structure of the organisation (Walsh & Ungson, 1991).

Looking at the engineering process, one could say that the implementation of developments on product is dependent on the memory of the engineers (interview engineer). Currently two engineering systems are used, a 2D and 3D system. The goal is to migrate all the engineers to working with the 3D system. Currently there are difficulties with working with the 3D system; for example, the integration with the ERP system is only partially automated. For one part this is due to the lack of technical knowledge of the information systems available in the company or at the market. For another part this is due to the fact that not everybody is convinced that the current system is the optimal system (interview head of engineering). Also not all engineers are convinced of the added value of drawing in 3D, while the quality of the products engineered with the 3D system is higher (interview head of production floor). Although there are two systems, the engineering process remains roughly the same (interview engineer). The drawing of a product starts with the section of a similar product from a previous project (see Figure 14). This drawing is copied and given a name that describes the place in the current project. For example, a transport belt with a certain width is used as the input for the new drawing, in the description of this file the description is adjusted to the description for the current project (Title/Descr. in Figure 14). Then the drawing is adjusted to the specifications of the project, meaning that, for example, the transport belt is adjusted to the proper length and the correct motor and transmission are drawn (interview engineer). As can be seen from Figure 14 and from the description above the used method is not flawless.



Version	Document Number	Maingroup	Subgroup	Related to	Title/Descr	Status	Item-nr Part/assy	Mat descr	Item nr mat	Reserved
	ENG-000107	PotenKantelaar		Potenkantelaar	Trillingsdemperhouder Rechts	00006 - Quick Fix		plaat Fe/zwart - 06,0 mm	000582	J. van Ma
A	ENG-000107	PotenKantelaar		Potenkantelaar	Trillingsdemperhouder Rechts	00003 - Released	009078	plaat Fe/zwart - 05,0 mm	000581	
	ENG-013860				Triplex ketting	00003 - Released				
	ENG-011471	Trogband T20 -...		J. van den Oord	Trogb. T20 -Fe- T160/SP160 - 0800 x 8620	00003 - Released		Hoofdsamenstelling Trogband		
	ENG-004314	Trogband T20 -...		McCain Aliment...	Trogb. T20 -Fe- TM215/SP220 - 0800 x 5525	00003 - Released		Hoofdsamenstelling Trogband		
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	ENG-015753				Trogband	00001 - Work in Progress				
	ENG-015750				Trogband	00001 - Work in Progress				
	ENG-015748				Trogband	00001 - Work in Progress				R. van He
	ENG-015765				Trogband	00001 - Work in Progress				
	ENG-013985				Trogband	00001 - Work in Progress				
	ENG-013821				Trogband	00003 - Released				
	ENG-007590				Trogband	00003 - Released				
	ENG-007583				Trogband	00003 - Released				
	ENG-007578				Trogband	00003 - Released				
	ENG-004941				Trogband	00003 - Released				
	ENG-002483	Trogband T20 800			Trogband 800 x 16700	00001 - Work in Progress				R. van He
	ENG-014206				trogband Aandrijf+Spandeel	00001 - Work in Progress				R. van He
	ENG-014461				trogband Aandrijf+Spandeel 2	00003 - Released				
	ENG-015288				Trogband concept 2	00003 - Released				
	ENG-015114				Trogband Concept 2	00003 - Released				
	ENG-015630				Trogband concept 3	00003 - Released				
	ENG-015629				Trogband Concept 3	00003 - Released				
	ENG-010094				Trogband RVS T20 500	00001 - Work in Progress				
	ENG-010596				Trogband schets	00001 - Work in Progress				R. van He
	ENG-004729				Trogband T20 Fe TM160 400 x 10000	00003 - Released				
	ENG-004738				Trogband T20 Fe TM160 400 x 3600	00003 - Released				
	ENG-004743				Trogband T20 Fe TM160 400 x 7200	00003 - Released				
	ENG-004916				Trogband T20 Fe TM160 500 x 11500	00003 - Released				
	ENG-004034				Trogband T20 Fe TM160 800x10600	00001 - Work in Progress				R. van He
	ENG-004074				Trogband T20 Fe TM160 800x11000	00001 - Work in Progress				R. van He
	ENG-004133				Trogband T20 Fe TM160 800x12600	00001 - Work in Progress				R. van He
	ENG-004055				Trogband T20 Fe TM160 800x14250	00003 - Released				
	ENG-004154				Trogband T20 Fe TM160 800x16000	00003 - Released				
	ENG-004096				Trogband T20 Fe TM160 800x5100	00001 - Work in Progress				R. van He
	ENG-004104				Trogband T20 Fe TM160 800x5400	00001 - Work in Progress				R. van He
	ENG-002837	Trogbanden	Bouwstenen		Trogband T20-800 Fe Banaandeel	00003 - Released				
	ENG-009627	Trogbanden	Bouwstenen		Trogband T20-800 Fe Banaandeel	00003 - Released				
	ENG-009669	Trogbanden	Bouwstenen		Trogband T20-800 Fe Banaandeel	00003 - Released				

Figure 14 – AutoDesk® Productstream Professional Pro Window

If errors occur during production the drawings are adjusted to solve the problem. This is done to make sure that if additional elements are ordered by a customer the drawings used are correct with the products delivered. Often adjustments are made to previous drawings if it concerns a major flaw in the design of the product. This is because engineers are free to choose their starting point and should not start with a drawing with errors in it. Controlling this is difficult, because of time constraints not all drawings can be adjusted or it is simply forgotten (interview engineer). When the drawing is finished the individual components are exported to the ERP system, for the larger part of the drawing this is automated, but manual control is still needed to make sure everything gets filled out correctly (interview engineer).

The engineer is free to pick the drawing as input for the new product, meaning that from the window of Figure 14 the engineer has more than 30 options to select as a starting point. This implies that everybody selects drawings based on previous drawings of themselves or one they just believe lies the closest to the product currently needed. Although some products can (or should be) characterised as standard in practise there are no standard products and each product is adjusted based on a previous product. Major errors found during production or assembly are discussed with the whole engineering team, but not recorded or made explicit. This implies that engineers have to trust and relay on their memory to include adjustments to previously occurred errors. On top of that the engineer is also free to choose the description given to the product. This implies that although the products can be the same or fall under the

same category they can be named differently making categorising difficult. Engineers can reserve the files if they are working on them making sure that nobody can change the file during the process of another engineer working on it. In practise this leads to engineers needing each other's files or forgetting to release them for others (interview engineer). With the drawings completely put into the ERP system, prints are made from all the individual components and these are sent to the purchasing department and work preparation.

The work preparation department gets the drawings from engineering. It is assumed that these drawings are the latest version available. The 2D drawings could be adjusted by the work preparation, but with the 3D drawings this is not possible because there are no software rights for that. All the individual components are checked by work preparation and are where needed corrected or inserted into the ERP system, which makes the purchasing and accounting of the individual components possible. The drawings are then ordered and given to the head of production floor sorted into construction, sheet work and lathe work. He then gives the drawings to the individual workers. The workers are in principle capable of executing all the tasks that are required to construct a product. This means that there is no need to wait until someone is finished on a product to hand him the product, while some other worker is waiting. The distribution of the drawings is somewhat biased by the individual preferences of the workers or their individual qualities, but this is in theory not needed (interview purchaser).

Retrieval of information often occurs. Projects of the past are used, because one does not have to reinvent the wheel (interview sales manager). With developing custom products this is, however, not possible. Another factor to look into the past for solutions to problems is speed. Sometimes a customer is satisfied with a solution from the past, so this is recommended and often provided again. This sometimes means that obvious solutions are overlooked, because another standard solution is chosen.

In determining the method of construction, knowledge from the past is always used. A worker together with the head of the production floor formulates a method for the construction of a product. This is determined before the actual production starts. From engineering there is no construction method included in the design. Only if difficulties are expected a small note is included in the drawing. If flaws in the design are spotted the worker can discuss these with the engineer who has drawn the products (this is stated at the bottom of the drawing). The conflict is solved immediately, ensuring the worker can continue production (interview head of production floor).

4.3.2 Interpretation of the Organisational Routines and Processes Results

The climate for teamwork needs to be high for the development of custom products, but may be low for the development of standard products. From what is said in the previous paragraph one can conclude that the climate for teamwork is not high. Multiple departments indicated that they prefer to work individually and it is believed that tasks can be completed faster this way. Due to the leave of the former head of engineering a lot of knowledge and experience was lost. This resulted in the need for cooperation and deliberation. Although this was experienced by the engineers as positive the old routines and believes still cause the engineers to want to search for solutions on their own, or being almost afraid to ask questions (e.g. to suppliers for technical specifications). Taken all this into account the current climate for teamwork is given a minus sign.

The climate for risk taking again needs to be high for the development of custom products and low for the development of standard products. From the interviews factors of risk taking are within the technical complexity, time constraints or size of a project. Asking further into the matter, revealed that although this are factors on which risk can be taken, the interviewees see risks within the boundaries of the projects done. In other words, although technical complexity is named as a factor of risk taking, it is not seen as doing complete new things because it is believed solutions from the past can do the same job. So technical complexity is seen as the need to search a lot of projects from the past for solutions used there. All interviewees considered themselves or their departments as conservative when it comes to making major decisions. Concerning all this, the current climate for risk taking is given a minus sign.

Although Figure 13 provides insight in how a products is developed and though which stages it goes before it reaches the customer, from a knowledge perspective it is more interesting to see what the influence of different departments is in this process. Figure 15 displays the interpretation of the results and thereby displays the influence of different departments during the development process.

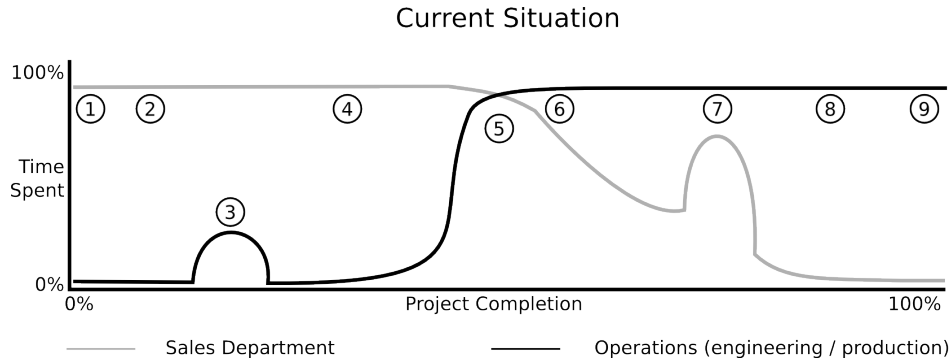

Figure 15 - Influence of Departments in Development Process

The numbers in Figure 15 correspond with the phases from Figure 13. On the vertical axis the time spent by the respected departments is stated. On the horizontal axis the time till project completion is stated. In the following process description the phases of the process (see Figure 13 and Figure 15) are indicated by using brackets including the respected phase number.

The process from order to product begins with the sales department contacting a potential customer (1). This first conversation is mainly to introduce one another. The second step, which can be done during the first meeting, is to discuss the technical specifications (interview sales manager). In general, this is done by the sales person without help of other people (e.g. engineers), engineers would like to contribute to this process, but currently this is not done (interview engineer). It can, however, be the case that the customer has done all the engineering work, this implies that Grisnich will be the executing party. With the technical specifications known in rough lines the engineering department will determine the layout of the new installation (3). The layout includes the (standard) products and the composition of them. This is then used by the sales department / and project leader to make a price (4). If the customer accepts the price the sale is made and the project leader takes over the project (5). This means, in theory, that the sales department is no longer involved in the project and can move on with acquiring another project. Practically the sales department stays involved in the process, because they know all the technical specifications and considerations made during the negotiation process which are needed during the design phase of the engineering department (7). Together with the project leader and the planning department a schedule is produced in which all the components of the project are given a beginning and end date so that the overall planning is known (6). This is the point where engineering starts to engineer the real products. The production process, sequentially, starts at the purchasing and work preparation department (8). This is where all the drawings are controlled and when needed corrected in the ERP system. Then the drawings are passed on to the production. The final phase is the assembly phase (9) where all the constructed and painted products are put together.

From Figure 15 it is interesting to see how large the influence of the sales department is on the total development process. Not only during the sales process, but also during the engineering process the sales department stays involved in the process, indicating not only their current importance, but also the difficulty of handing over a project (interview head of production) and their trouble to move on to a next project (interview head of production floor). Another aspect that is interesting is the relative short period of the process in which information (and knowledge) transfer takes place (3, 5, 7). This will be elaborated in the next three sections (see section 4.4, 4.5, and 4.6). The remaining of this section will focus on the methods used for the acquisition, retention and retrieval of knowledge.

The sales department mainly does the acquisition of information from outside the company and internally it is only done when problems occur. On top of that the main form of communication is verbal communication, which makes the acquisition of information very subjective. The retention of information is for the designs controlled in two phases of the entire process (7 and 8). This should minimise errors, but because the engineer is free to choose the design to start with (phase 3 and 7) and errors/problems are not made explicit flaws often occur. This makes the retention of information also subjective or biased. The retrieval of information can be done automatically or in a controlled way (see section 2.2.3). When knowledge is retrieved automatically standard procedures are used to retrieve information, while if knowledge is retrieved in a controlled way information systems are used. As said earlier, the design process (for the engineering department as well as the sales department) starts with the question: "Have we done this before?". This results in automatic retrieval of information leading to a routine response, in other words, the solution for the customer will be based on previous work and thereby be routine based or incrementally better. Since AutoDesk® Productstream Professional Pro software is used the retrieval of information is also controlled. This controlled retrieval process is initiated at all cases even when a non-routine decision needs to be made. So instead of contributing, this system actually disturbs the engineering/creativity process. Taken all this in account organisational memory is given a minus sign (see Table 7).

	Ideal Situation Standard Products	Ideal Situation Custom products	Current Situation
Climate for Teamwork	-	+	-
Climate for Risk Taking	-	+	-
Organisational Memory	+	±	-

Table 7 - Results Organisational Routines and Processes

Looking at the table above one can conclude that the current situation is better suited for the development of standard products than for the development of custom products. This is mainly due to the organisational climate that has grown this way from the past. To get a grip on either the development of standard product or custom products the organisational memory needs to be used in a better way.

With the knowledge stock, knowledge network and organisational routines and processes explained the factors of knowledge transfer remain to be discussed; this is done in the next sections.

4.4 Learning Factors

Learning factors are an important category for the development of custom products. From the theoretical framework it became clear that all the factors (ease of relationship, shared understanding, and absorptive capacity) are important for the development of custom products. For the development of standard products this is almost the same, ease of relationship and shared understanding need to the equal, but absorptive capacity can be low. The results describing the current situation are stated below.

4.4.1 Results from Data Collection on Learning Factors

The first factor to analyse is the ease of the relationship. It is obvious that a good relationship allows good knowledge transfer, but the opposite is true as well (Ko et al., 2005). Having a difficult relationship with someone can decrease the efficiency of knowledge transfer. From the interviews there can be defined three relationships that are relatively difficult: the relationship with the sales department, the relationship with the engineering department and the relationship with Tolsma.

The relationship with the sales department is hard to establish, because they have a very strong opinion (interview head of engineering). Often they determine solutions on their own and tell the engineering what to do. Although there is a dialogue later in the process (phase 7, in Figure 15) at the beginning of the process (phase 2, 3, in Figure 15) there is relatively little room for discussion (interview sales manager, interview engineer). On the other hand the sales department feels that a lot of expertise has left the company is the sales department (because of the leave of the former head of engineering). This has

implied that he has lost his sparring partner and thereby the man with whom he likes to discuss technical details. Another aspect of the lack of communication of the sales department is the fact that the information is often generalised by the engineering department so that it can be used for other projects. The competitive advantage lies in the details of a project and no generalised facts from other projects should be used, according to the sales manager. Consequently he now makes decisions on his own (interview sales manager). Looking at the questionnaire the relationship between the employees seems good, however, with 31 of 35 of important relationship being rated as good (score of 3+ on a 5 point scale).

As mentioned earlier mistakes that are not corrected directly, have the risk of not being corrected at all (interview engineer). On top of that the main form of communication is verbal communication, which also causes mistakes not to be made explicit (interview head of production floor). All this causes frustration with the other departments of the company, because it seems that nothing is done with the input they provide (interview purchaser; interview head of production floor). At the engineering department the blame is given to the CAD systems and the difficulty of the ERP system (interview head engineering). Another aspect mentioned by the engineering department as well as by the other departments is the fact that no "master drawings" are used, meaning a standard drawing that functions as a starting point for all new products made. The main reason for this is the transfer to the 3D drawing system (interview engineer). It is, however, believed that these master drawings need to be made (interview head of engineering). Overall these struggles lead to a difficult relationship between the engineering department and the other departments.

Tolsma, that acquired Grisnich (see section 1.1), provides the electrical elements and assembly work that goes into the products. Six out of six interviewees, however, stated not to have much contact with people from Tolsma. Reason provided for this is that Tolsma is not sharing the same thoughts about the products of Grisnich as the employees from Grisnich do. Since there are no electricians working at Grisnich the relationship can be seen as a supplier relationship, where products are just purchased. Also, during the development of the products there is no attention for the inclusion of electrical systems. This has let to situations where the design of a product had to be modified after its total assembly due to electrical work that needed to be included according to specifications (interview head of engineering).

Shared understanding is the second factor to analyse. Currently the understanding of the engineers depends on the completeness of the technical specifications of a project. No engineer is included in the current sales process (see section 4.3.2). Adding an engineer to the sales process in a later stage of the process is seen as beneficial, by the sales department (interview sales manager) as well as exciting by the engineers (interview engineer).

In the past Grisnich employed their own electricians, currently the electricians of Tolsma assemble the electronics needed in the products. There is, however, no communication during the design (interview engineer) or during the construction (interview head production floor) about the electronics, so no preparations are made for them. This causes long work on the assembly of electronics in the system. It is also not known what the electricians would prefer in the design to make the assembly easier. This is, however, not a made choice but grown from the past. Currently the head of the production floor coordinates the assembly of products (interview head of engineering; interview head of production floor).

On the production floor everybody is familiar with the technologies that are put into the products (also see section 4.1.1). This is mainly because when new products are developed they are not becoming more complex. It are incremental changes and there is notion for it, because the quality of the products increases. Due to standardisation in the drawings provided construction workers are less dependent on knowledge of others for construction (interview head of production floor).

In the last couple of months a prototype was engineered for a new transport belt and the drawings were given to the production department. After constructing the prototype it was transported to an area of the

production floor where nobody would see or notice it. This was done because none of the production workers liked the design since it used technologies from the 80's and had a cheap build-quality. There has been no communication between the engineering department and the production department, although the production department is willing to function as a sparring partner in the development of products (interview head of production floor). The same was true for the development of the 3M products. On top of that the development went chaotic, because parts of the development were outsourced and sometimes not (interview head of engineering). Not only do these examples illustrate the lack of shared understanding, they also point towards the relative difficult relationships mentioned before.

A couple of years ago there were a couple of journals on which the engineering department was subscribed. This allowed the engineering department to see what the movements of the sector and industry were in which they operated. Currently there are no subscriptions to any of these journals, only on management-focussed journals or non-technical journals. The journals were written often and it allowed discussion within the engineering department (interview engineer).

Absorptive capacity, the last factor to analyse, is about the ability to oversee the total stream of information and be able to understand it and apply it. On of the elements to test this, was questioning whether or not the vision of the company was clear. For the sales manager the vision is not clear, the same is true for the head of engineering. The most difficult part of the understanding of the vision is how to relate this to the daily activities and why thinking so far ahead can currently be beneficial (interview sales manager; interview head of engineering). For the production department this is different. There is an understanding that things need to change, but not how these need to be changed. This causes resistance to that change, mainly due to the fact that the vision is being imposed (interview head of production floor).

Another element of absorptive capacity is the ability to oversee the entire flow of information. One element that is hard for everybody at Grisnich is the ability to see the entire picture, this cause people to get stuck into the daily routines or details (interview head of production). The purchaser makes an example supporting this statement where he states that engineering can save him hours of work on a project by filling in the technical specifications in the ERP system and sorting the drawings provided to him. This is, however, more work for the engineering department, about one to two hours of work. Currently it is only done sporadic though (interview purchaser).

There is an understanding of what goes into the products, because they have not been making new products in the last years. The only real development that has taken place is the development of the 3M book sorting machines. One aspect that became clear is that the employees were not able to understand all the technology that went into the products. Another aspect that can be learned from the 3M development is the fact that it was difficult for engineers to work with standardised procedures and forms that needed to be filled out. Rapid change of components was hard for the company and the ability to gain support from everybody. This has let to drop in quality and a lot of people not understanding each other, or the process they were included in (interview purchaser). What can be seen within the engineering department (and confirmed in the interviews) is that some persons do not want to develop new things, but just want to perform their own activities. This causes them to being closed to new knowledge made available in the engineering department.

4.4.2 Interpretation of the Learning Factors Results

As stated at the beginning of this paragraph this is an important element of knowledge transfer with almost all the factors needed to be high for the development of standard products as well as for the development of custom products.

The first factor of analysis was the ease of the relationship. As became clear from the results there are some relationships that are not optimal and relative harsh for the transfer of knowledge. These relationships include the relationship with the sales department, the relationship with the engineering department and the relationship between Grisnich and Tolsma. When these relationships are placed in

perspective to the development process (Figure 15), one can see that this causes potential problems in the phases 3, 5, 6, 7, and 9 (see Figure 15) because in these phases knowledge needs to be transferred between or towards one of more of the respected departments. This indicates difficult knowledge transfer process. Results from the questionnaire on the other hand indicate the opposite, where the majority of the individuals state that they have no problems with sharing information and communicating with others. This can be explained by the fact that the majority of the employees have been working together of a long time and the company culture is very informal. On top of that it needs to be said that during the period in which this research has taken place there was no pressure due to a high demand. Therefore the relationship was not tested thoroughly. Taken all this into account the factor ease of the relationship get given a plus minus sign, because the informal relationship is good, but there are structural issues that will submerge during times of pressure downgrading the efficiency of the knowledge transfer.

The second factor to analyse was shared understanding. On the technological field the shared understanding is good. Everybody understands the technology and knows why certain elements in the design of the products are the way they are. When it comes to developing new products on the other hand the shared understanding decreases. For example, there is the understanding that things need to change, but how and in what direction is not clear. Looking that the development of new products, there is no single factor on which all departments agree new products should be developed on (all interviews). Factors that are often stated (in 5 out of 6 interviews) are factors that are present in the current products, the same products on which was agreed they needed to change. To generalize the statement there is a shared understanding of the past, but no shared understanding of how the future looks like. Taken this into account, shared understanding gets a minus sign.

The last factor was absorptive capacity. Absorptive capacity is concerned with three aspects, being able to create an overview, being able to understand it, and apply it. From the results it became clear that the creation of an overview is hard for most of the employees. First of all it was stated literally in one interview (interview head of production) but it also became clear from the example of the purchaser. The second part is to be able to understand the overview of information. This is also hard for the majority of the employees. The examples from understanding the vision of the CEO support this. The last part of absorptive capacity is the ability to apply the overview of information. This again is hard for the majority. Their daily activities are not the problem, but translating a vision into daily activities is. Since all three aspects of absorptive capacity have a low score absorptive capacity is given a minus sign (see Table 8).

	Ideal Situation Standard Products	Ideal Situation Custom products	Current Situation
Ease of the Relationship	+	+	±
Shared Understanding	+	+	-
Absorptive Capacity	-	+	-

Table 8 - Results Learning Factors

With the learning factors or knowledge transfer analysed, the next category of factors for analysis is the motivation factors.

4.5 Motivation

Motivation is important for the transfer of knowledge. When individuals are motivated, whether operating individual or in a team, the performance increases. Not only the performance of the output, but also the knowledge transfer. This can also be seen in Table 1, where intrinsic motivation as well as extrinsic motivation is important for the development of standard products and intrinsic motivation and to some extent extrinsic motivation being important for the development of custom products.

4.5.1 Results from Data Collection on Motivation Factors

The first factor is extrinsic motivation. About 20% of the individuals that answered the questionnaire answered positive to questions about getting motivated by monetary means. These questions included

subjects of having monetary goals and being aware of the fact that promotion/better working could lead to a higher salary or bonus. On top of that 33% of the questionnaires answered positive to questions concerning the need of a personal gain in order to be motivated to do additional work. Questions concerning willingness to only learn additional skills if it was compensated with monetary means 13% answered positive. From the results no pattern can be made up of departments that are more extrinsically motivated than others, though.

The second factor is intrinsic motivation. Employees of Grisnich feel very involved in the process they are in and the products they develop. Due to this it is hard for individuals to handover a project to another department. Perfectionism and the desire to deliver a good product contribute to this struggle to handover a project (interview sales manager). These examples do, however, underline the high level of intrinsic motivation that is present at the majority of the employees.

Biggest motivation is the application of technology for the sales manager (interview sales manager). For the head of the production floor the biggest motivation is the feeling that things are achieved together. For the other interviewees the biggest motivation was the fact that in the end the people of Grisnich have achieved something together.

The greatest frustration of the interviewees (all mentioned this in some way) is the fact that things get talked through, but in the end the daily routine wins from the intended plans. Often this has resulted in developments being postponed (interview head engineering).

4.5.2 Interpretation of the Motivation Factors Results

The motivation of the interviewees can mainly be described as intrinsic motivation. Team spirit and achieving something together are seen as the most important aspects of motivation for all the interviewees. Money does not play an important role, but making good quality products together is the most important aspect of motivation. One important element needs to be considered and that is the fact that currently not everything that is discussed is executed, because of daily routines taking over. Taken all what is said into account intrinsic motivation receives a plus sign and extrinsic motivation a plus-minus sign (see Table 9).

	Ideal Situation Standard Products	Ideal Situation Custom products	Current Situation
Extrinsic Motivation	+	±	±
Intrinsic Motivation	+	+	+

Table 9 - Results Motivation Factors

Only the last category of knowledge transfer factors remains and that are the communication factors.

4.6 Communication Factors

Communication, obviously, is important for the transfer of knowledge. Good communication ensures that knowledge gets passed on correctly and people understand what they need to do. For the development of standard products the source credibility as well as the communication competence are important and need to be high. For the development of custom products the source credibility is less important, but the communication competence also needs to be high.

4.6.1 Results from Data Collection on Communication Factors

The first factor is source credibility. From the questionnaire the importance of information sources to the people of Grisnich became clear (see Table 10).

Information Source	Colleagues within department	Colleagues outside department	Drawings of Parts	ERP System	Drawings of Layout
Score	61	50	28	25	25

Table 10 - Score of Information Sources

The score is based on a raking people gave to the twelve available information sources. The best is scored with 5 point, second with 4 point, etc. This resulted in the top 5 presented above. No information sources from outside the company are present in the top 5. Relating to this is the fact that most information from the market is currently provided via informal conversations with other people from the industry or suppliers (interview sales manager). Internally the most information comes from the sales department. Although this is the only source of information, the information provided is sometimes doubted, because it seems like it is very little and could be more accurate (interview head of production). An issue, indicated by the sales manager, is that people are making assumptions without discussion, or take decisions on their own (interview sales manager). Due to this, the sales manager has lost overview of the complete project.

The second factor is communication competence. Written communication is very difficult in the current company culture. This probably has its roots in the past where nothing was made explicit and people were told what to do (interview head of production). From the questionnaire the 46% indicated that the communication is good, 40% indicated that their colleagues were to the point, and 53% indicated that their colleagues communicated efficient (score of 4 or 5 on a 5-point scale). Only 20% indicated that people were quick in responds to mail and other types of questions. Looking at verbal and written communication 80% indicated the verbal communication between colleagues as easy to understand, while 60% indicated the written communication between colleagues as easy to understand.

On top of that not all information is shared, because others have the tendency to generalise aspects of one project to another project (interview sales manager). It is, however, tried to share as much information as possible, but sometimes it is not possible. Due to the rise of a project leader the frequency of communication is decreased (interview sales manager). Communication on the technical specifications is mainly verbal, experience from the past has proven that writing down does not work, because information is understood differently or aspects are not clear (interview sales manager). Information is, however, only spread to the ones that are thought of needing it. Conflicts are solved by using arguments, but almost never is the middle way chosen, it is mainly the opinion of the head of production floor that wins (interview head of production floor).

4.6.2 Interpretation of the Communication Factors Results

The first factor of analysis was the source credibility. Overall the employees of Grisnich trust each other, but are not happy with what they do with the information they receive. To be more precise, people are, for example, using customer specific information to generalise to other products, or to tell others they do their job the wrong way. This has caused some people to be selective in the information they share. Everybody is willing to share information with each other, but some are selective in the people they tell it to. For example, members of the management team are not willing to share all the information they know. This makes sense from their position, since telling everything could lead to unwanted chaos. But the sales manager also is selective in providing information, since he is convinced people do not understand him, or they do not need the information. This leads to a lack of information further in the process, causing people to work with assumptions or additional meetings to gain the information needed. On top of that there are no external sources of knowledge in the top 5 of the knowledge sources, which indicated how locked-in the current situation is. Taken all this into account the source credibility is given a plus-minus sign.

Communication is mainly in verbal form. This is done during the main procedures and moments knowledge needs to be transferred (e.g. from sales to project leader). There are, however, difficulties with the verbal communication. Also there are no formal procedures, or procedures that require writing down

of information. The only point in which this should be done is with the technical specifications of the customer. This is, however, sometimes made after the order is engineered already. It is not the case that if the technical specifications are not written down by the sales department or the project leader that the development cannot start. Development starts as soon as someone hears that the development can start, often this is just verbal communication. From the questionnaire it became clear that although people may like the communication and find it easy to understand each other, the communication between them is not good with over half of the employees indicating this, so communication competence is indicated with a minus sign (see Table 11).

	Ideal Situation Standard Products	Ideal Situation Custom products	Current Situation
Source Credibility	+	±	±
Communication Competence	+	+	-

Table 11 - Results Communication Factors

With all the knowledge creation and transfer factors explained in the sections above the next section will provide a summary of what is said in this chapter.

4.7 Conclusion

From the results above and the interpretation of them it became clear that the current situation and the ideal situation for both the development of standard products and custom products lies apart from each other. Although questioned explicitly there is currently no difference in the development of standard and custom products. Looking at the individual product types, it can be said that the current situation lies closer to the ideal situation for that development of standard products than that it lies close to the development of custom products. Eight out of seventeen factors score 'ideal' for the development of standard products, while only four do the same for the development of custom products (see Table 12). For the development of standard products the main difference lies in the knowledge transfer, while for the custom products this lies in the knowledge creation. The table below summarizes the results of the research done on the current situation; with SP standing for standard products, CP standing for custom products, and CS standing for the current situation (see Table 12).

	Knowledge Creation										**Knowledge Transfer**						
	Knowledge Stock			Knowledge Networks				Org. Routines and Processes			Learning Factors			Motiva-tional Factors		Commu-nication Factors	
	Experience	**Formal Education**	Knowledge Diversity	**Number of Direct Contacts**	Network Range	Strength of Network Ties	**Structural Holes**	Climate for Teamwork	Climate for Risk Taking	**Organisational Memory**	**Ease of Relationship**	**Shared Understanding**	Absorptive Capacity	Extrinsic Motivation	Intrinsic Motivation	Source Credibility	**Communication Competence**
SP	+	**±**	-	**+**	±	+	**±**	-	-	**+**	**+**	**+**	-	+	+	+	**+**
CP	±	**+**	+	**±**	+	+	**+**	+	+	**±**	**+**	**+**	+	±	+	±	**+**
CS	+	**-**	-	**-**	±	+	**-**	-	-	**-**	**±**	**-**	-	±	+	±	**-**

Table 12 - Summary of Results

What can be seen from the table above is that the development of products in general could be done better looking at the knowledge creation and transfer factors analysed in this research. Several paths can be taken in order to overcome these differences. There are some factors that received a to low score for both the development of standard products as well as custom products. These factors are displayed in bold. Looking at these factors (formal education, number of direct contacts, structural holes, organisational memory, ease of relationship, shared understanding, and communication competence) tells that the main problems lie in the network, communication and the understanding of the total picture. The low scores on these factors can be the result of no separate development process and because of that low

knowledge on how this needs to be done. Recommendations should focus on enhancing these factors. Looking at the current situation in which Grisnich is at the moment costly investments or hiring new staff is not a realistic option. Therefore, solutions to overcome the found differences need to be found elsewhere. Based on the results and current situation high benefits can be achieved by changing the business process, making it more suitable for the development of products. What can be seen is that the method for knowledge creation as well as the method for knowledge transfer needs a change. A model to achieve this for standard and custom products is formed in the next chapter.

5 Product Development Based on Knowledge Creation and Transfer

One of the main conclusions that can be drawn from the results chapter is that there currently is no distinction made between the sales process and the development process. Another conclusion is that the largest gap between the ideal and current situation and thereby the main areas for improvement lie in the network, communication, and the understanding of the bigger picture. Solutions to these problems cannot be sought in the hiring of new employees or in making high investments due to the current (financial) position of Grisnich. Solutions therefore need to be sought in improving the current methods used. Since currently no distinction is made between the sales and the development process, there is a need to construct a new method for developing products. A starting point for constructing this method can be found in the results conclusion, a quick summary.

1. There are problems with acquiring new knowledge (see section 4.6.2).

2. Obvious solutions are overlooked (see section 4.3.1).

3. The redesign of a product (standard or custom) requires time and no money is made yet (see section 4.3.1).

4. There is little two-way communication between different departments (see section 4.2.2), because information provided is often generalised, or used for the wrong purpose (see section 4.6.2).

5. People understand the current products (see section 4.1.2), but have difficulties to understand why and how new products need to be introduced see sections 4.4.2 and 4.5.2).

From these points it can be concluded that the main hurdle of the development process lies at the beginning of the product development with difficulties to acquire knowledge, difficult communication, time-consuming redesign, and obvious solutions overlooked. A product development method needs to encounter all these problems and given the nature of them will focus on the beginning of the development process, the part where a solution needs to be found for a problem.

From the results (see Table 12) standard and custom product specific scores on factors also showed that things could be improved. These values can be contradicting sometimes and therefore cannot be captured in a single method. Two methods will therefore be discussed in this chapter, one for standard products and one for custom products. Both will be based on the same underlying principles of knowledge creation and knowledge transfer factors, but differ in their practical execution.

Section 2.4 introduced a model that describes the problem solving capabilities of a company. The development of products can be seen as solving a problem, whether the customer or the company itself is the initiator of the problem does not matter in this sense (Byttebier, 2002). That is why the problem solving capacity model will function as a framework, thereby providing the structure, for the final product development method. The first phase is the creativity phase.

5.1 The Creativity Phase

In section 2.4.1 the creativity phase was introduced. In this creativity phase two activities take place, the formulation of a goal (or problem) and the generation of ideas to reach the goal (or solve the problem). These two activities introduced in section 2.4.1 need to be done sequentially and can therefore be seen as two steps in the first phase of the product development method. But how do these steps need to be filled, in other words: what criteria does a method for these step need to fulfil?

There are several handles for constructing the method for these two steps. Beginning with what is said in the introduction of this chapter the method should increase the easiness of acquiring information (point 1), make sure that obvious solutions are not overlooked (point 2), and increase two-way communication

(point 4). The other points (or parts of them) are included in later phases, because they are more relevant there. To optimise the creation and transfer of knowledge during the creativity phase the relevant individual factors of knowledge creation and knowledge transfer also need to be included. From Table 2 the importance of knowledge creation and transfer factors for each phase can be made up. Together with the results in Table 12 required actions on each factor can be determined (see Table 13). These required actions together with the relevant points from the introduction form the criteria for the construction of a method for the creativity phase.

	Ideal Situation SP	Ideal Situation CP	Current Situation	Required Action SP	Required Action CP
Knowledge Diversity	-	+	-		↑
Experience	+	±	+		↓
Formal Education	±	+	-	↑	↑
Network Range	±	+	±		↑
Structural Holes	±	+	-	↑	↑
Absorptive Capacity	-	+	-		↑
Intrinsic Motivation	+	+	+		
Communication Competence	+	+	-	↑	↑

Table 13 - Starting Point Creativity Phase

Table 13 displays the relevant factors of knowledge creation and knowledge transfer for the creativity phase (derived from Table 2). In the second to fourth column the ideal and current situation scores are given that where determined earlier (see Table 12) with SP standing for standard products and CP standing for custom products. Based on the differences between the current and ideal situation an action is required for either the development of standard or custom products or both as can be seen in the last two columns of Table 13. An arrow pointing upwards means that the respected factor needs to be increased, while an arrow pointing downwards means the score of the current situation is to high but adjustments are only needed if it limits the development of products. As said a method for the formulation of a goal or the generation of ideas should enhance the relevant problem points of the introduction of this chapter as well as including the required actions of Table 13.

This thesis continues with the two steps of the creativity phase and how these steps need to be organised for the development of standard or custom products.

5.1.1 Step 1: The formulation of a Goal/Problem

The first step in the creativity phase is the formulation of a goal or problem. Currently the sales manager comes with an order of a customer or a set of technical specifications for a certain order and this basically forms the basis for the development or redesign of a product. This is not ideal and therefore a new method for the formulation of a goal or problem needs to be introduced. Although this may seem like a simple step it is often forgotten or done incorrect with serious consequences. This is why first the principles of how to formulate of a goal or problem are explained and second the concrete methods for Grisnich are explained.

Underlying Principles

Formulating the goal or problem correct in this early stage needs to be done in a structured matter, not only is this important for the later phases (e.g. Van Wulfen, 2006) of the development process (see section 5.2) it also helps to increase the communication competence by making sure that de encoding and decoding of this information goes as planned. People are forced to make their statement explicit and need to convince other of their view. Forcing people to make statements explicit in such an early stage of the entire process also helps to create an overview and act according to it (i.e. enhancing the absorptive capacity).

According to Byttebier (2002) one has a problem if: (1) One is not satisfied with the current situation, or (2) one does not have a direct answer on how to manipulate the current situation so one can be satisfied. The second part of this definition differentiates a task (i.e. the daily work) from a problem (i.e. the need to develop a new product). Questions that can be categorised as a task (one has a direct answer to them) are concerned with the daily work (routines) and creativity is less helpful in solving these questions. The first part of the definition indicates that there is an unsatisfied feeling about the current situation. This feeling releases energy and desire to solve the problem; creativity could help in this situation (Byttebier, 2002).

When formulating a problem for, for example, a brainstorm session there are rules to follow, since the formulation of the goal has influence on the amount (Lichtfield, 2008) as well as the direction (Ward et al., 2002) of the ideas generated. A method for the formulation of a goal (Byttebier, 2002; Lichtfield, 2008):

- Scouting; when beginning with the formulation of a goal, the first thing to do is to scout the problem area. Three factors are of particular interest during this scouting: (1) feeling – do you feel that this problem area needs attention at the moment, how is this with the rest of the organisation? Is there the desire to tackle this problem? (2) Thinking – is all the data available? Do we have enough time to tackle the problem, or can the problem be solved with creativity? (3) Desire – what is the priority of this problem? Does solving this problem fits in the overall vision of the company? These factors determine the motivation there is for solving a particular problem. From the results of this research one could see that intrinsic motivation in general was good (see section 4.5), how the motivation for the solving of the problem is can be determined during this scouting part of the goal formulation. It also determines how much knowledge there is about the subject. If little is known additional research might be needed before the creative session can be initiated.

- Scope; with the scouting done the scope of the goal formulation can be determined. Lichtfield (2008) has shown in his research that if a goal requests solutions to fit in a certain category of a larger problem the idea generation will provide ideas that can be fit into these categories and thereby making them useful for specific purposes. For example, generate solutions for a potato sorting machine that is either optical, mechanical, or uses air to sort potatoes will result in much more specific results than saying generate solutions for a potato sorting machine that can sort variable potato sizes. This is useful for the development of different products. A highly focussed formulation could be used for the development of standard products, while a more broad formulation is needed for the development of custom products.

  Defining the scope has additional advantages for the organisational memory. Making the scope explicit allows categorising the creative sessions held by the company. This has the advantage that when formulating additional creative sessions the goal formulations of successful sessions can be used with the formulation of a new goal. On top of that it can also be beneficial in the scouting part to look at the results from previous creative sessions. Since making explicit the goals of the creative session and recording them at some place relies less on the memory of the employees this contributes to the organisational memory.

- Final goal formulation; Ward et al. (2002) have researched that the formulation of a goal for a brainstorm session influences the knowledge that people use to generate solutions to that problem. This is an important fact for the development of different product types. Since it is true that the formulation of a problem causes people to use different knowledge it means that by formulating the goal correctly the knowledge diversity of the group can be influenced. Key is to determine what kind of formulation provides what kind of results. Figure 3 shows a distribution between the novelty and usefulness of an idea, this can be taken into account when formulating a problem.

  The goal of a creative session should be formulated in one single sentence. The goal should have some focus, the higher the degree of abstraction the more general the provided solutions will be. The problem owner should be included in the formulation. It should be in a question form starting with

the words “how” or “think of”, how focuses on the methods of realising something, while think of focuses on the end result of the creative session. Finally, the goal should be formulated challenging and attractive. This will help to energise the participants of the creative session and help them achieve the goal (Byttebier, 2002).

Method for Grisnich’s Standard Products

The starting point for the development of standard products is often the current version of the standard products. The problems that occur in this type of products are often noticed first with the service and maintenance staff. They should be able to initiate the development of standard products.

Since the scouting is in this case is done by the service and maintenance staff the next thing to do is to verify this with the head of production floor to see if it is the right problem for the right time and whether or not time is available or can be made available to solve the problem. This can be discussed with the management if it is a structural problem.

Second, the scope of the problem needs to be determined by the head of production floor together with the management. It is important to include the management in this stage, because they can free time or other resources for the development of standard products.

Third, the problem needs to be formulated so it can be discussed in the other departments of Grisnich. This means that it has to be presented in such a way that it is easy to understand for everybody. The goal should be formulated in one sentence, should have a focus, include the problem owner, should start with “how” or “think of”, and should be formulated challenging and attractive. Appendix F includes a form to structure the goal formulation and allows the participants of a creativity setting to be informed quickly. This form consists of a date, a category and a topic. Not only will this allow the participants of a creative session to put this into perspective, it also helps to store this form later in some kind of database. Next, the goal of the session is stated and finally a short description of the total problem (see Appendix F).

Method for Grisnich’s Custom Products

The formulation of a goal or problem requires not only good communication and an overview of the bigger picture; the management also needs to support the direction of the solutions of the ideas. Therefore it is the management that needs to formulate the goal or problem. This means that the management has to execute the three-part method described above.

First, the management has to scout the problem area. In this scouting part the relevance (feeling) of the problem needs to be determined. Does this problem affect the whole organisation and is it the right time for dealing with this problem now? Questioning this makes sure that no problems of only individuals are solved and that the right problem is treated at the right time. Also, the management needs to determine whether or not time can be made available to solve the problem and if it is a problem that needs to be treated with creativity and not, for example, with better equipment or more money. Last, the management needs to give the problem priority. This means that the management will support that it requires time and possible loss in efficiency to solve it. Only if these three things can be answered positive it is useful to continue. If one of the parts is answered negative the problem can better be approached another time or another problem can better be solved.

Second, the management needs to determine the scope of the problem. The scope of the problem determines for a large part the direction in which solutions are sought and is therefore important to choose correctly. For standard products and incremental innovation the scope can be chosen relatively narrow as can be seen above, while for custom products and more radical innovations the scope needs to be chosen more broad. Figure 3 can help with determining the scope of a problem with terms indicating the properties of a problem formulation.

Third, the management needs to formulate the goal and be able to present it to the group of people that will be generating ideas using the goal formulation. This means that the goal needs to be presented in an

easy and quick way so it is understandable to everybody. The goal should be formulated in one sentence, should have a focus, include the problem owner, should start with "how" or "think of", and should be formulated challenging and attractive. Appendix F includes a form to structure the goal formulation and allows the participants of a creativity setting to be informed quickly. This form consists of a date, a category and a topic. Not only will this allow the participants of a creative session to put this into perspective, it also helps to store this form later in some kind of database. Next, the goal of the session is stated and finally a short description of the total problem is given (see Appendix F).

5.1.2 Step 2: Organising a Creativity Session

The starting point for this step is the filled out form of the first step. Relating this to the current situation means the list of technical specification or idea of the customer about how a product should look like. Normally this would be given to an individual and used to develop according to this list of 'demands'. Since the sales and development process ideally are separated another approach is suggested. Again first the underlying principles are explained, after which the methods for Grisnich are explained.

Underlying Principles

A method for organising a creativity session contains several parts. A creativity session is used to increase the knowledge diversity used in finding a solution, increase the ego networks of individuals, and increase the climate for teamwork and risk taking. The individual parts of the creativity session are explained next.

- Group formulation; formulating a group for the creative session forms a paradox, on the one hand the more participants the higher the diversity, but a high number of participants means a less effective creative session. Several scholars have researched the group size for a brainstorm session (e.g. Byttebier, 2002; Kelley & Littman, 2004; Kelley & Littman, 2005) they have determined that the optimal groups size for a brainstorm session should not be smaller than 6 and not exceed 14 participants. This still is a large variation, but an ideal group has different types of members according to the function they perform in the overall process (Van Wulfen, 2006). Van Wulfen (2006) also states that a brainstorm group should consist of at least three different types of persons, core members – who are involved in the later phases of the development process as well, non-core members – who are only partially involved in the development process, for example the management team, and outsiders – who are just present for the brainstorm session. In percentages this should be 50% core members, 35% non-core members, and 15% outsiders. Having outsiders into the group will not only enhance the knowledge diversity, but in a way also the network position. This is, because having an unknown member into the group causes structural holes looking at the total group, these structural holes are, as said before, important for the development of custom products.

  The core members are the ones that have the market knowledge or other background information about the problem at hand. Core members can differ per development project and it is wise to choose them according to the type of product and problem at hand. Non-core members are partially involved in the process, mainly during the creativity phase. These non-core members can be from the management team, but preferably they are specialist in a particular field. Internally at Grisnich it is known what the capabilities of the engineers are, which can help to choose specialists for a specific problem. Outsides are members from outside the company; this can be clients, experts, suppliers or others like interns. These people are important, because they can provide a new perspective to the problem at hand. It needs to be said that the outsides of course need to tread the information provided as confidential and they could be given a nondisclosure agreement upfront to secure this. Last but not least a facilitator needs to be appointed. This person leads the creativity session and is preferably enthusiastic in nature and has knowledge about the entire process.

- Briefing; before the real creativity can start it is important to get everybody to the same point (e.g. Byttebier, 2002; Van Wulfen, 2006). In this short briefing the focus and goal of the brainstorm should become clear and the participants should be motivated to find solutions. Potential misunderstandings need to be eliminated and possible changes to the brainstorm goal can be made.

- Brain dump; this is the moment where the creativity session really starts (Van Wulfen, 2006). All the group members need to be present including the non-core members and outsiders. The form that describes the goal and problem is handed out to all the participants. Now is the time to basically dump all the ideas that have been in the core and non-core members' heads. Letting all this out will cause a flow of ideas that all need to be written down onto little Post-it like notes. Not only does this allow to capture all the ideas it will also make them explicit which is helpful in a later stage (Kelley & Littman, 2004). It is important that the outsiders also write down the ideas they come up with. Not only allows this additional perspective to the problem it also increases the knowledge diversity and total range of the network. This initial brain dump should last for a maximum of 30 minutes (Van Wulfen, 2006).

- Creativity techniques; after the initial brain dump of ideas the energy of the group can decrease (Van Wulfen, 2006). Creativity techniques are designed to enhance the energy and motivation and can help to create additional ideas that can be either more useful or novel based on the formulation of the goal of the creative session and the technique used. Appendix F shows a list of creativity techniques that can be selected for the development of either standard or custom products.

  Although each creativity technique is different from each other, applying the techniques is done by a general structure (Byttebier, 2002; Van Wulfen, 2006). Each technique should have the philosophy "one task, one deadline" (Byrge & Hansen, 2008, p.52). Meaning that if one technique is passes, it is over and everybody should go on with the next one. On top of that it can be the case that different techniques are used for different tasks sequentially. It is important that all participants move on to the next job and not stay behind in previous ones (Byrge & Hansen, 2008). Each technique should last for about 10-15 minutes and a maximum of 4 should be used (Van Wulfen, 2006).

- Roundup; with the final technique done, it is time to end the creative session with a roundup of the day. During this roundup all the ideas from the participants are collected and the further process is discussed (see section 5.2). This is also the time to thank the outsiders for their participation and they leave the development process completely (Van Wulfen, 2006).

Method for Grisnich's Standard Products

Applying the method described above to Grisnich means that four things have to be done, (1) the formulation of a group, (2) the briefing of that group, (3) the generation of ideas, and (4) the roundup of the creativity session.

As said before for the development of standard products the factors teamwork and risk-taking do not need to be high. Therefore it is not necessary to organise a group brainstorm session for the development of standard products. Individuals, that are carefully chosen, can perform the same steps as if in a group brainstorm. When choosing the individual for the development of a standard product it is important that this individual has experience in the development of the type of product before, meaning that (s)he knows the product inside-out. Not only does this speed up the process, it also makes sure that no previously failed solutions are suggested. This means that the formulation of a group for the development of standard products is in fact the selection of an engineer. This needs to be done by the head of the engineering department.

The filled out form (see Appendix F) from the head of production floor is the starting point for the generation of ideas. The head of production floor (together with the identifier of the problem) goes to an engineer and discusses the problem according to the filled out form. If everything is clear for the engineer the generation of ideas can start.

For the generation of ideas the engineer can use individual creativity techniques. These techniques are focussed on individual use, meaning that they can be performed by individuals and do not require any form of group activity. On top of that the ideas for the development of standard products should include a high degree of usefulness and a relative low degree of novelty. Taken this into account the best creativity

techniques for the development of standard products are: Assumptions, Flukes, Free Incubation, and SCAMPER (see Table 18). These techniques are aimed at generating in-depth solutions and need to be performed individually (see Appendix F).

The roundup of the creativity session for the development of standard products is not really a roundup. This is the part where all the ideas need to be collected to be ready for the next phase.

Method for Grisnich's Custom Products

For custom products the same four things need to be done, (1) the formulation of a group, (2) the briefing of that group, (3) the generation of ideas, and (4) the roundup of the creativity session. The management is only involved in two things, the formulation of the group and the briefing of them. After that their influence on the generation of ideas and later steps is minimal until the final step of the development process.

For the development of custom products a group needs to be formed with 50% core members, 35% non-core members, and 15% outsides. Practically this means that a group of six should consist of three engineers, two people from production and one supplier or customer. A group of six is recommended, because it is large enough to generate ideas and carry them to the next phases sufficiently, while it is also small enough to not have a to large influence on the different departments (since some of the daily productivity is lost while engaging in the development process). The management needs to form this group.

The briefing of the engineers and production employees (core and non-core members) of the group according to the filled out form of the first step is next. After this briefing the engineers and employees of production have two weeks to gather as much information about the problem as possible (Van Wulfen, 2006). It is important that the individual group members do not talk to each other about the problem. This is to let every individual form his/her own opinion and make sure that people do not enter the creativity session with already a consensus reached. It also increases the intrinsic motivation and to some extent the network range, because information needs to be sought by the individual group members. After two weeks a creativity session is held.

The creativity session starts with a brain dump. As said this is the moment were all the information and ideas from the last two weeks are dumped. This is good, because it creates a base on which new (and sometimes better) ideas can be generated. The brain dump also ensures that more ideas are generated than only the obvious ones, because they are already thought of in the two weeks prior to the creativity session. After the brain dump creativity techniques can be used to further generate ideas. Group techniques are better suited for the development of custom products. Including the whole group into a creativity technique decreases the average experience of the group and increases the knowledge diversity of it, both needed for the development of new installations. Ideas with a high degree of novelty should be strived when developing this type of products, taken all this into account the best creativity techniques for the development of custom products are: Direct Analogue, Superhero, Flukes, Free Incubation, and Guided Fantasy (see Table 18). These techniques are aimed at generating novel solutions and can be performed in groups (see Appendix F).

Gathering all the individual Post-it notes and other means on which ideas are expressed rounds up the creativity session. The outsiders are no longer involved in the process and need to be thanked for their input. The rest of the process needs to be explained to the other group members.

5.1.3 Summary

In the previous sections the starting point of the development process is stated. Aim of this process was to increase the score of knowledge creation and transfer factors for either the development of standard products or custom products based on the difference found in the results (see Table 13). A general structure of goal formulation, briefing, creativity and round up was introduced. This whole process lasts

for about three weeks, in the first week the goal of the development process and/or current problem needs to be made explicit. It depends on the type of product whether or not the management needs to initiate this problem. Product development for standard products is often concerned with (incremental) improvements on existing products. Service and maintenance staff is in contact the most with the products in use and therefore have the highest knowledge on what can be changed. They should initiate the development of standard products. Product development for custom (and often more radical) products often requires more resources and it is therefore important that the management is supporting the development of them. This is why the management needs to formulate the problem as a starting point for the development. Having a problem description allows increasing the absorptive capacity, communication competence and organisational memory factors of knowledge creation and knowledge transfer. To communicate the problem Appendix F can be used. This form allows communicating the problem easily and making sure that the people how try to find solutions understand the bigger picture in which they are working. A creativity group also needs to be formed consisting of core members, non-core members and outsiders. The former two are informed after the goal has been formulated and need to do some (market) research in order to find possible solutions to the problem. After two weeks they meet, together with the outsiders, for the creativity session. This session lasts for about half a day, in which a brain dump of ideas gathered during the prior two weeks and creativity techniques are performed to generate as much ideas as possible. The techniques used depend on the type of product that needs to be developed and has influence on the climate for teamwork and risk taking, experience and knowledge diversity factors of knowledge management. The gathering of all the ideas forms the final part (roundup) of the creativity session.

5.2 The Comprehensiveness Phase

As mentioned in the theoretical framework this step of the problem solving process includes the formulation of a business model. The starting point is shown in a table, with the factors that are important for this phase (see Table 14) similar to the previous section. The factors thus need to be increased by the formulation of a business model. Before the business model can be formulated though, a rough selection of the ideas needs to be made, because it is simply impossible to make a business model of all the generated ideas.

	Ideal Situation SP	Ideal Situation CP	Current Situation	Required Action SP	Required Action NI
Number of Direct Contacts	+	±	-	↑	↑
Strength of Network Ties	+	+	+		
Absorptive Capacity	-	+	-		↑
Source Credibility	+	±	±	↑	
Communication Competence	+	+	-	↑	↑
Shared Understanding	+	+	-	↑	↑

Table 14 - Starting Point for the Comprehensiveness Phase

This section continues with the two steps of the comprehensiveness phase and how these steps need to be organised for the development of different products. The formulation of the steps and the chosen methods in the steps will be based on the needed increase of a knowledge creation of transfer factor that can be seen in the last two columns of Table 14.

5.2.1 Step 3: A Rough Selection of the Ideas

After the idea generation a selection of the ideas needs to be made. Before the practical method is explained first the underlying principles are introduced.

Underlying Principles

The rough selection of ideas consists of three things: (1) categorising of ideas, (2) rating of ideas, and (3) selecting ideas.

- Categorising of ideas; before the ideas are selected it is more easy to gain an overview if the ideas are categorised. A useful way of categorising ideas is by using similar criteria as where used when constructing the goal or problem. Now distinctions need to be made between realisable and original. The graph of Figure 3 can be categorised into four squares with (1) low realisable / low originality – meaning not for now ideas, (2) low realisable / high originality ideas – meaning good ideas but better for the future, (3) high realisable / low originality – meaning easy to implement and low risk, and (4) high realisable / high originality – meaning breakthrough ideas (see Figure 16).

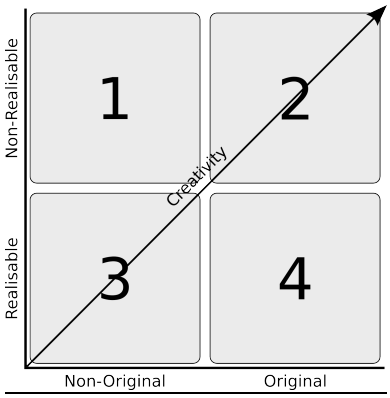

Figure 16 - Idea Selection (Adapted from Byttebier, 2002)

- Ratings of ideas: as said before it is important to let the participants of the development process rate the ideas. Not only causes forms this basis for success later on in the process it also makes sure that people stay motivated to continue the development process (Byttebier, 2002). Before ideas can be rated though, an understanding of the ideas needs to be there. This is why; before the ideas are rated the thinker of the ideas explains the special ones. This requires a maximum of 5-10 minutes per group member (Van Wulfen, 2006).

  Sequentially, the rating of the ideas happens according to a simple method. Every group member gets five, for example, five yellow stickers and one red one. The yellow ones should be placed at ideas that the individual group members prefer, while the red one should be placed at what they believe is the best idea (Van Wulfen, 2006). When all group members have placed their stickers it is time to select they ideas.

- Selecting ideas; selecting ideas is a simple process. All the ideas that did not get any sticker can be removed. After this, the ideas can be ranked according to the number of stickers they have (yellow and red ones included). As a rule of thump, the selection of ideas should be twice the number of core members of the group. So, if there are 3 core members the number of ideas that goes through the selection is 6, if there are 4, 8 go through. This is because each core member is going to work out two ideas into a business model. If there are, however, ideas that got red stickers and they are not included it can be wise to consider replacing them with others in the list that do go through (Van Wulfen, 2006).

Method for Grisnich's Standard Products

As said, for the development of standard products there is no need to increase the climate for teamwork. That is why the generation of ideas for standard products is done individually. As a consequence the things described in this section also need to be done individually. First the categorisation of the ideas in the four squares needs to be done. Ideas for standard products should mainly fall into category number 3 or 4, because it is important for the development of standard products that they are realisable. The rating and selection of ideas also needs to be done individually. In practice this means that the two best ideas need to be chosen by the engineer.

Method for Grisnich's Custom Products

The rough selection of ideas needs to be done on the same day of the creativity session because all the core and non-core members are the ones that have to rate the ideas to be able to make a selection (Kelley & Littman, 2004). Before this can be done the ideas should be categorised. This is done the same way as with the ideas of standard products, but the ideas for custom products should mainly fall into category 2 and 4 because novelty is important for this type of products. It is up to the group, however, to decide where the ideas are placed. This can be done on a large board or flip over with the four squares of Figure 16 displayed. The individual ideas, written on Post-its, can be placed on the board.

The group members, each having five yellow and one red sticker, rate the ideas. With the Post-its of the ideas on a large board the group members can put their stickers with the ideas they think are best. This can all be done at the same time, so the group members are influenced the least by the scoring of others.

Last, the core members chose two ideas each that they will be working with. Of course they can only chose out of the ideas that received the most stickers. Since these were rated as the best this is obvious.

5.2.2 Step 4: Develop a Business Model

The next step is to make a business model of the chosen ideas. This needs to be done in order to be able to compare the different ideas in a structured manner and be able to make a final selection of the idea(s) that will be further developed, but first the underlying principles of a business model.

Underlying Principles

In the theoretical framework the nine aspects of a business model where stated, because the aspects of the business model where formulated for a company, Table 15 provides an overview for a business model for products.

Pillar	Business Model Building Block	Description
Product	Value Proposition	Gives an overall view of the added value of the product
Customer Interface	Target Customer	Describes the segments of customers a product wants to offer value to
	Distribution Channel	Describes the various means of the product to get in touch with its customers
	Relationship	Explains the kind of links a product establishes between itself and its different customer segment
Infrastructure Management	Value Configuration	Describes the arrangement of activities and resources
	Core Competency	Outlines the competencies necessary to execute the product's business model
	Partner Network	Portrays the network of cooperative agreements with other companies necessary to efficiently offer and commercialize value
Financial Aspects	Cost Structure	Sums up the monetary consequences of the means employed in the business model
	Revenue Model	Describes the way a product makes money through a variety of revenue flows

Table 15 - Aspects of a Business Model (adapted from: Osterwalder, 2005)

All the aspects are interrelated to each other, meaning that they have an influence in some way to another. It is important to know how the different aspects influence each other, because by knowing this one can determine an optimal strategy for the business model (Chesbrough, 2006). Figure 17 displays the relationships of the aspects of the business model.

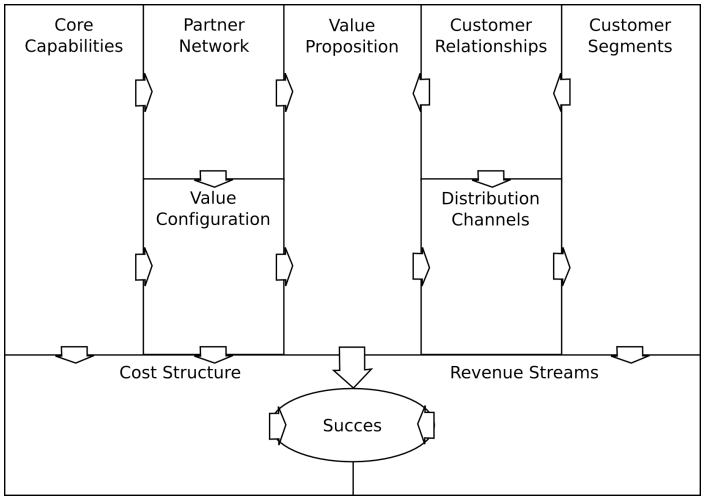

Figure 17 - Relationship Between the Aspects of a Business Model

Knowing the relationship between the items of a business model is important, because it allows understanding where the additional value can be made (Chesbrough, 2006). On top of that it also provides a method for comparing the business model. It is key that the core members try to fill in as much of the business model as possible, because it allows making a better decision in the next phase. Since the core members are individually responsible for the completion of the business model they are forced to search for information needed. It might be possible that they need to go to experts on a particular field to research the possibilities of a particular idea. The financial department can, for example, assist in determining the cost and revenue streams. Because of this research, that needs to be done to fill in the business model, the number of direct contacts the individual core member has can rise. On top of that their absorptive capacity, communication competence and eventually shared understanding also will be higher because of the explaining of the idea to other and the discussions that follow from it. This will also increase the climate for teamwork and organisational memory, but to a less extend. If the business plans are formed the final decision can be made on which idea goes through to the development stages.

Method for Grisnich's Standard Products

For the development of standard products (that are often incremental changes of existing products in the case of Grisnich) a previous business model can be used and adapted. This not only saves time, it also allows to rethink the ideas generated and the ability to adjust the idea. This is especially important for the development of standard products, because the selection as well as the generation of ideas is done by the same person thereby having the possibility of tunnel vision. If there is no business model available, the method that is described for custom products below can be used.

Method for Grisnich's Custom Products

The core group members each have two ideas to start and after a two-week period two business models should be finished. In order to create a business model the starting point is the value proposition (see Figure 17). Often the value proposition is the idea generated and if not this is the first thing that needs to be formulated. From this value proposition the core group member have to go in the opposite direction of the arrows for determining the business model. This results in the three adjoining rectangles need to be filled, this process is repeated (every time going against the arrows), until the cost and revenues only need to be determined. In order to able to fill out all these rectangles the engineer must contact his/her network, search on available information source, etc. The cost and revenue rectangles are done last together with a financial expert (from the financial department). The result is a complete business model that can be presented during the next step.

5.2.3 Summary

In the comprehensiveness phase two major things happen. First, the convergent phase is ended and a divergent phase is coming and second, the creativity is transformed into logic. Apart from the personal

adaption this requires by the individuals working on the ideas it also starts a new phase in the development process where ideas need to be made explicit and need to be turned into concepts. This is done by making a rough selection of the ideas based on a score given by the participants of the creativity session. Not only ensures this that the motivation stays high for the people that need to work out the business model it also makes it easier to get a basis since the management has not influenced the ideas chosen. Next, a business model needs to be made within a two-week period. This allows the further consider the idea and spot potential weaknesses in the initial idea. It also helps to create a better understanding of the idea, increase the communication competence and absorptive capacity of the member developing the business plans. This will increase the overall knowledge transfer capability of the company. After two weeks the business models need to be finished and the management team can judge them according to criteria developed at the beginning of the process. This is done in the consensus phase.

5.3 The Consensus Phase

As said before, this is the phase where the ideas return to the management again. There are, however, still some factors of knowledge transfer that need to be increased. Especially for standard products, as can be see in Table 16.

	Ideal Situation SP	Ideal Situation CP	Current Situation	Required Action SP	Required Action NI
Ease of Relationship	+	+	±	↑	↑
Extrinsic Motivation	+	±	±	↑	
Communication Competence	+	+	-	↑	↑

Table 16 - Starting Point for the Consensus Phase

This section continues with the fifth step of the process, the making of the final decision of which concepts will go through for being developed further.

5.3.1 Step 5: The Final Decision

The starting point for this step is the filled out business models from the previous step. In this final step the decision needs to be made about which idea(s) go through for further development. Before the practical method is explained the underlying principles are stated.

Underlying Principles

What can be seen in the results is that there are no arrows going to the CEO, This can of course be because of the current organisational processes, but for the development of products it is important to have the management on board so to speak (Kelley & Littman, 2005). This is why, in the consensus phase the management is involved in the process again. This is the moment on which a decision is made to further develop any concepts thought of in the earlier phases of the process. The decision is based on a presentation of the business models of each of the ideas, provided by the responsible group member of the creativity session. Appendix F contains a presentation sheet of the business model that can be used for the presentation. This again increases the communication competence of the individuals presenting the concepts, but also of the ones being present at the presentations. The business models can be stored in a database, which increases the organisational memory and can be helpful in later creative sessions or business model developments.

As can be seen in Table 16 the extrinsic motivation needs to be high for the development of standard products. Since in the final stage of the development the decisions need to be made fast, money could be set on the ones giving the best presentation and having the best business model.

Method for Grisnich's Standard Products

The head of the engineering department is responsible for the products that are developed. That is why the (standard) products that need to be developed need his approval. The (adjusted) business models therefore need to be presented to him. This presentation can be done according to Figure 17 with the

possible changed fields highlighted. If an idea shows significant improvements or potential the idea can be further developed. The head of engineering with his experience should be able to judge the ideas.

As a form of motivation money can be awarded for the best improvement or the fastest generation of the business model.

Method for Grisnich's Custom Products

For custom products the presentation is again for the ones that have set the goal or determined the problem. In this case that was the management. Following the same procedure as with standard products the ideas can be presented using Figure 17. This time, all the aspects need to be presented though and all the core members need to present their two ideas. For Grisnich this means that six ideas will be presented. From these six ideas the management can decide which are good enough to go through for further development, need modifications, or are not good enough for further development. The management with their experience and holistic view of the company should be able to make this decision.

5.3.2 Summary

During the final phase the ideas return to the management team again. This allows the management team to make a decision on which concepts are best inline with the corporate strategy and they can be chosen to further develop. The management team has made the first criteria and goal in the first phase and therefore no real surprises should arise in this phase. With the methods of earlier phases the communication should be so everybody can understand the total concept. Money can be rewarded for the best business model in order to stimulate people's extrinsic motivation.

5.4 Grisnich's Development Model for the Development of Different Products

This section forms a summary of what is said in this chapter. On top of that it tries sum up how to close the gaps identified between the current and ideal situation, thereby answering the last research question.

The first change that needs to be made in order to close the gaps between the current and ideal situation is to separate the development process from the sales process. This allows focusing on the sales during the sales process and on knowledge creation and transfer during the development process. Five steps are included in the development model for Grisnich.

In the first step the problem is formulated. This can be a problem with the current products or can be a desire or goal from the management. The individuals that have the authority to decide which ideas can be developed into prototypes are the ones that need to formulate the problem or goal. For standard products this will mean that the head of the engineering department, the head of the production floor and the management can be the ones for formulating the problem or goal, while for custom products it can only be the management. This is because in this way the support for the development of ideas is more secured. The goal form presented in Appendix F can function as a guide for the formulation of the goal or problem.

The second step includes communicating the problem or goal to the people that will start to work on solutions for it and generating ideas for solving the problem or reaching the goal. This means that the problem or goal has to be communicated through the company's different departments. Not only will this create more involvement in the development process by multiple departments it also forces communication and creating a shared understanding of the goal or problem at hand. This is needed because ideas are also generated in this step. For standard products the ideas are generated individually, but for custom products the ideas are generated in groups. These groups consist of three engineers, two people from production and one outsider, for example a supplier or customer. Several creativity techniques are listed in Table 18 each with their own purpose and characteristics. For standard products there are individual techniques and for custom products group techniques, but also basic and more advanced techniques can be used.

The third step aimed to bring the bulk of ideas down to a reasonable amount in order to be able to select a couple of them. In other words, the number of ideas needs to be reduced in order to be able to further develop them. Participants of the creativity session are the ones to do this and not the management, head of the engineering department or head of the production floor. This is to motivate the people that will be working on developing the ideas further. If they believe in an idea and can be the ones that can try to make it a success the motivation is high. Figure 16 can help with categorising the ideas, making it easier to select the best ideas of that session.

The fourth step is the making of a business model. This is done, because the making of a business model ensures that every aspect about an idea gets checked. By making sure that elements of the business model can contribute to the organisation, the idea proofs to be worth to be developed. In other words the possible enthusiasm of an idea is now grounded with facts that proof its contribution. Not only is this important for custom products, it is also important for standard products since they already exist and a change has to be significant in order to change the standard. Appendix F shows the elements of a business model and can help the employees by making it. The method for making a business model is to start at the value proposition and work against the arrows until all the elements are filled out apart from the financial ones (see Appendix F or Figure 17). Together with the financial department the cost and revenue streams can be determined. Making a business model also makes it possible to compare the ideas to each other. This makes the last step much easier.

In the final step, called consensus, a final selection is made between the business models. This is the point where the ideas return to the ones that have formulated the goal or problem, because they have the authority to make the decision for further development. Ideas that fit into the vision of the company can be further developed. The development model for Grisnich can be summarized as in Table 17.

An additional benefit of this model is that it can be seen as a type of stage-gate model. This allows evaluating different stages of the development of products, but also deadlines can be given for individual stages making sure that progress is made. Currently no deadlines are given, with as result that often development gets overruled by the daily routines. The proposed model of this chapter should prevent this from occurring.

Phase	Step	Action	Involved Departments	Tool(s)
Creativity	Step 1	Determine the Problem	Management Team, Various	Goal Form
	Step 2	Organise the Creativity Session	Various, Outsiders	Creativity Techniques
Comprehensiveness	Step 3	A Rough Selection of the Ideas	Various	
	Step 4	Develop a Business Model	Various, Finance	Business Model Sheet
Consensus	Step 5	Final Selection	Management Team, Various	Business Model Sheet

Table 17 - Grisnich's Development Model

With the methods determined for closing the gabs between the current situation and the ideal situation the next chapter states the conclusions of this research.

6 Conclusion

With all planned steps of the research taken the central question can be answered and recommendations can be provided to the management of Grisnich. Because no research is ever fully complete the limitations of this research and suggestions for further research are included at the end of this chapter.

6.1 The Current and Ideal Situation of Knowledge Creation and Knowledge Transfer

During this research the goal was to research how Grisnich could make better use of their existing knowledge for the development of products. Since Grisnich has two major types of products; standard products and custom products were chosen as the two focus groups, with standard products being products that where made before and custom products being customised products. Further questioning and research resulted in the following central question:

> *How should knowledge for the development of standard and custom products be created and transferred at the engineering department of Grisnich to optimise the development process?*

For answering this question two research questions were formulated researching the ideal and current situation. Based on the differences between those situations a third research question was needed to determine how to get from the current to the ideal situation. This question forms the basis for the recommendations provided later (see section 6.2), but first the answer to first two questions is stated.

For the creation of knowledge three aspects are of importance: (1) the knowledge stock, (2) the knowledge network, and (3) the organisational routines and processes. Knowledge transfer is also based on three aspects: (1) learning factors, (2) motivation, and (3) communication. Knowing that these aspects are important for the creation and transfer of knowledge is a start, but it does not explain how knowledge needs to be created and transferred during the development process. In order to determine when which aspects and their related factors are of importance a model or process is needed. This model was found in the form of a problem solving capacity model, this model provides a link with the current methods used by Grisnich and allowed to allocate all the knowledge creation and transfer factors of importance. This resulted in a theoretical three-phase model that in shown in Figure 7.

To determine the current situation of knowledge creation and knowledge transfer the individual factors were analysed with three methods, by conducting interviews, a questionnaire, and an analysis of data from completed projects. The results indicated that the creation and transfer of knowledge are currently not optimal. Main problems lie in the communication, network and understanding of the bigger picture. More specific there are problems with the acquisition of new knowledge, determining proper solutions, two-way communication between departments, redesigning of products, and quickly understanding new products. Main reasons for this are that the majority of the communication is verbal communication and employees are depending on their knowledge and memory. This results in people reaching back to solutions used in the past, or people generalising information to other projects. On top of that there is no structure for the development of new products, since all the products are build to order. This lack of structure also causes the daily routine overtaking the development process. Looking at the individual product types, the current situation lies closer to the ideal situation for the development of standard products than it does to the development of custom products (see section 4.7). The current situation scored ideal on eight out of seventeen factors of knowledge creation and transfer for the development of standard products, while it scored ideal on only four for the development of custom products.

To get from the current situation to the ideal situation large investment in money or other resources like hiring new staff are not an option. Due to this the solutions need to be sought in changing the current methods used. Looking at the central question, Grisnich should create and transfer knowledge according to the method described in the next section in order to optimise the development process.

6.2 Recommendations

The recommendations for the management can be divided into two different categories; recommendations on how to change the current working methods and recommendation on how to implement the recommended working method.

6.2.1 Recommendations for Closing the Gab Between the Current and Ideal Situation

In order to go from the current to the ideal situation a five-step method was constructed. The steps are:

- First; a goal or problem needs to be formulated by (or in corporation with) the individuals that have the authority to make the decision of which ideas go through for further development and prototyping. In the case of custom products this is the management and in the case of standard products this can be the management or the head of the engineering department.

- Second; a creativity session needs to be held. Before this session participants need to be informed about the goal or problem at hand and need a period to search for information and form an opinion about the subject at hand. After that a brainstorm session is held that is individually for standard products and in a group form for custom products.

- Third; the participants of the creativity session rate and choose the best ideas.

- Fourth; some of the group members for custom products and the individual for standard products work out a business model for two ideas per person. During the making of the business model all the relevant business aspects of the idea need to determined and this creates a better understanding of the potential of the ideas.

- Fifth; the ideas need to be presented to the ones that have set the goal or formulated the problem at the beginning. These are the person(s) that are authorised to make the decision to further develop the ideas and they can create the support needed for further development.

Applying this method increases the two-way communication between department, because all departments are involved in either the creativity session or supporting the making of the business model or both. By including two information gathering points (before the creativity session and during the making of the business model) individuals are forced to acquire new information and explore their network. Making a business model for a product also ensures that a proper solution is chosen, because all the aspects of the product are highlighted. On top of that it also helps to understand the product and see how it fits into the bigger picture of the company. This means that by applying the method described above the main problem areas are addressed thereby optimising the development process. How this can be implemented is explained in the next section.

6.2.2 Recommendations for Implementing the Method

Applying the method as described above can optimise the current situation of knowledge creation and transfer and this therefore highly recommended. This section focuses on providing recommendations on how to implement this method.

- First; the development and sales process need to be separated. This means that products need to be developed on the initiative of Grisnich itself and not only when a customer asks. It allows integrating the method when Grisnich is ready for it, in other words it allows to start working on a project when the engineering department sees an opportunity. The five-step method recommended needs to be used to start the development process and is aimed for the generation of ideas, therefore customers for the ideas can be sought after this process has taken place. This means that the start of this method should be on the initiative of Grisnich and not of a customer.

  The separation can be done by organising a creativity session without having the people from the sales department as core members. They can (and should be) part of the creativity session due to

their relative high knowledge of the industry, but they can participate as non-core members of the creativity session. This way their input can be used, but their influence during the rest of the process is limited.

- Second; a test case is needed to pilot the method. It is recommended to use the standard transport belt for this, because efforts have been made to innovate this model but have not been proven successful. Because all the employees know the project everybody had been able to form an opinion about it and since it is a standard product it has a closer nature to the activities that Grisnich is currently best at. On top of that the standard transport belt is a product that has been produced a lot and is one of the core products for most employees it is not a technological difficult product. This makes the selection of employees for this project easier because everybody can understand it and (probably) has an opinion about the product.

  During this pilot it is important to introduce people to the process and let them understand the principle of it. Everybody should be aware that no miracles can happen and new methods take time to get used to. After the five weeks that the method requires it is important to evaluate and try again.

- Third; for a second test case the sorting machine is recommended. This is because, the model is currently out of date and needs to be updated and it has already been indicated that the sorting machine needs to be changed and an update is planned for November, giving it a deadline and priority it needs. The sorting machine is technologically more complex; this means that the section of people for the creativity session and especially the core members is more important. The management should use the experience gained in the first pilot for the second pilot.

With these two test cases the method should be more familiar and could be implemented in the activities of Grisnich. With this method implemented the creation and transfer of knowledge should become better and optimise the development process. Apart from the practical relevance this research is also relevant from a scientific perspective.

6.3 Scientific Contribution of the Research

As said before (see section 1.3.2) knowledge creation and knowledge transfer are often seen as two different processes. Often they require separate (information) systems. In other words they are seen as individual processes and thereby not integrated into other business processes. This research tried to combine knowledge creation and knowledge transfer into a problem solving process that can be implemented into the current daily processes. Not only does this provide insight in how knowledge creation and knowledge transfer can contribute to each other in particular situations it also showed when particular factors of knowledge creation or knowledge transfer are important when solving problems. Integrating the concepts of knowledge creation and knowledge transfer into a time perspective is the highest novelty factor of this research.

Another relevant aspect of this research was the link between knowledge creation and knowledge transfer in relation to standard and custom products. The current scientific literature does not make a clear distinction between standard and custom products in relation to knowledge creation and knowledge transfer. This research tried to do by creating a theoretical framework for this and performing empirical research using this framework. The theoretical framework showed that there is a possibility to make a distinction between the two product types. This contributes to the understanding of the two principles used. The empirical research, however, showed that in practice the distinction between standard and custom products is difficult to maintain (also see section 6.3.1).

There are, as said, limitations of the research and suggestion for further research that will be explained in the next sections.

6.3.1 Limitations of the Research

The first limitation comes from the empirical part of this research. Although specifically researched, the distinction between standard and custom products was not applied in practise. This caused the results to only be for the produced products in general. Further recommendations on how to optimise the development process could be made based on the results, but could have been more specific if currently a distinction was made between the two product types.

The second limitation is concerned with a major event that has occurred in the last years at Grisnich, the acquirement by Tolsma Beheer B.V. This could and should results in synergy advantages, but currently nothing of that is present (see section 4.2). This research also has excluded the possible synergy advantages that could be achieved when both companies are collaborating closer. The main focus of the research was the engineering department of Grisnich and data collection as well as recommendations provided is focused on this department.

Another limitation of the research is that the final development model only focuses on the first part of the product development. This is done, because the bottleneck was located there and with the attraction of a new head of engineering expertise on the later part of the development process was gained. Still this research will ad a significant benefit, because it suggests a possible method and procedure that is currently not present.

The third limitation has to do with the ability to generalise the results of this study. Due to the limited number of cases the scientific relevance is not as high as it could be when multiple cases where studied. Because this research was set up as a single case study this was not possible, however.

With the limitations stated suggestions for further research are explained.

6.3.2 Suggestions for further Research

Because of the limitations of this research and the type of research chosen there is room for further research on this particular topic.

The first suggestion for further research is to add additional cases to this research in order to increase the possibilities of generalisation of the results. Currently generalisation of the results is not possible due to the single case study character of this research. In order to make this research of academic significance additional research and cases are needed.

The second suggestion is concerned with additional research on the later part of the development process. This was excluded from the current research due to several reasons, but additional research perhaps in combination with the first suggestion can be done, though.

The final suggestion for further research is concerned with another limitation of the research, namely the integration with Tolsma. It is possible that with the organisation of similar methods at or together with Tolsma even greater synergy advantages can be reached. Only further research can tell.

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Appendix

A. Determination of Measurements

1) Measurements for Knowledge Creation

Knowledge creation capability is determined by ten different factors. Each of these factors has to be made measurable in such a way that they can provide insight into the current situation of knowledge management practices. It is therefore important to determine what is to be asked for each of the factors. Scores of individual employees are not compared in the analysis. This is not needed, because the goal is to provide recommendations about the management of knowledge. Difference between product types, on the other hand, needs to be highlighted.

- Experience: to measure experience several measurements can be taken. Wright and Wright (2008) made a distinction in their study between general work experience, industry work experience, and task experience. The conclusion of the study was that the measurement of industry experience explained a persons experience best. Because of this and the fact that other scholars use this measurement as well (e.g. Smith et al., 2005), it is used as a measurement for experience. The purpose of using this measurement is to see what experience is available within the company and to see how this experience is used. For determining which knowledge is available within the company the measurement of experience is used in the questionnaire. To see how this experience is used, experience is analysed during the project analysis.

- Formal Education; education is measured using the years of formal education (Smith et al., 2005). Because schools can be followed without completing them, the highest finished education also needs to be questioned. This also makes sure that someone who has done 10 year on a bachelor level of education does not come higher than someone who has done, for example, a PhD research in 3-4 years. Questioning education of employees is useful, because it provides an indication of one capabilities to create an understanding and thereby an indication of ones ability to absorb information. Since the measurement of education provides an indication of the capabilities to process information it is not sufficient to only as this to the engineering department and therefore will be part of the interview as well as the questionnaire.

- Knowledge Diversity: is measured by looking at the different technologies that are brought into the development of a product (Smith et al., 2005). Questioning the individuals about the knowledge of technologies they possess and relate them to finished products can do this. By looking at which individuals are involved in the development an estimate can be made of the diversity of knowledge that has gone into the development. Before this can be questioned to all the employees, a list of possible technologies has to be developed (Smith et al., 2005). The goal of this measurement is to see what kind of knowledge is put into a project. This factor will be asked during the questionnaire to see what knowledge is available within the company and used during the project analysis to see how the knowledge is used. When analysing and questioning this factor the differences in development of standard products and new installations will be emphasised.

- Number of Direct Contacts: measuring this factor can easily by just saying list all the contacts you have. This, however, is not so usable. Dividing this list into the categories defined earlier can provide additional insight into the type of contacts one possesses and the knowledge related to this contacts (Smith et al., 2005). A higher number of direct contacts is seen as the more contracts a person has. This higher number of direct contacts is needed to gain an understanding of the size of the network individual employees posses. The size of the network says something about the knowledge accessible for the creation of new knowledge (Smith et al., 2005) and is therefore important to question to more

employees than the engineering department alone. This factor will be questioned during the questionnaire and the interviews.

- Network Range; as said earlier knowledge diversity and network range contain similarities, they both are concerned with the mixture of knowledge input available. With knowledge diversity focussing on the knowledge of the individual, network range focuses on the knowledge in the network of the individual. Network range can be measured by listing the number of groups a person is contacted to (Smith et al., 2005). The more contact groups a person has, the broader the network range of that individual is. The same list of contact categories is used to measure this. The goal of questioning about the network range of individuals is to see how broad the network of individuals is, which in its turn is useful for the creation of knowledge (Nonaka & Takeuchi, 1995). This factor will be used in the questionnaire as well as in the interview.

- Strength of Network Ties; the strength of a tie can be measure by the duration relationship, frequency of interaction, emotional intensity (Levin & Cross, 2004; Smith et al., 2005). Having relationships that last a large number of years, frequent interaction with relations or high emotional intensity is seen as factors for a high strength of network ties. Because it is impossible to request individuals to specify it for each contact they have, an average is asked by contact category. This will again provide additional insight in the network individuals possess, which is needed to gain an understanding of the total network. During the interview the focus will lie on the overall network of the individuals, goal is to gain additional qualitative data. In the questionnaire the goal is to construct ego-networks of individuals and see the tie strength. To measure this, the method of Smith et al. (2005) is used. This method calculates an index for tie strength according to the criteria introduced above.

- Structural holes; structural holes are measured by Ahuja (2000) using a method from Burt (1991, in: Ahuja, 2000). This method uses a formula to measure the proportion of interaction to different contacts and the strength these contact have with other contacts. Although this formula measures the structural holes correctly it is very difficult to apply this in qualitative research by conducting, for example, interviews. The principle behind the formula stated by Burt (1991, in: Ahuja, 2000) is to determine how much the contacts of Actor A interact with each other. This factor will be questioned during the interviews as well as during the questionnaire. In the interviews the focus will lie on the type of network, while during the questionnaire the focus lies on the structural holes in the networks of individuals.

- Climate for Teamwork; the climate for teamwork is something which is beneficial for the development of new installation, but not beneficial for the development of standard products. Having this in mind it is interesting to look into the climate for teamwork. To measure the climate for teamwork the focus has to lie on the perceived quality of collaboration between personnel (Davenport, Henderson, Mosca, Khuri & Mentzer, Jr., 2007). So it does not depend on the quality of the teamwork, but on how individuals perceive the quality of working together. Davenport et al. (2007) have constructed a list of measurements for measuring this perceived quality. Measurements include questions about how communication, coordination, balance of team member contributions, mutual support, effort, and cohesion are perceived by individuals. The goal is to get an indication of how different departments look at teamwork and how teamwork is related to the development of different products. This will be emphasised during the questioning. It is not needed to have this information from each individual. This list will be used in the interviews to see how individuals representing different department perceive teamwork. The project analysis is done to see if, when, and how long teams are working together on projects. This means that this factor will be used in the interviews and during the project analysis.

- Climate for Risk Taking; an environment in which risk-taking is naturally is in the area of entrepreneurship (Lumpkin & Dess, 1996). Entrepreneurship is seen as an activity that, amongst other things, requires risk-taking. To measure risk-taking on the organizational level, which is needed

to understand the climate (Lumpkin & Dess, 1996), Venkatraman (1989) has developed a measurement. This measurement measures the perception that individuals have about the risk-taking attitude of the organization. This makes it ideal for this research. On top of that, one would like to know the privilege for certain types of projects and the type of current products that are done (Miller & Friesen, 1982). In order to measure this Miller and Friesen (1982) have constructed questions using statements related to these variables. The goal of this measurement is to gain an understanding of how different departments stand against risk-taking. Again, the difference of standard products and new installations needs to be emphasised. The goal is similar to the factor 'climate for teamwork' and therefore the same data collection methods will be used; the interview and the project analysis. The interviews will focus on how individuals perceive the risk-taking environment of Grisnich, while the project analysis focuses on if and when risks are taken. This is measured by looking at which projects include things new to the company.

- Organizational Memory; is important for the development of products, but is often misused (Walsh & Ungson, 1991). The most important things to research are therefore the use of organizational memory and the situation in which it is used. First an understanding of the situations in which organizational memory is used needs to be determined, after which the resources that are put into the process need to be determined. The goal is to understand when and how knowledge from the past is used. This helps to clarify, for example, how currently the balance between the development of standard products or new installations is handled. This factor will be questioned during the interviews and in the questionnaire. During the interviews answers to the events questioned above need to be provided, while in the questionnaire the focus will lie on how many times products are developed using drawings from previous projects and possible differences in retrieval of knowledge of different product types.

As said in section 3.3 most of the factors will be asked during in-depth interviews. The measurement for which this is not possible, or for the ones where additional insight is desirable a questionnaire will be held to gain this information or previous projects will be analysed. Table 4 provides an overview of which factors are included in which data collection method.

2) Measurements for Knowledge Transfer

Following the same procedure as for the factors of knowledge creation, knowledge transfer is to be made measurable. As a guide for measuring knowledge transfer, items from the questionnaire by Ko et al. (2005) will be used. This questionnaire is based on the factors of knowledge transfer identified earlier by Szulanski (1996). For each factor the goal behind asking questions about the factor and the collection method will also be stated.

- Ease of the Relationship; measures the quality of the relationship. This is done by asking questions concerning the ease of communicating and the initiation of the communication (Ko et al., 2005). Although this factor shows similarities with the factor 'strength of network ties' there are differences. The factor 'strength of network ties' focuses on the frequency of interaction for groups of ties, while intimacy of the relationship focuses on whether or not people are willing to go to another person instead of turning to company documents. The goal of this measurement is to determine the intimacy of relationships individuals have within the company as well as outside the company. This will be asked to persons of different departments during the interviews and questionnaire.

- Shared Understanding; is measured by determining the extent to which individuals have similar heuristics and prior experiences (Szulanski, 1996). This is asked by questioning if people of different department agree on: (1) what is important during the process, (2) how a project should be implemented, (3) how a problem should be approached, (4) if they understand the people they talk with, and (5) if they have notion of the complete process of product development (Ko et al., 2005). Asking this during the interviews creates understanding of how this is perceived on a department level since the heads of department are interviewed. Asking it during the questionnaire will create an

understanding of how it is perceived on an individual level. The goal is to determine how the transfer of knowledge is currently understood.

- Absorptive Capacity; measures ones ability to value external information, assimilate it, and apply it (Ko et al., 2005). In other words, it measures ones ability to understand and use external information. Looking at this one can see similarities with de factor 'education', but absorptive capacity has a different focus. Absorptive capacity is measured by asking questions about whether or not people had a vision about what was tried to achieve during the knowledge transfer process. If they knew what their function was during the development process and had the skills to implement the product development (Szulanski, 1996). Education only provides an indication about the capabilities of a person to process information, but says nothing about it. Absorptive capacity analysis this matter much deeper. The goal of this measure is to determine whether or not individuals know what they are doing and see where the company is going. This factor will be questioned during the interviews and in the questionnaire. Since this factor is important for finding a balance for the simultaneous development of different products, emphasis will be put on the development of these different product types by asking questions concerning development of standard products and new installations separately.

- Extrinsic Motivation; is measured by asking how satisfactory the monetary rewards are to a person. On top of that a person's awareness of how their performance relates to receiving monetary rewards is questioned (Ko et al., 2005). This is done to find out what motivates people. It is asked during the interviews and the questionnaire. The focus of the interview will lie on department level, while during the interview the focus lies on individual motivations.

- Intrinsic Motivation; intrinsic motivation measures to what extent persons can find satisfaction in the activity they perform themselves (Ko et al., 2005). Although the subject is quite similar to extrinsic motivation, the questions are different. They do not ask peoples awareness to possessing knowledge and receiving monetary awards, instead they ask how satisfactory obtaining new knowledge and doing ones task is (Szulanski, 1996). Again the goal of asking questions like this is to find out what motivates people. This factor will also be questioned during the interview and the questionnaire. As with extrinsic motivation, the focus of the interview will lie on department level, while during the interview the focus lies on individual motivations.

- Source Credibility; is measured by asking ones perception about the persons they work with (Szulanski, 1996). Topics to question are the trustworthiness, open-mindedness, and experience (Ko et al., 2005). Even though it is highly subjective how and different for each employee, summing the answers to this question can indicate a feeling of how people feel each other. The focus will lie on the sources within the company. This focus is chosen, because internal knowledge transfer is very important for the development of products (Ko et al., 2005) and potential problems should be solved as soon as possible. The goal of this measurement is to determine how trustworthy people perceive their colleagues. It will be used during the interviews and the questionnaire.

- Communication Competence; communication competence is measured in two ways, encoding and decoding (Ko et al., 2005). Encoding is concerned with the ability to express ideas clearly. Questions that need to be asked are in the direction of the clarity of written as well as verbal communication. Decoding has to do with ones ability to listen and respond. Questions that need to be asked are related to ones attention to others and ability to talk to. This needs to be asked in order to find out how effective (fast) knowledge can be transferred. The focus of the interview will lie on department level, while during the interview the focus lies on individual perception of communication competence.

B. List of Contact Categories

As said in the methodology the list of contact categories is used in the questionnaire. Because the questionnaire is conducted in Dutch a Dutch version is included as well.

1) List of Contact Categories (Dutch Version)

1 Toeleverancier Mechanisch
2 Toeleverancier Electrisch
3 Toeleverancier Diensten
4 Toeleverancier Hydroliek
5 Afdeling Verkoop
6 Afdeling Inkoop
7 Afdeling Werkvoorbereiding
8 Afdeling Productie
9 Afdeling Montage
10 Afdeling Financiën
11 Klanten GrisBook
12 Klanten GrisCrop
13 Klanten GrisLock
14 Klanten GrisFish
15 Branche Verenigingen
16 Business Clubs
17 Scholen / Kennisinstelling
18 Potentiële Klanten
19 (Samenwerkings)partners
20 Concurrenten

2) List of Contact Categories (English Version)

1 Supplier Mechanical
2 Supplier Electrical
3 Supplier Services
4 Supplier Hydrolics
5 Sales Department
6 Purchasing Department
7 Work Preparation Department
8 Production Department
9 Assembly Department
10 Finance Department
11 Customers GrisBook
12 Customers GrisCrop
13 Customers GrisLock
14 Customers GrisFish
15 Branche Organisations
16 Business Clubs
17 Schools / Knowledge Institutions
18 Potential Customers
19 Partners
20 Competitors

C. List of Technologies

As said in the methodology the list of technologies is used in the questionnaire. Because the questionnaire is conducted in Dutch a Dutch version is included as well.

1) List of Technologies (Dutch Version)

Dynamica
Statica
Sterkteleer
CAD/CAM
Bewegingsleer
Vermogensleer
Plaatwerk
Verspaning
Snijwerk
Puntlassen
Gietwerk
Spuiten
Poeder Coaten
Lassen
Galvaniseren
Thermisch verzinken
Ketting Aandrijving
Tandriem Aandrijving
Riem Aandrijving
Lagers
Aandrijving Electro
Metalen
Rubbers
Kunststof
Pneumatiek/Hydroliek

2) List of Technologies (English Version)

Dynamics
Statics
Strength of Materials
CAD/CAM
Physics
Powers and Forces
Sheet Metal
Machining
Metal Sculpting
Spot Welding
Casting
Painting
Powder Coating
Welding
Galvanise
Thermical Zinc
Chain Transmission
Sprocket Transmission
Belt Transmission
Barings
Electronic Transmission
Metals
Rubbers
Plastics
Pneumatics/Hydrolics

D. Questionnaire

As said in the methodology the questionnaire was conducted in Dutch, therefore a Dutch version is included.

1) Questionnaire (Dutch Version)

Vragenlijst Afstudeeropdracht Simon Zomerdijk

Voor mijn afstuderen ben ik aan het onderzoeken hoe de kennis van de mensen van Grisnich optimaal gebruikt kan worden. Om een goed beeld te kunnen krijgen welke kennis er momenteel aanwezig is binnen Grisnich wil ik een vragenlijst voorleggen. Ik zal de antwoorden op de vragenlijst gebruiken om aanbevelingen te doen aan de afdeling engineering over hoe ze het beste de ontwikkeling van producten kunnen organiseren.

Het invullen van de vragenlijst zal ongeveer 20-30 minuten in beslag nemen. De vragenlijst bestaat uit een aantal vragen over je opleiding en kennis die je zelf bezit, maar ook over de personen met wie je contact zoekt als je met een vraag zit. Deze vragen zijn voornamelijk gesloten (aankruisen van een hokje is voldoende), maar er zitten een aantal open vragen tussen. Het laatste stuk zal gaan over de communicatie en kennis die daarbij wordt overgedragen, deze vragen zijn allemaal gesloten.

Ik heb zelf geen belang bij antwoorden van personen individueel en zal de gegevens ook niet aan anderen verstrekken zonder toestemming. Door het invullen help je mij enorm.

Mochten er onduidelijkheden zijn over het invullen van de vragenlijst laat het me dan weten, dan proberen we er samen uit te komen. Het is mogelijk om de vragenlijst digitaal in te vullen, in de grijze vakken kan getypt worden, of een hokje aangevinkt worden. Printen en een hardcopy inleveren mag natuurlijk ook.

Naam:

Functie:

1	Mijn hoogst genoten opleidingsniveau is: WO/Universiteit ☐ HBO/HTS ☐ MBO/MTS ☐ VMBO/LTS ☐ Anders, ☐ Anders, nl.:
2	De richting van mijn laatst genoten opleiding is: Richting:
3	In de laatste (drie) jaren heb ik nog (avond)cursussen gevolgd. Ja ☐, Welke: Nee ☐, Welke zou je willen volgen:
4	Ik werk al … jaar voor Machinefabriek Grisnich BV 0-3 ☐ 4-6 ☐ 7-10 ☐ 11-15 ☐ 15+ ☐
5	Ik ben al … jaar actief in de industrie 0-3 ☐ 4-6 ☐ 7-10 ☐ 11-15 ☐ 15+ ☐
6	Ik heb al … jaar de zelfde functie 0-3 ☐ 4-6 ☐ 7-10 ☐ 11-15 ☐ 15+ ☐
7	Van de volgende technologieën/technieken heb ik het meeste verstand (noem er maximaal 5) Dynamica ☐ Statica ☐ Sterkteleer ☐ CAD/CAM ☐ Bewegingsleer ☐ Vermogensleer ☐ Plaatwerk ☐ Verspaning ☐ Snijwerk ☐ Puntlassen ☐ Gietwerk ☐ Spuiten ☐ Poeder Coaten ☐ Lassen ☐ Galvaniseren ☐ Thermisch verzinken ☐ Ketting Aandrijving ☐ Tandriem Aandrijving ☐ Riem Aandrijving ☐ Lagers ☐ Aandrijving Electro ☐ Metalen ☐ Rubbers ☐ Kunststof ☐ Pneumatiek/Hydroliek ☐

8	Ik haal mijn kennis over technologieën/technieken vooral uit de volgende bronnen (noem er maximaal 3) Uit mijn dagelijkse werk (individueel) ☐ Uit mijn dagelijkse werk (uit overleg) ☐ Vanuit nieuwe wetgeving ☐ Uit mijn netwerk (extern) ☐ Vanuit de boeken van de leveranciers ☐ Uit (vak)bladen ☐ Beursbezoeken ☐ Uit voorgaande projecten ☐ Van internet ☐
9	Kennis van deze technologieën/technieken gebruik ik vooral voor de ontwikkeling van Standaard producten ☐ Nieuwe (eenmalige) producten ☐ Het opstellen van een layout ☐ Het opstellen van offertes ☐
10	Kennis van deze technologieën/technieken zou ik vooral willen gebruiken voor de ontwikkeling van Standaard producten ☐ Nieuwe (eenmalige) producten ☐ Het opstellen van een layout ☐ Het opstellen van offertes ☐
11	Met de volgende typen contacten heb ik contact 1 Toeleverancier Mechanisch ☐ 2 Toeleverancier Electrisch ☐ 3 Toeleverancier Diensten ☐ 4 Toeleverancier Hydroliek ☐ 5 Afdeling Verkoop ☐ 6 Afdeling Inkoop ☐ 7 Afdeling Werkvoorbereiding ☐ 8 Afdeling Productie ☐ 9 Afdeling Montage ☐ 10 Afdeling Finance ☐ 11 Klanten GrisBook ☐ 12 Klanten GrisCrop ☐ 13 Klanten GrisLock ☐ 14 Klanten GrisFish ☐ 15 Branche Verenigingen ☐ 16 Business Clubs ☐ 17 Scholen / Kennisinstelling ☐ 18 Potentiële Klanten ☐ 19 (Samenwerkings)partners ☐ 20 Concurrenten ☐
12	Benoem zo nauwkeurig mogelijk het aantal contacten per contact type (de nummers komen overeen met de nummers gebruikt in vraag 11) Aantal Contact Type 0-3 4-6 7-10 11-15 15+ 1 ☐ ☐ ☐ ☐ ☐ 2 ☐ ☐ ☐ ☐ ☐ 3 ☐ ☐ ☐ ☐ ☐ 4 ☐ ☐ ☐ ☐ ☐ 5 ☐ ☐ ☐ ☐ ☐ 6 ☐ ☐ ☐ ☐ ☐ 7 ☐ ☐ ☐ ☐ ☐ 8 ☐ ☐ ☐ ☐ ☐ 9 ☐ ☐ ☐ ☐ ☐ 10 ☐ ☐ ☐ ☐ ☐ Aantal Contact Type 0-3 4-6 7-11 10-15 15+ 11 ☐ ☐ ☐ ☐ ☐ 12 ☐ ☐ ☐ ☐ ☐ 13 ☐ ☐ ☐ ☐ ☐ 14 ☐ ☐ ☐ ☐ ☐ 15 ☐ ☐ ☐ ☐ ☐ 16 ☐ ☐ ☐ ☐ ☐ 17 ☐ ☐ ☐ ☐ ☐ 18 ☐ ☐ ☐ ☐ ☐ 19 ☐ ☐ ☐ ☐ ☐ 20 ☐ ☐ ☐ ☐ ☐

13	Ik neem het vaakst contact op met de volgende personen, vanwege hun expertise op een bepaald vakgebied Naam Expertise 1 2 3 4 5
14	Contact met de volgende personen is voor mij vereist om mijn doelen te halen / werk te kunnen doen Naam Expertise 1 2 3 4 5
15	Met de personen uit vraag 14 heb al … jaar contact Naam Jaar contact 0-3 4-6 7-10 11-15 15+ 1 ☐ ☐ ☐ ☐ ☐ 2 ☐ ☐ ☐ ☐ ☐ 3 ☐ ☐ ☐ ☐ ☐ 4 ☐ ☐ ☐ ☐ ☐ 5 ☐ ☐ ☐ ☐ ☐
16	Met de personen uit vraag 14 heb ik gemiddeld … keer per maand contact Naam Aantal keer per maand contact 0-3 4-6 7-10 11-15 15+ 1 ☐ ☐ ☐ ☐ ☐ 2 ☐ ☐ ☐ ☐ ☐ 3 ☐ ☐ ☐ ☐ ☐ 4 ☐ ☐ ☐ ☐ ☐ 5 ☐ ☐ ☐ ☐ ☐

17	Hoe sterk is de relatie met de personen uit vraag 14 Naam 1 Sterk ☐ ☐ ☐ ☐ ☐ Zwak 2 Sterk ☐ ☐ ☐ ☐ ☐ Zwak 3 Sterk ☐ ☐ ☐ ☐ ☐ Zwak 4 Sterk ☐ ☐ ☐ ☐ ☐ Zwak 5 Sterk ☐ ☐ ☐ ☐ ☐ Zwak
18	Het laatste project waar ik aan gewerkt heb kan worden gezien als een Standaard product ☐ Nieuwe (eenmalige) producten ☐
19	Voor de ontwikkeling van standaard producten maak ik vaak gebruik van kennis uit het verleden. Volledig mee eens ☐ ☐ ☐ ☐ ☐ Volledig mee oneens
20	Voor de ontwikkeling van nieuwe (eenmalige) producten maak ik vaak gebruik van kennis uit het verleden. Volledig mee eens ☐ ☐ ☐ ☐ ☐ Volledig mee oneens
21	Tijdens mijn laatste project heb ik vooral gebruik gemaakt van mijn eigen kennis. Volledig mee eens ☐ ☐ ☐ ☐ ☐ Volledig mee oneens
22	Ik maak (vrijwel) nooit gebruik van kennis van anderen als ik ergens niet uitkomt. Volledig mee eens ☐ ☐ ☐ ☐ ☐ Volledig mee oneens
23	Als ik opzoek ben naar informatie vind ik de volgende bronnen belangrijk: (geef een rangorde aan in de belangrijkheid van de informatiebronnen met een 1 voor de belangrijkste, 2 voor de op een na belangrijkste, enz.) Collega's binnen mijn afdeling Collega's buiten mijn afdeling Isah Tekeningen (opstelling) uit het verleden Tekeningen (onderdelen) uit het verleden Foto's van de netwerkschijf Planning Nacalculatie Anders, nl.

24	Ik haal gemiddeld … keer per maand informatie uit de informatiebronnen. Informatiebron — aantal keer per maand contact: 0-3 / 4-6 / 7-10 / 11-15 / 15+ Collega's binnen mijn afdeling ☐ ☐ ☐ ☐ ☐ Collega's buiten mijn afdeling ☐ ☐ ☐ ☐ ☐ Isah ☐ ☐ ☐ ☐ ☐ Tekeningen (opstelling) uit het verleden ☐ ☐ ☐ ☐ ☐ Tekeningen (onderdelen) uit het verleden ☐ ☐ ☐ ☐ ☐ Foto's van de netwerkschijf ☐ ☐ ☐ ☐ ☐ Planning ☐ ☐ ☐ ☐ ☐ Nacalculatie ☐ ☐ ☐ ☐ ☐ (Vak)bladen ☐ ☐ ☐ ☐ ☐ Wetenschappelijke artikelen ☐ ☐ ☐ ☐ ☐ Internet ☐ ☐ ☐ ☐ ☐ Boeken leveranciers ☐ ☐ ☐ ☐ ☐ Anders, nl. ☐ ☐ ☐ ☐ ☐
25	Ik vertrouw voor het oplossen een probleem altijd op de zelfde informatiebron Volledig mee eens ☐ ☐ ☐ ☐ ☐ Volledig mee oneens
26	Ik ben geneigd naar oplossingen te zoeken die hun resultaat in het verleden hebben bewezen Volledig mee eens ☐ ☐ ☐ ☐ ☐ Volledig mee oneens
27	Ik houd er niet van om projecten aan te pakken volgens een standaard methode Volledig mee eens ☐ ☐ ☐ ☐ ☐ Volledig mee oneens
28	Ik ben van mening dat ieder probleem een andere aanpak vereist Volledig mee eens ☐ ☐ ☐ ☐ ☐ Volledig mee oneens
29	De collega's van mijn laatste project en ik zijn het eens over wat belangrijk is. Volledig mee eens ☐ ☐ ☐ ☐ ☐ Volledig mee oneens
30	De collega's van mijn laatste project en ik hebben vergelijkbare ervaring met de implementatie van projecten. Volledig mee eens ☐ ☐ ☐ ☐ ☐ Volledig mee oneens
31	De collega's van mijn laatste project en ik lossen problemen op de zelfde manier op. Volledig mee eens ☐ ☐ ☐ ☐ ☐ Volledig mee oneens

32	De collega's van mijn laatste project en ik begrijpen elkaar wanneer we met elkaar spreken. Volledig mee eens ☐ ☐ ☐ ☐ ☐ Volledig mee oneens
33	De collega's van mijn laatste project en ik zijn niet veel tijd kwijt aan het begrijpen van elkaar. Volledig mee eens ☐ ☐ ☐ ☐ ☐ Volledig mee oneens
34	Het implementatieproces was duidelijk voor mijn collega's al tijdens het project. Volledig mee eens ☐ ☐ ☐ ☐ ☐ Volledig mee oneens
35	De klant van mijn laatste project en ik zijn het eens over wat belangrijk is. Volledig mee eens ☐ ☐ ☐ ☐ ☐ Volledig mee oneens
38	De klant van mijn laatste project en ik begrijpen elkaar wanneer we met elkaar spreken. Volledig mee eens ☐ ☐ ☐ ☐ ☐ Volledig mee oneens
39	De klant van mijn laatste project en ik zijn niet veel tijd kwijt aan het begrijpen van elkaar. Volledig mee eens ☐ ☐ ☐ ☐ ☐ Volledig mee oneens
40	Ik vind het leuk om technische of bedrijfskundige kennis op te doen uit mijn projecten. Volledig mee eens ☐ ☐ ☐ ☐ ☐ Volledig mee oneens
41	Des de moeilijker een project te begrijpen is des de meer voldoening het mij geeft om dit te proberen te begrijpen. Volledig mee eens ☐ ☐ ☐ ☐ ☐ Volledig mee oneens
42	Ik vind het leuk om technische of bedrijfskundige kennis op te doen in gebieden die nieuw voor mij zijn. Volledig mee eens ☐ ☐ ☐ ☐ ☐ Volledig mee oneens
43	Ik heb het gevoel dat ik er persoonlijk beter van moet worden om technische of bedrijfskundige kennis op doen van projecten. Volledig mee eens ☐ ☐ ☐ ☐ ☐ Volledig mee oneens
44	Ik voel me meer op mijn gemak als ik zelf mijn doelen mag stellen voor het opdoen van bedrijfskundige of technische kennis over projecten. Volledig mee eens ☐ ☐ ☐ ☐ ☐ Volledig mee oneens

45	Ik ben mij bewust wat mijn inkomensdoelen zijn als ik technische of bedrijfskundige kennis opdoe bij projecten.					
	Volledig mee eens	☐	☐	☐	☐	☐ Volledig mee oneens
46	Ik raak sterk gemotiveerd door het geld dat ik verdien als ik technische of bedrijfskundige kennis opdoe van projecten.					
	Volledig mee eens	☐	☐	☐	☐	☐ Volledig mee oneens
48	Als ik kennis opdoe uit een project wil ik anderen laten merken hoe goed ik ben.					
	Volledig mee eens	☐	☐	☐	☐	☐ Volledig mee oneens
49	Ik raak sterk gemotiveerd door de erkenning die ik krijg als ik technische of bedrijfskundige kennis opdoe.					
	Volledig mee eens	☐	☐	☐	☐	☐ Volledig mee oneens
50	Ik heb het gevoel dat ik iets moet verdienen voor het opdoen van technische of bedrijfskundige kennis.					
	Volledig mee eens	☐	☐	☐	☐	☐ Volledig mee oneens
51	Mijn collega's hebben een goede manier van communiceren.					
	Volledig mee eens	☐	☐	☐	☐	☐ Volledig mee oneens
52	Mijn collega's komen direct ter zake.					
	Volledig mee eens	☐	☐	☐	☐	☐ Volledig mee oneens
53	Ik kan efficiënt met anderen omgaan.					
	Volledig mee eens	☐	☐	☐	☐	☐ Volledig mee oneens
54	De geschreven communicatie van mijn collega's is moeilijk te begrijpen.					
	Volledig mee eens	☐	☐	☐	☐	☐ Volledig mee oneens
55	Mijn collega's uitten hun ideeën duidelijk.					
	Volledig mee eens	☐	☐	☐	☐	☐ Volledig mee oneens
56	De verbale communicatie van mijn collega's is moeilijk te begrijpen.					
	Volledig mee eens	☐	☐	☐	☐	☐ Volledig mee oneens

57	Mijn collega's zeggen meestal het juiste op het goede moment.					
	Volledig mee eens	☐	☐	☐	☐	☐ Volledig mee oneens
58	Het is gemakkelijk om met de klant van mijn laatste project te praten.					
	Volledig mee eens	☐	☐	☐	☐	☐ Volledig mee oneens
59	De klant van mijn laatste project reageert vaak snel op berichten (telefoon gesprekken, rapporten, etc.).					
	Volledig mee eens	☐	☐	☐	☐	☐ Volledig mee oneens

Hartelijk dank voor het invullen van de vragenlijst!

2) Questionnaire

Questionnaire Master Thesis Simon Zomerdijk

For my master thesis I am researching how knowledge of the employees of Grisnich can be used optimal for the development of products. In order to gain an understanding of currently available knowledge I would like you to fill out this questionnaire. I will use this questionnaire to provide recommendations to the engineering department on how to organise the development of products.

Filling out the questionnaire will consume about 20-30 minutes of you time. The questionnaire consists of questions about your education and knowledge you possess, but also questions about the persons in you personal network or with whom you seek contact when having a question. The majority of questions are closed (multiple-choice) questions, but open questions are also included. The last part of the questionnaire is about the communication and the knowledge that gets transferred during this communication, all those questions are closed.

I personally have no interest in the individual scores and will not provide the scores of individual to other parties without your permission. By filling in this questionnaire you would help me a lot.

If you have any questions about filling out the questionnaire please let me know so we can search for a solution together. It is possible to fill out the questionnaire digitally, they grey areas can be used for typing or crossing of a box. Handing in a hardcopy is of course also possible.

Name:

Job title:

1	My highest form of education is: WO/Universiteit ☐ HBO/HTS ☐ MBO/MTS ☐ VMBO/LTS ☐ Other, ☐ Other, meaning:
2	My last diploma was in the following field of education: Field of education:
3	In the last (three) years I have followed courses. Yes ☐, Which: No ☐, Which would you like to follow:
4	I have been working … years for Machinefabriek Grisnich BV 0-3 ☐ 4-6 ☐ 7-10 ☐ 11-15 ☐ 15+ ☐
5	Ik have been … years active in the industry 0-3 ☐ 4-6 ☐ 7-10 ☐ 11-15 ☐ 15+ ☐
6	I have the same function of … years 0-3 ☐ 4-6 ☐ 7-10 ☐ 11-15 ☐ 15+ ☐
7	Of these technologies/techniques I know the most (name a maximum of 5) Dynamics ☐ Statics ☐ Barings ☐ CAD/CAM ☐ Physics ☐ Metals ☐ Sheet Metal ☐ Machining ☐ Metal Sculpting ☐ Spot Welding ☐ Casting ☐ Painting ☐ Powder Coating ☐ Welding ☐ Galvanise ☐ Thermical Zinc ☐ Chain Transmission ☐ Sprocket Transmission ☐ Belt Transmission ☐ Strength of Materials ☐ Electronic Transmission ☐ Powers and Forces ☐ Rubbers ☐ Plastics ☐ Pneumatics/Hydrolics ☐

8	I get my knowledge of these technologies/techniques from the following sources (name a maximum of 3) From my daily work (individual) ☐ From magazines ☐ From my daily work (team meetings) ☐ From fair visits ☐ From new regulations ☐ From previous projects ☐ From my network (external) ☐ From internet ☐ From supplier brochures ☐
9	Knowledge of these technologies/techniques I use the most for the development of Standard products ☐ Custom products ☐ Designing a layout ☐ Making offers ☐
10	Knowledge of these technologies/techniques I would like to use the most for the development of Standard products ☐ Custom products ☐ Designing a layout ☐ Making offers ☐
11	Met de volgende typen contacten heb ik contact 1 Supplier Mechanical ☐ 11 Customers GrisBook ☐ 2 Supplier Electrical ☐ 12 Customers GrisCrop ☐ 3 Supplier Services ☐ 13 Customers GrisLock ☐ 4 Supplier Hydrolics ☐ 14 Customers GrisFish ☐ 5 Sales Department ☐ 15 Branche Organisations ☐ 6 Purchasing Department ☐ 16 Business Clubs ☐ 7 Work Preparation Department ☐ 17 Schools/Knowledge Inst. ☐ 8 Production Department ☐ 18 Potential Customers ☐ 9 Assembly Department ☐ 19 (Development) Partners ☐ 10 Finance Department ☐ 20 Competitors ☐
12	Name as accurate as possible the number of contacts per contact type. (the numbers correspont with the numbers used in question 11) Number / Number Contact Type 0-3 4-6 7-10 11-15 15+ / Contact Type 0-3 4-6 7-11 10-15 15+ 1 ☐ ☐ ☐ ☐ ☐ / 11 ☐ ☐ ☐ ☐ ☐ 2 ☐ ☐ ☐ ☐ ☐ / 12 ☐ ☐ ☐ ☐ ☐ 3 ☐ ☐ ☐ ☐ ☐ / 13 ☐ ☐ ☐ ☐ ☐ 4 ☐ ☐ ☐ ☐ ☐ / 14 ☐ ☐ ☐ ☐ ☐ 5 ☐ ☐ ☐ ☐ ☐ / 15 ☐ ☐ ☐ ☐ ☐ 6 ☐ ☐ ☐ ☐ ☐ / 16 ☐ ☐ ☐ ☐ ☐ 7 ☐ ☐ ☐ ☐ ☐ / 17 ☐ ☐ ☐ ☐ ☐ 8 ☐ ☐ ☐ ☐ ☐ / 18 ☐ ☐ ☐ ☐ ☐ 9 ☐ ☐ ☐ ☐ ☐ / 19 ☐ ☐ ☐ ☐ ☐ 10 ☐ ☐ ☐ ☐ ☐ / 20 ☐ ☐ ☐ ☐ ☐

13	I most often contact the following persons due to their expertise in a certain area Name Expertise 1 2 3 4 5
14	I need to contact the following persons in order to do my job / reach my goals Name Expertise 1 2 3 4 5
15	With the persons of question 14 I have … years of contact Name Years of contact 0-3 4-6 7-10 11-15 15+ 1 ☐ ☐ ☐ ☐ ☐ 2 ☐ ☐ ☐ ☐ ☐ 3 ☐ ☐ ☐ ☐ ☐ 4 ☐ ☐ ☐ ☐ ☐ 5 ☐ ☐ ☐ ☐ ☐
16	I contact the persons of question 14 on average … times a month Name Average times of a month 0-3 4-6 7-10 11-15 15+ 1 ☐ ☐ ☐ ☐ ☐ 2 ☐ ☐ ☐ ☐ ☐ 3 ☐ ☐ ☐ ☐ ☐ 4 ☐ ☐ ☐ ☐ ☐ 5 ☐ ☐ ☐ ☐ ☐

17	How strong is the relationship with the persons of question 14 Name 1 Strong ☐ ☐ ☐ ☐ ☐ Weak 2 Strong ☐ ☐ ☐ ☐ ☐ Weak 3 Strong ☐ ☐ ☐ ☐ ☐ Weak 4 Strong ☐ ☐ ☐ ☐ ☐ Weak 5 Strong ☐ ☐ ☐ ☐ ☐ Weak
18	The last project I have been working on can be seen as a Standard product ☐ Custom product ☐
19	For the development of standard products I often use knowledge from the past Completely agree ☐ ☐ ☐ ☐ ☐ Completely disagree
20	For the development of custom products I often use knowledge from the past Completely agree ☐ ☐ ☐ ☐ ☐ Completely disagree
21	During my last project I mainly used my own knowledge Completely agree ☐ ☐ ☐ ☐ ☐ Completely disagree
22	I (almost) never use knowledge of other when I do not know the solution to a problem Completely agree ☐ ☐ ☐ ☐ ☐ Completely disagree
23	When searching for information I find the following sources important. (provide an order of importance with 1 being most important 2 being second most important, etc.) Colleagues within my department Colleagues outside my department Isah Drawings (layouts) from the past Drawings (parts) from the past Pictures on the network disk Planning Calculations Other, namely.

24	On average I retrieve information from the following sources … times a month Information source — average times a month: 0-3 / 4-6 / 7-10 / 11-15 / 15+ Colleagues inside my department ☐ ☐ ☐ ☐ ☐ Colleagues outside my department ☐ ☐ ☐ ☐ ☐ Isah ☐ ☐ ☐ ☐ ☐ Drawings (layouts) from the past ☐ ☐ ☐ ☐ ☐ Drawings (parts) from the past ☐ ☐ ☐ ☐ ☐ Pictures on the network disk ☐ ☐ ☐ ☐ ☐ Planning ☐ ☐ ☐ ☐ ☐ Calculations ☐ ☐ ☐ ☐ ☐ Magazines ☐ ☐ ☐ ☐ ☐ Scientific articles ☐ ☐ ☐ ☐ ☐ Internet ☐ ☐ ☐ ☐ ☐ Supplier brochures ☐ ☐ ☐ ☐ ☐ Other, namely ☐ ☐ ☐ ☐ ☐
25	I always relay on the same information source for solving a problem Completely agree ☐ ☐ ☐ ☐ ☐ Completely disagree
26	I apt to search for solutions that have proven to be successful in the past Completely agree ☐ ☐ ☐ ☐ ☐ Completely disagree
27	I do not like to work on projects using a standard method Completely agree ☐ ☐ ☐ ☐ ☐ Completely disagree
28	I believe every problem needs a different approach Completely agree ☐ ☐ ☐ ☐ ☐ Completely disagree
29	The colleagues of my last project and I agreed on what was important Completely agree ☐ ☐ ☐ ☐ ☐ Completely disagree
30	The colleagues of my last project and I have similar experience in implementing projects Completely agree ☐ ☐ ☐ ☐ ☐ Completely disagree
31	The colleagues of my last project and I solve problems in a similar way Completely agree ☐ ☐ ☐ ☐ ☐ Completely disagree

32	The colleagues of my last project and I understand each other when we speak Completely agree ☐ ☐ ☐ ☐ ☐ Completely disagree
33	The colleagues of my last project and I do not spent much time understanding each other Completely agree ☐ ☐ ☐ ☐ ☐ Completely disagree
34	The implementation process was already clear for my colleagues during the development process Completely agree ☐ ☐ ☐ ☐ ☐ Completely disagree
35	The customer of my last project and I agree on what is important. Completely agree ☐ ☐ ☐ ☐ ☐ Completely disagree
38	The customer of my last project and I understand each other when we speak Completely agree ☐ ☐ ☐ ☐ ☐ Completely disagree
39	The customer of my last project and I do not spent much time understanding each other Completely agree ☐ ☐ ☐ ☐ ☐ Completely disagree
40	I like to gain technological or business knowledge from my projects Completely agree ☐ ☐ ☐ ☐ ☐ Completely disagree
41	The harder the project the more satisfaction is gives my trying to understand it Completely agree ☐ ☐ ☐ ☐ ☐ Completely disagree
42	I like to gain technological or business knowledge in areas that are new to me Completely agree ☐ ☐ ☐ ☐ ☐ Completely disagree
43	I have the feeling that I need to gain from it personally before gaining technological or business knowledge from projects Completely agree ☐ ☐ ☐ ☐ ☐ Completely disagree
44	I feel more comfortable setting my own goals for gaining technological or business knowledge about projects Completely agree ☐ ☐ ☐ ☐ ☐ Completely disagree

45	I am aware of my salary goals if I gain technological or business knowledge at projects Completely agree ☐ ☐ ☐ ☐ ☐ Completely disagree
46	I get highly motivated through the money I earn when gaining technological or business knowledge from projects Completely agree ☐ ☐ ☐ ☐ ☐ Completely disagree
48	I if gain knowledge I want other to know how good I am Completely agree ☐ ☐ ☐ ☐ ☐ Completely disagree
49	I get highly motivated by the acknowledgements I receive when gaining technological or business knowledge Completely agree ☐ ☐ ☐ ☐ ☐ Completely disagree
50	I have the feeling that I need to earn something before gaining technological or business knowledge Completely agree ☐ ☐ ☐ ☐ ☐ Completely disagree
51	My colleagues communicate in a good manner Completely agree ☐ ☐ ☐ ☐ ☐ Completely disagree
52	My colleagues are to the point Completely agree ☐ ☐ ☐ ☐ ☐ Completely disagree
53	I can deal with other efficiently Completely agree ☐ ☐ ☐ ☐ ☐ Completely disagree
54	The written communication of other is hard to understand Completely agree ☐ ☐ ☐ ☐ ☐ Completely disagree
55	My colleagues express their ideas clearly Completely agree ☐ ☐ ☐ ☐ ☐ Completely disagree
56	The verbal communication of my colleagues is difficult to understand Completely agree ☐ ☐ ☐ ☐ ☐ Completely disagree

57	My colleagues say the right thing at the right moment Completely agree ☐ ☐ ☐ ☐ ☐ Completely disagree
58	I it easy to take with the customer of my last project Completely agree ☐ ☐ ☐ ☐ ☐ Completely disagree
59	The customer of my last project reacts quickly to messages (mail, phone, reports, etc.) Completely agree ☐ ☐ ☐ ☐ ☐ Completely disagree

Thank you very much for answering the questionnaire!

E. Interview Example

The original interviews where conducted in Dutch. Because of this the interview questions where made in Dutch as well. A translated English version is included in the second part of this Appendix. It has to be said that the individual interviews all slightly differed from each other based on knowledge gained from previous interviews. The given examples, however, do reassemble the interviews conducted.

1) Interview Example (Dutch Version)

Introductie vragen

1. Wat is je functie?
2. Wat houden je dagelijkse activiteiten in?
3. Beschrijf het proces van order tot aan productie vanuit het perspectief van jou functie.
4. Wat zijn jou invloeden in dit proces?

Ego Netwerk

Aantal directe contacten

1. Met hoeveel contacten heb je contact tijdens een gemiddeld project? Zit er een verschil in projecten, bijvoorbeeld tussen standaard producten of nieuwe producten die ontwikkeld dienen te worden? Is het verschil in hoeveelheid contacten het grootste verschil tussen de ontwikkeling van producten?
2. Met hoeveel contacten heb je contact binnen Grisnich? En met Tolsma?

Netwerk breedte

1. Hoe ziet je bedrijfsnetwerk eruit? Is het breed, of heb je contact met een select gezelschap? Is de industrie van Grisnich een ons kent ons wereldje?
2. Heb je met verschillende contacten contact als je aan verschillende contacten werkt? Zit er een verschil in de kennis die je van verschillende contacten nodig hebt? Is het zo dat je voor een bepaald project opzoek bent gegaan naar nieuwe contacten om kennis op te halen?
3. Met welke afdelingen heb je contact binnen Grisnich? En binnen Tolsma?

Sterkte van het netwerk

1. Welke informatie ben je bereid om binnen je netwerk te delen met verschillende contacten? Ben je wel eens gevraagd om een product ontwikkelingstraject in te gaan met iemand uit je netwerk? Waarom heb je dit wel/niet gedaan?
2. Hoe frequent wissel je informatie uit met contacten uit je netwerk? Zit hier een verschil in tussen projecten?
3. Is het contact met je netwerk contacten even intens tussen de verschillende contacten? Met wie heb je het meest intense contact?

Organisatie processen

1. Kun je het ontwikkelingsproces van 3M beschrijven? In hoeverre werd er gewerkt naar de methodiek van 3M en wat voor effect had dit op de ontwikkeling van de producten?

2. Als je 3M vergelijkt met bijvoorbeeld de ontwikkeling van de telescoopband, sorteermachine of kistenkantelaar, waar liggen dan de grootste verschillen?

3. Waren er verschillende in de gebruikte informatiebronnen en samenwerking tussen partijen, zo ja, welke waren dit?

Klimaat voor Teamwork

1. Hoe is de coördinatie tijdens een project? Verschilt dit erg tussen de projecten?

2. Heeft jou afdeling de voorkeur voor het werken in teams of individueel? Waarom is dit het geval? Hoe is dit in het verleden gegaan?

3. Hoe lagen de verhoudingen in teams qua input, motivatie en verschilt dit erg tussen projecten?

Klimaat voor het nemen van risico

1. Vind je het leuk om projecten aan te gaan die een uitdaging vormen? Waar liggen de uitdagingen dan vooral? In de grootte, of moeilijkheid?

2. Is jou afdeling conservatief als het aankomt op het nemen van grote beslissingen? Hoe vaak wordt kennis uit voorgaande projecten gebruikt als input voor het nemen van beslissingen?

3. Hoe worden innovaties goedgekeurd door het management? Via een stage-gate model of carte blance?

Organisatie geheugen

1. Is er een moment in het ontwikkelingsproces waarin voorgaande projecten worden gebruikt, zo ja waar en welke kennis?

2. Beschrijf het ontwikkelingsproces? Welke fasen bevat dit proces?

3. Hoe wordt kennis uit voorgaande projecten opgeslagen? Op welke momenten wordt dit gedaan? Is er een methode voor het opslaan van deze kennis?

Kennis overdracht

1. Hoe worden fouten voorkomen die in voorgaande projecten gemaakt zijn?

2. Hoe ziet het versiebeheer van het tekenbestand eruit, en wordt hier voldoende aandacht aan besteed?

3. Is het duidelijk voor iedereen binnen jou afdeling wat de visie van het bedrijf inhoud en hoe iedereen kan werken aan het bereiken van deze visie. Is er begrip voor deze visie?

4. Begrijpt iedereen de technologie die in de producten zit? Wat wordt eraan gedaan om ervoor te zorgen dat iedereen op de hoogte is/blijft van de huidige technologieën? Worden ideeën van mensen besproken onder elkaar?

5. Hoe wordt er omgegaan met nieuwe beschikbare informatie? Welke informatie is on behoefte aan binnen de afdeling?

6. Wat motiveert de mensen van jou afdeling?

2) Interview Example (English Version)

Introduction Questions

1. What is your function?
2. Can you describe your daily activities?
3. Can you describe the process from order to manufacturing from your functions' perspective?
4. What is your influence in this process?

Ego Network

Number of Direct Contacts

1. With how many different contacts do you have contact with during an average project? Is there a difference between the development of standard products or new installations? Is this difference mainly in type of contacts or number?
2. With how many contacts do you have contact within Grisnich, and with Tolsma?

Network Range

1. What does your business network looks like? Is it a broad range of contacts, or very focused?
2. Do you contact different persons when working on different projects? Is there a difference in the number of different industrial sectors you contact when working on different projects?
3. With which departments do you have contact within Grisnich, and within Tolsma?

Strength of Network Ties

1. How long on average do you have a relationship with contacts in different departments?
2. How frequent do you have contact with these contacts?
3. How intense is the contact with your ties?
4. Is there a difference between the contact you have with ties that are concerned with standard products or new installations?

Position in the Network

1. Do all your contacts in your network know each other? If yes, do they have contact with each other?
2. Can you point out if, and how your ties are clustered?

Organisational Processes

Climate for Teamwork

1. How is the coordination of tasks during a project? Is there a different between the coordination of standard products or new installations?

4. Do you / does your department prefer to work in teams, or rather individually and why?
5. If working in a team, do all the team members contribute equally to the process? And how often do they have contact and exchange knowledge?

6. Did conflicts in teams where quickly resolved?

7. Did everybody wanted to be part of a project, and how was the (knowledge) input of individual team members?

Climate for Risk Taking

1. Does your department like to take on projects that form a challenge? What do you see as challenges?

2. Is your department rather conservative when it comes to major decision making? How often is knowledge of past projects used to make major decisions?

3. How does the management approve innovations? On a stage-by-stage process, or a carte blance?

Organisational Memory;

1. Is there a moment in the development process that includes using projects from the past? If so, at which moments do you use knowledge from past projects?

2. How does the development process look like? Which phases does it include?

3. Is there a difference in the use of knowledge between the development of different projects?

4. What is done with knowledge gained from a project? At what moments is knowledge gained?

5. Is there a methodology for the storage of knowledge? If so, where is knowledge stored?

Learning

Ease of the Relationship

1. Do you have relationships that are hard to establish, for example, with highly placed individuals?

2. Who initiates the collaboration in those kinds of relationships?

3. How is the communication within the department?

4. How is the communication outside the department?

Shared Understanding

1. Do you agree with you colleagues on what is important during a project? And what about the implementation of that project? On what topics are the most conflicts?

2. What is the most important factor to make development decisions on?

3. Do you understand how a problem should be approached? Of what phases does a problem solving process consist? Do you have an understanding of the complete process of product development? Where do you/ does your department fit in this process?

4. Do you understand the people you talk with?

Absorptive Capacity

7. Do you have a clear understanding about the vision of the company? How does this vision of the company is affecting your department/work?

8. Do you have the managerial competences to absorb the business knowledge included in the projects?

9. Do you have a common language with you colleagues to deal with orders that come in? How does this express itself? Is there a difference between projects?

10. Do you have the capacity to understand the technological knowledge included in the project? Does this apply to all the people of your department? Is there a difference between the development of standard products and new installations in this understanding?

11. Do you have an understanding of what the implementation of projects means and how this affects the company as a hole?

12. How do you deal with newly received information? Do you try do exploit this immediately?

Motivation

Extrinsic Motivation

1. Are you motivated by monetary means? And what about your staff?

2. Do you believe that if you work harder you should get paid more?

3. Do you want to let other people know that you are good at something?

Intrinsic Motivation

1. Are you motivated though you daily activities? Can you motivate your staff in this way? Or are they already motivated by their daily activities?

2. Are you eager to learn the technological aspects about the projects of Grisnich? Do you set your own goals?

3. Do you prefer difficult or easy projects? Does this affect your motivation?

Communication

Communication Competence

1. Are you able to express your ideas clearly? What is done with them?

2. Are you good at writing things down? Do you make, for example, manuals for standard procedures?

3. Can you deal with others effectively? Do you understand others needs?

4. Are you easy to talk to?

F. Development Tools

1) Goal from

Date:	Category:
Topic:	
Goal:	
Description:	

2) Creativity Techniques (Adapted from: Byttebier, 2002; Van Wulfen, 2006)

i) Assumptions

Assumptions are thinking patterns that occur naturally when a person is confronted with a certain problem. They can be very valuable since they simplify the daily life. Assumptions can be used aware (e.g. when booking a flight you assume that it is the fastest means of transportation) or unaware (e.g. you assume that the pilot of that flight is respecting the safety rules when in flight).

How does it Work?

The technique focuses on tracing aware and unaware assumptions, to temporarily switch them off. In order to identify assumptions a basic technique exists.

1. Starting with the goal of the creative session one identifies the key terms.
2. All assumptions associated with each key terms need to be written down.
3. Take each assumption written down and try to turn it around.
4. Use the feedback method to come up with new ideas.

Example

1. Goal of a brainstorm: How to shorten a queue at the checkout of a supermarket? Key terms in this goal are: shorten, queue, checkout, and supermarket.
2. Taking the term 'queue' basic assumptions are that they stand in a queue.
3. Take the assumption down would suggest that they do not have to stand in line but can be in the room randomly.
4. Feedback can give the idea of a system with numbers that let people know it is their turn.

ii) Direct Analogy

One states that two objects are analogue if they have (from our point of view) similar characteristics. These similar characteristics are called the basis for analogy. This is a basic function of the human brain and allows us to recognise patterns. For creativity purposes this is useful, but in a different way.

How does it Work?

The direct analogy technique lets one be inspired by a topic that is far from the goal of the session. One uses this topic to feedback to the problem at hand. The basic technique is done in the following procedure.

1. Starting with the goal of the creative session one picks one key term.
2. Choose a topic that will serve as inspiration.
3. Choose to work with differences (a) or similarities (b), see (Figure 18).
    a. 4. Associate the characteristics that are specific for the topic chosen.
       5. Use the feedback method to come up with new ideas.
    b. 4. Associate the similarities between the key term and the chosen topic.
       5. Use the feedback method to come up with new ideas.

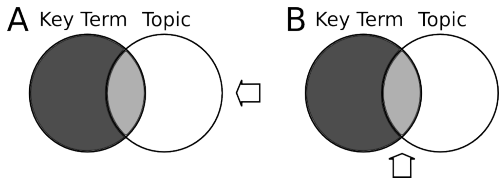

Figure 18 - Differences and Similarities Explained

Example

1. Goal of a brainstorm: How to shorten a queue at the checkout of a supermarket? Key term chosen: queue.
2. Topic that serves as inspiration: Bees
3. Choose to work with similarities
4. Similarities found: both can be seen as a group, are concerned with transportation of good, etc.
5. Feedback can give the idea to spread the checkouts so people have multiple options for standing in a queue.

iii) Superhero

During this technique superheroes are given a new life in the current problem situation. It is an example of a fantasy analogue. By using fantasy the problem is approached from a new perspective.

How does it Work?

By using the characteristics of a superhero the problem at hand is approached from a different angle and perhaps an unusual angle that can lead to new insights and ideas. The feedback method is used to come up with new ideas.

1. Starting with the goal of the creative session one picks one key term.
2. Choose a superhero that will serve as inspiration.
3. Associate all the characteristics of that superhero.
4. Describe how your superhero would approach the problem with the characteristics you gave to him.
5. Use the feedback method to come up with new ideas.

Example

1. Goal of a brainstorm: How to shorten a queue at the checkout of a supermarket? Key term chosen: queue.
2. Superhero that serves as inspiration: Leonardo da Vinci
3. Characteristics: excellent engineer, visionary.
4. Have an engineering and visionary approach to the concept of checkouts.
5. Feedback can give the idea to equip all checkouts with a helicopter blade and let them hover to the customer.

iv) Personal Analogue

This technique focuses on the ability of persons to empathise themselves into the object of the problem statement. In other words, the ability of a person to look at a problem from the perspective of the problem itself.

How does it Work?

By placing yourself in the object of the problem statement you are able to see different aspects of the problem, thereby approaching the problem differently. With this new insight the feedback method can be used to come up with new ideas.

1. Starting with the goal of the creative session one picks one key term.
2. Choose an object that will serve as inspiration.
3. Try to answer the question: how would I feel if I was that object in that particular situation?
4. Try to answer the question: how would I react in that particular situation?
5. Try to answer the question: what actions would I take in that particular situation?
6. Use the feedback method to come up with new ideas.

Example

1. Goal of a brainstorm: How to shorten a queue at the checkout of a supermarket?
2. Object chosen: checkout.
3. I would not be motivated if I would see a long line of people waiting for me and not being happy about it.
4. I would react by trying to work harder or look the other way so I would not see all the people waiting.
5. I would like the queue not to be visible or evenly distributed amongst the other checkouts as well.
6. An idea could be to have a general waiting point (room) where people wait until they get a checkout assigned to them.

v) Flukes

This technique emerged from the believe that the human brain is capable to make connections to everything it knows. This allows to start with a random thought and translate it to the problem at hand.

How does it Work?

Basically the technique starts with random information used as inspiration and with this inspiration new ideas are generated using the feedback method.

1. Starting with a random term.

2. Write down all associations with that term.
3. Use the feedback method to generate ideas from the associations made in the previous step.

Example
Goal of a brainstorm: How to shorten a queue at the checkout of a supermarket?

1. Random term: Skyscraper.
2. Associations with skyscraper: many windows, tall building, elevators, and very rigid.
3. An idea could be that if the supermarket has a parking lot above or below the supermarket the checkout could be placed in the elevator where people have to wait anyway.

vi) Free Incubation
Incubation in this sense corresponds to taking the problem at hand out of its logical context. Incubation refers to a period where one is not actively involved with the problem, but has its mind on other things. One steps consciously away from the problem and waits until new insights emerge.

How does it Work?
This technique works best at the end or after an intense creative session. How it works is not explained scientifically yet, but practical results are known extensively. The greatest example known is people getting their good ideas on the toilet or in the shower.

1. Perform one of the previous techniques explained.
2. Leave the problem aside.
3. Wait.

Example
Because there is no real example for this technique some ways to leave the problem aside are given.

- Other project; Continue working on another project
- Relax; for example, take a shower or lay in the sun.
- Eastern meditative techniques; for example, yoga, meditation, or tai-ji.
- Physical activity; for example, walking or ice-skating.
- Go to a different environment; for example, outside the company, or in a restaurant.

vii) Guided Fantasy
During this technique the incubation does not happen freely, but is guided via a scenario. The scenario causes problems to disappear, provides elements of inspiration, and moments of feedback.

How does it Work?
The facilitator of the creative session things of a scenario that allows the participants of the creative session to relax and empathise in the story provided. Symbols and images from the scenario are then used to generate ideas about the problem statement.

1. Relax.
2. Listen to the scenario given memorising symbols and images from it.
3. Associate the problem with the symbols and images.
4. Use the feedback method to generate ideas from the symbols and images.

Example
Because scenarios differ from each other extensively, some examples are given of the topics suitable for the story.

- A vacation at the beach with a nice cocktail party
- Sailing on the ocean in beautiful weather seeing dolphins swimming aside.
- Flying with a parasail between the Swiss Alps, looking down on the small villages.

viii) SCAMPER
This is a technique that is developed to be used when developing products. It is an acronym for the steps that are involved in executing the technique.

How does it Work?

This technique highlights seven perspectives (in the form of questions) of a product which all need to be handled in order to create a new product idea. It is important that in each of the step ideas are generated.

1. S = Substitute. What can be changed about the assembly, material, design, and size of the product?
2. C = Combine. What can be combined with the product so it will increase the value for the customer?
3. A = Adapt. Can the product be adapted so it performs a different task, or can something from other industries be copied into the product?
4. M = Magnify/Minimize/Modify? What can be magnified, minimized or modified on the current product?
5. P = Put to other uses. Can this product be used for something else?
6. E = Eliminate. What can be left out of the design of the product?
7. R = Reverse/Rearrange. Can something be reversed, turned insight out, or be assembled in a different order?

Example

To illustrate the method an example for a standard ballpoint is provided.

1. S = Substitute. The material can be made from a material that forms to ones hand, like a mattress.
2. C = Combine. An extra tip with correction fluid could be attached to the back so corrections can be made easily.
3. A = Adapt. With a rounded back it could function as a massage device.
4. M = Magnify/Minimize/Modify? The tube of the pen can be modified so a larger ink tank can be installed in the pen, for example, at the palm of ones hand.
5. P = Put to other uses. The product could be used as a pointing device.
6. E = Eliminate. The mechanism that drives the point of the pen in and out the shaft can be eliminated.
7. R = Reverse/Rearrange. The tank can be placed outside the pen, so it can be replaced easier and it is better to see the usage of the ink.

Creativity Technique	Required Time	Threshold	Depth	Best Situation	Best Product Type
Assumptions	Little	Low	Wide	Not at personal topics	Standard Products
Direct Analogue	Little	Low	Wide	Always	New Installations
Superhero	Little	Low	Wide	Always	New Installations
Personal Analogue	Little	High	Deep	Technical Topics	Standard Products
Flukes	Very Little	Medium	Wide	Best in combination with other techniques	Both
Free Incubation	Much	Low	Deep	When time is available	Both
Guided Fantasy	Medium	High	Deep	With experienced participants	New Installations
SCAMPER	Medium	Medium	Very Deep	Technical Topics	Standard Products

Table 18 - Creativity Techniques

3) Business Model Form