Transfer of production knowledge to small and medium-size enterprises
- a suggested model

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Abstract

The work that this thesis is a result of has the ambition to suggest a model for knowledge transfer to small and medium-size enterprises (SMEs). The knowledge in focus here is competitive production methods such as: lean production, six sigma, continuous improvement, total quality management or total productivity maintenance.

To invest in research in the SMEs, that often are the larger company’s suppliers, gives effects in the entire supply chain. Another point of view is that bigger companies are often divided into smaller sub-units that in many cases are more or less autonomous and have, in a sense, SME characteristics.

There are some main problems that are identified:

- The relation between the numbers of SMEs compared to the number of knowledge transfer teachers regarding newly developed methods is too great.
- In many cases the methods need to be adjusted to fit SMEs regarding the difference to larger companies.
- “The Learning Paradox”, i.e. that the companies need to know about existing methods and their potentials before they can ask for knowledge about them.
- “The Swedish Paradox”, i.e. that little effect comes out from the research conducted in Sweden and the research and transfer processes must be more effective.
- There is also a lack of understanding regarding the importance of SMEs and the need for supporting activities in their company development activities.
- The competition is becoming harder because many companies learn to use different production methods more systematically to obtain competitive advantages.

The overall aim with the work presented in this thesis is to create improved conditions and understanding regarding knowledge transfer of competitive manufacturing methods to Swedish SMEs.
The objective with this thesis is to suggest a knowledge transfer model that is suitable to the current problem description and is also built on state-of-the-art knowledge regarding knowledge transfer.

A literature review with the objective to seek current knowledge of knowledge management has been carried out. The process of knowledge creation of competitive production methods and transfer to SMEs cover many research fields. The width of the area for this thesis requires a multidisciplinary approach were the knowledge transfer process has been illuminated within different topics.

The different methods have different abilities to support knowledge or technology transfer. The different factors have not been weighted in this analysis but imply that networks, e-learning, the IVF model, publications and courses are more effective ways for knowledge transfer to SMEs.

To be able to perform an effective knowledge transfer different activities and knowledge needs to be connected into a system or in a context. Once the knowledge is created it is transferable to companies. The DCT-model is a repeatable systematic approach that has three steps: 1) Dissemination, 2) Clustering, and 3) Transfer.

There are still activities to do before the model is both valid and verified (if now the model is a solution to the problem). The following activities and questions are planned to be done in the doctoral work:

- The problem description in this thesis must be validated and verified.
- Does the DCT-model need to be further developed regarding eventual changes in the problem description?
- What type of method shall be used in order to verify the DCT-model? This will be one of the major research questions in the doctoral work.
- How does the DCT-model work? And: How effective is it?

**Key words:** knowledge transfer, technology transfer, SME(s), methods, tools, portfolio management
Foreword and acknowledgments

Knowledge, and its creation and transfer to smaller manufacturing companies, is an interesting topic. From time to time when I have visited small and medium-sized companies I have wondered how it is possible that they still are in business. It seems that everything that we today in the academic world consider as competitive production methods is more or less ignored. But they are still in business even though they might bleed. There is a great potential though but for some companies the time is running out. If we as industrial researchers could be more effective in our activities to create and transfer knowledge regarding effective production methods to the companies many of them could be competitive in Sweden and hold the outsourcing trend down. The larger companies would probably benefit from this research as well.

For me as an employed industrial researcher I have found myself doing research on my own character, which is interesting in different ways. Am I challengeable to myself? Anyhow it is interesting for me as a former production system developer to use my skills and experience to be part of developing this more intangible process.

The opportunity that was given to me regarding this doctoral research training is not given to many. For this I am grateful to my company, IVF, and to the initiative takers who came up with this postgraduate education program.

I would like to express my appreciation to my wife Anna and my children who have been supportive and understanding during the period when I was writing this thesis. Thank you indeed Peter Gröndahl, my supervisor, who with his sharp eyes and analytic manner has contributed in many ways. Without Björn Langbeck, my mentor at IVF, this thesis would not have existed – many thanks Björn. Many thanks to my dear research colleagues and family for all the suggestion of improvement possibilities in the thesis script: Daniel Axelson, Stefan Tangen, Niklas Tjärnberg, Kenneth Karlsson, Patrik Kenger, mother Barbro, father Jan and mother in law Anna-Lisa. I hope that you are somewhat pleased with the “final” result. Last but not least I would like to thank my colleague Lars Avellán who has contributed with new angels of thinking when my own thoughts faded.

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Abbreviations and definitions

Many of the words that are used have different meanings and definitions in literature. In this thesis words and abbreviations will be used:

*Academy system* = universities and their organisation of research, education and support to companies.

*Innovation system* = An innovation system is the combination of policy, infrastructure and organisations that exist to create innovations by transforming resources to growth. Organisations that are involved are for example: universities, research institutes, financers, companies and governmental authorities.

*IUC* = Industriella Utvecklingscentra (Industrial Development Centers).

*IVF* = IVF Industrial Research and Development Corporation. In Swedish: IVF Industrieforskning och utveckling AB

*Knowledge* = the term knowledge is in this thesis used for describing knowledge in its widest meaning, i.e. something that someone knows.

*Knowledge creation* = the process where the knowledge is “born”, e.g. in research programs.

*Knowledge management* = a systematic and structured way of planning, acquiring, transfer and development of knowledge within an organisation.

*Knowledge transfer* = the actual event when the knowledge travels from a sender to a recipient such as staff transfer, publications or seminars.

*Method* = a structured way of solving a task or a problem. The term is used as uniting for the terms: philosophies, methods and tools.

*OEM* = Original Equipment Manufacturer, i.e. the organisation which sells the product to the end-user/customer.

*SME* = Small and medium-size enterprise.

*Technology* = a more aggregated form of knowledge such as building blocks for competitive advantage which implies that there is a technical parameter involved unlike a method which is a structured way or a procedure.
1 Introduction

In this first chapter the reader is introduced to the background, research area, and the main problem description. The research questions and delimitations are presented.

1.1 Outline of the thesis

The work, that this thesis is a result of, has the endeavour to suggest a model for knowledge transfer to small and medium-size enterprises (SMEs). The knowledge of competitive production methods is in focus here. A competitive manufacturing method addresses one or many of the main competitive variables in the manufacturing system: cost, quality, delivery or flexibility and contributes to improved profitability. Competitive production methods are defined in this thesis as philosophies, methods and tools which when applied give the company a competitive advantage or improvement. Examples of such methods are: lean production, six sigma, continuous improvement, total quality management or total productivity maintenance.

The thesis is built up logically through a collection of demands and factors that affect the transfer, from a provider to a user, process, from the background description, the literature study and results from case studies. The demands have been assembled in an aggregated problem description. From this problem description a model is developed. Finally the work and the results are reviewed and future research is suggested. A general overview of the thesis is described in figure 1.

The content of each chapter in short is:

1. The introduction chapter describes the problem area and the research questions.

2. The research approach chapter describes the research context and how the research result has been produced.

3. The knowledge transfer models chapter is a result of the literature study and describes different ways to transfer knowledge.
4. The knowledge transfer environment chapter describes different affecting parts connected to the knowledge transfer process such as the characteristics of production methods, SME characteristics and creating knowledge for SMEs.

5. The empirical studies chapter describes three different cases from which conclusions are drawn.

6. In the aggregated problem description chapter demands and affecting factors are collected and structured. In the model description chapter the Hopper model is described as a solution to the aggregated problem description.

7. Finally the results are summarised. General conclusions are described and the results are reviewed. The thesis is ended with a discussion about future research.

Figure 1. How the different demands build up the suggested model and how the different chapters build up the logic of this thesis. The digits in the figure correspond to the numbering of the chapters.
1.2 Background

W. Edwards Deming wrote in “Out of the crisis” that: "Knowledge is a scarce resource. Knowledge in any country is a national resource. Unlike rare metals, which cannot be replaced, the supply of knowledge in any field can be increased by education. Education may be formal, as in school. It may be informal, by study at home or on the job. It may be supplemented and rounded out by work and review under a master. A company must, for its very existence, make use of the store of knowledge that exists within the company, and learn how to make use of help from the outside when it can be effective.” (Deming, 1986) These words are as important today as they were in 1986, if not more important. From the 50’s Toyota have developed from a mediocre local vehicle builder to the most profitable global car building company and the second largest at present. This has become possible through developing Toyota Production System and the use of different production methods. The methods depend on the single worker’s competence and the unleashing of the creativity and knowledge creation forces within the company but also the company’s attitude to knowledge as a competitive factor. Toyota has proved that many things can be done with very little resources to improve the production system’s performance by just being smart.

The research about knowledge transfer from knowledge developers to SMEs has not been extensive in Sweden. Svensson et al. (2002) state that a central task for future research is to study the interaction between innovation and learning processes within and between different companies. The future research could not be limited to just studies and analysis, but also take a part in the organising of the innovation and learning processes.

The need of and the ability to adapt new knowledge correspond to the environment of the knowledge transfer process. According to Morey and Frangioso (1998) a knowledge transfer event has the following characteristics:

- Subject, i.e. the knowledge “package” that is supposed to be “transmitted” from the ‘Teacher’ to the ‘Receiver’.
- Description, i.e. what the knowledge contains.
- Quality is the utility of the knowledge to the receiver.
- Viscosity is the difficulty of the knowledge transferred
- Date of the transfer, i.e. the timing of the event
- Teacher, the person who executes the knowledge transfer event
- Receiver, the person who receives the knowledge
To fit the purposes of this thesis a general model based on Morey and Frangioso (1998) is described in the figure 2. This model will be used to explain the different parts of the thesis and their connection to the model.

![Figure 2: A general model of knowledge creation and knowledge transfer to SMEs.](image)

This process is affected by different courses of events and factors and some of them are described in this section. Important areas are:

- A paradigm shift from mass production to lean production
- Knowledge is essential for competitive advantage
- The importance of SMEs
- Competitive production methods as a solution
- Changes and limitations in the national innovation system
- Potentials regarding improving knowledge in SMEs

1.2.1 A paradigm shift from mass production to lean production

The Ford mass production system is today considered as inferior to the Toyota production system or “Lean Production” regarding car manufacturing (See for example Womac et al., 1990). Lean production has its roots in the Toyota Corporation and its principles are now spreading over the world due to its abilities to facilitate competitive production systems. Taiichi Ohno\(^1\) describes

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\(^1\) Taiichi Ohno (1912-1990) was one of the persons behind Toyota Production System and developed among other things the principles behind just-in-time production and kanban.
why it was developed: ”After the companies crises during the 50’s we learned that improvement of productivity and cost reduction demands development of both system for manufacturing of small lots and short lead times. It meant that we should only manufacture only what could be sold and only when it was possible to sell it. We came to an understanding that a strategy to enhance productivity only of economical reasons was not useful. Therefore we avoided imitating American principles for mass production.”

Several authors point out that today’s situation of rapid technological change and globalisation is forcing business throughout the world to dramatically rethink their approaches for commercial success (see for instance Comstock, 2004). A possible way is to strive from mass production to what is known as mass customisation. Helling (2004) describes a paradigm shift from mass production to lean production where the old value of exploiting resources develops to a bottom-up supported continuously improved production systems. This course is described in figure 3.

- Craft production represents industrial craftsmanship, i.e. manufacturing in small volumes and specialised products.
- Mass production represents large volumes, standardised products and job separation.
- Art production represents middle-size production volumes, differentiated products and advanced product technologies.
- Lean production represents small and large volumes, total quality, continuous improvements and total commitment of human resources.

Figure 3. Automotive industry transformation during the last century. Source: IMVP/Jan Helling 1990/2000.
From the automotive industry the principles of lean production is now spreading to other lines of business and other types of manufacturing.

1.2.2 Knowledge is essential to be competitive

Decentralisation of competence and authority in the organisation reflects a new management and production philosophy. Forslin and Thulestedt (1993) state that in the new and more complex production situation competence is a central factor. If the industry earlier has strived towards replacing skilled labour with centralised experts and detail control the development is going the other way now. A general description of companies’ situation is:

- Increased competition demands increased customer focus.
- Continuously efficiency improvement demands evaluation of the processes.
- Many new variants of products demand continuous changes.
- Increased complexity demands co-operation and mutual adjustments between the buyer and supplier.

To be able to cope with this in general, learning and competence development is needed, both individually and within the organisations. One of the major challenges an organisation faces is to manage its knowledge assets. Increasingly, the use of knowledge is seen as a basis for competitive advantage (Goh, 2002). Knowledge tends to be consumed and/or be obsolete and must be refilled. For example in the software corporation SAP the “half-life” of knowledge is 18 months and therefore a knowledge management system is needed (Lee, no year).

Yamashina (2000) states that to become a world-class manufacturer you have to implement the production method Total Productive Maintenance (TPM) successfully. You must also create a very active organisation where people know their problem, methods to solve them and how to involve all the people to attack them. To make this movement possible it requires definite cultural changes of the organisation. The top management has to create an environment for accepting changes and making continuous improvement. Generally, it can be managed by:
• Obtaining competent leaders and managers
• Investing in people through education and training
• Empowering and facilitating people under their supervision and constantly following up results and taking proper measures for support and freedom in terms of time, resources, etc.

According to lean production, which has been proven competitive, competence and knowledge are the key factors to success. Helling (2004) states that the management logics from a company’s view are:

• We are a knowledge driven company. The nature and the markets set the terms. We win through mastering these forces.
• The most important production factor is knowledge.
• With knowledge we can reduce cost and exploit the benefits we have due to low cost for working hours per product, capital and material.
• The company has only one kind of co-worker. All together create knowledge and act in favour of the best for the whole.
• Knowledge cannot be purchased. Fusions, in general, result in losing knowledge. We must create knowledge through learning by ourselves. The most important we learn from continuously improvement of products and processes.

Knowledge and competence are key factors to be competitive.

1.2.3 The importance of SMEs

The SMEs are corner stones in the industrial structure. Of approximately 12800 industry companies\(^2\) in Sweden only 500 are bigger than 200 employees and 8600 have less than 10 employees. The bigger companies have the greatest turnovers in total, 490 billion SEK of a total of 600. In spite of the fact that the SMEs have a minor part of the industry turnover a statement of the Swedish government member Per Nuder could illustrate the importance of SMEs: “To be able to secure the welfare in the future the growth must be secured. To get growth more people must have jobs. The jobs will not come in the large companies; they must come in the small and the medium sized. (Hennel, 2003)” Also Duan and Kinman (2000) state that small manufacturing business is critical to most national economies. Not only do they directly provide a

\(^2\) SNI92:28-36 year 2003
major component of manufactured output, they are the essential seeds from which larger business grow. Johansson (2002) argues in the same way and states that SMEs are not usually a major source of economic trade but contribute in three other ways:

- Small firms act as suppliers to larger multinational firms in the area.
- New small firms constitute the seedbed from which larger export-oriented domestic companies grow and emerge.
- The sales and market share which new small firms hold on local markets act as substitutes for potential imports, thus contributing to the strength of the local economy.

SMEs have, regarding knowledge transfer, several differences compared to larger companies. In a study (Chapman and Sloan, 1999), where differences in implementation of continuous improvement (CI), it was revealed that many of the motives for CI were the same for both the smaller and the larger firms. Despite this it was also found significant differences between the two when comparing support methods and the use of problem solving tools within the CI process. The larger used more training and the smaller used more of incentive systems According to Ylinenpää and Lassinantti (1999) small firms are different from larger. Generally the advantages of a large firm are the small firm’s disadvantage. Among the advantages the SME have:

- Little bureaucracy.
- Rapid decision-making.
- Motivated and committed management.
- Capable of fast learning and adapting routines and strategy.

One conclusion is that SMEs in general seem to have great potential to adapt new production methods but also have different needs and prerequisites than larger companies regarding adaptation of new methods.

1.2.4 Competitive production methods are a solution

In times when outsourcing to low wage countries has become common, companies need to become more competitive and profitable. This is important both to suppliers and OEMs (Original Equipment Manufactures). Scientific knowledge of engineering within an innovative industrial decision process has a potential to improve quality and productivity in industrial operations and by that improve profitability which in turn is a precondition for economic growth, which in its run is necessary to improve welfare (Sohlenius et al., no year).
In a Swedish study about the “best” companies in the world (“Bäst i världen”, 1991) it is stated that they accentuate education and training. They also use production methods the best companies deliberately limit the time resources and therefore create a change pressure such as continuously improved lead-time targets through just-in-time philosophies. Methods such as *concurrent engineering* are used to shorten time-to-market.

Many companies have accomplished competitive advantage through developing different methods. For example Motorola developed the Six sigma concept and Toyota the Toyota Production System which have been critical success factors to them. In some cases it is not likely that methods developed in one company are directly applicable to all Swedish SMEs. In some cases the methods have become general and are now reachable knowledge for anybody willing to learn.

### 1.2.5 Limitations in the national innovation system

Technology transfer is a way to increase the efficiency in the innovation system. It gives a profitable utilisation of the research and development (R&D) results, gives strength to the companies, supports R&D implementation when recognising industry R&D problems and gives benefit through the feedback of experiences from the R&D companies. Particularly for SMEs with little R&D technology of their own, transfer is unavoidable. Knowledge supply is necessary in order to be able to develop and put innovations to market (Pleschak, no year).

Research institutes have traditionally developed their own expertise through research and development work in areas that are supposed to have future strategic significance, without having a specified customer for the work being involved. They have also carried out problem-oriented research and development in collaboration with companies, universities and other research organisations and are commissioned to do research. In general terms, their work is based on existing knowledge that the institutes develop, refine and combine in new ways or apply to new situations and problems. The concept behind the institute is to convert research and development results into profits. This has been accomplished primarily by transferring the results on an ongoing basis to existing Swedish companies, but also in some cases through spin-off companies (VFI 2003:1). Today many of the research institutes are suffering from poor profitability and the support to SMEs has decreased.

The universities have had difficulties to act supportive and interactive to their surroundings that have lead to new actors and new forms of co-operation. The demand on specialist knowledge and research is growing with increasing
global competition and the need for continuous development in more and more areas. It is not sufficient for the companies just to follow the knowledge development but they must act more proactive. Knowledge becomes the company’s most important competitive priority (Svensson, 2002).

A prerequisite for growth is that the society manages to release positive driving forces in people and companies. Driving forces that lead to new products, services and to, perhaps more important, more effective production. This often occur through applying new technology but also through more effective structures (Rogberg (Ed.)/Deiaco et al. 2002).

Vice chairman of the Swedish parliament’s committee of education Britt-Marie Danestig states that R&D is one of the most important driving forces for economical growth and employment. The research policy is to create good opportunities for the R&D and investments and should not be seen as costs but necessary for the future. The problem in Sweden is that there are difficulties to commercialise the research results that is called “the Swedish Paradox”. The industry research institutes have an important role as a bridge between the academia and industry. The last years of change in the Swedish innovation system has resulted in decreasing amount of R&D personnel. According to a survey conducted by Vinnova (VINNOVA, 2004) there are approximately 500 persons are involved in research regarding product and production system design and improvement in Sweden today. How many of them that has ambition, knowledge and ability to conduct a structured knowledge transfer of industrial methods to SMEs can only be speculated in, an estimation is that less than 200 persons or more probably 100 persons in Sweden could be active with knowledge transfer to the 3500 SMEs.

1.2.6 Potentials regarding improving knowledge in SMEs

In many cases SMEs do not have a developed knowledge management strategy due to lack of resources and/or competence. For example: a small company in Sweden has limited resources and has access to own experts in a limited number of fields. It operates with small economic margins and the white-collar resources are limited and focused on operative productive work. Due to lack of economical resources, and not being exposed to new ideas, training and development are low prioritized (Forslin and Thulestedt, 1993). It is therefore necessary for industrial researchers to design knowledge in ways that are transferable.

The competence level in SMEs in Sweden can be improved. In a study concerning Swedish industry suppliers approximately 55 per cent do not have any university-educated engineers (Axelsson and Lagerholm, 2003). McAdam
and Reid (2001) agree and state that the SME sector would appear to need to develop their understanding of knowledge management further as a key business driver rather than as a resource-intensive additional initiative.

There are several ways to increase the knowledge, e.g. education, recruitment, through consultants, e-learning etc. However companies cannot ask for knowledge they do not know about. This phenomenon is known as “The Learning Paradox” which is a core problem to many SMEs. It implies that you have to learn enough to see what you need to learn. If a SME wants to acquire knowledge there are many that are willing to offer you help. There are various actors and support organisations aiming to support SMEs.

Some of them are:

- ALMI
- NUTEK
- Swedish ESF
- IUCs (Industrial Development Centres)
- Teknikbrostiftelserna (Seven regional technology “bridge” organisations)
- Universities
- Research institutes
- Consultant companies

The palette of actors seems to confuse many SMEs. The possibilities to interact is also weakened by the fact that the understanding of SMEs by institutes is low or as Yusof and Aspinwall (2000) put it: “Large companies tend to readily adopt any ”new management” and ”new technology”, be it JIT, MRP, TPM, concurrent engineering, WCM that comes their way. The small business owner’s or CEO’s understanding of TQM has come through what they have been told by consultants, academics, experts, who may not have a real understanding of the context in which small businesses operate and the true constraints they face.”
1.3 To improve production knowledge in SMEs – problem description

To invest in research in the SMEs, that often are the bigger company’s suppliers, gives effects in the entire supply chain. Another point of view is that bigger companies are often divided into smaller sub-units that in many cases, are more or less autonomous, and have SME characteristics.

To summarise the background description there are some main problems that are identified:

- The relation between the numbers of SMEs compared to the number of knowledge transfer teachers regarding newly developed methods is to great.
- In many cases the methods need to be adjusted to fit SMEs regarding the difference to larger companies.
- “The Learning Paradox”, i.e. that the companies need to know about existing methods and their potentials before they can ask for knowledge about them.
- “The Swedish Paradox”, i.e. that little effect comes out from the research conducted in Sweden and the research and transfer processes must be more effective.
- There is also a lack of understanding regarding the importance of SMEs and the need for supporting activities in their company development activities.
- The competition is becoming harder because many companies learn to use different production methods more systematically to obtain competitive advantages.

1.4 Objectives and research questions

In this licentiate thesis the aims, objectives and research questions are considered as guidelines in this stage of the total doctoral research work. This will be further explained in next chapter – research approach.
1.4.1 Aim and objective

The overall aim with the work presented in this thesis is to create improved conditions and understanding regarding knowledge transfer of competitive manufacturing methods to Swedish SMEs.

The objective with this thesis is to suggest a knowledge transfer model that is suitable to the current problem description and also is built on state-of-the-art knowledge regarding knowledge transfer.

1.4.2 Research questions

How should research results, regarding competitive manufacturing methods, be created and transferred so they are better adopted by SMEs? It is a wide question that needs to be further divided which, in turn, leads to the following research questions:

1. What different methods of knowledge transfer are in use today and how effective are they?
2. What factors and environment affect knowledge transfer of competitive manufacturing methods?
3. What preconditions do SMEs have regarding competitive production methods?

The research questions have served more as guidance rather than that they have to be answered. In the “Further research” section the research questions will be reviewed to set direction for the doctoral work.

1.5 Focus areas and delimitations

Focus in this thesis lies on transfer and its environment of competitive production methods regarding manufacturing in SMEs, i.e. there are four main focus areas:

- Knowledge transfer and its environment.
- Small and medium size manufacturing enterprises as receivers.
- The knowledge described as production methods.
- The sender as knowledge developers, e.g. research institutes and universities.
Knowledge transfer is a large topic. Sveiby (2001) has developed a knowledge-based theory that is used here to describe the focus and delimitations. This thesis concerns knowledge transfer between an external structure, for instance a research institute and an internal structure, a manufacturing SME. The arrow 7 in figure 4 illustrates the focus. Knowledge transfer within a company is often used but is not the focus of this thesis.

Figure 4. The focus area is represented by the arrow 7- knowledge transfer from external to internal structure according to ”A knowledge-based theory”. (Source: Sveiby, 2001)
2 Research approach

In this chapter the research context is described. In the research description the main thoughts of how the research activities have been divided between the licentiate thesis and the plans for the doctoral research.

2.1 Research context

This thesis is one of the results from an institute development program funded by KK-stiftelsen. The objective with the program is to elevate the competence at the research institutes by giving opportunities to institute employed personnel to perform a postgraduate education. IVF and the author together chose the field for this project – to study the process in which knowledge is transferred to industrial companies and the environment of this process. In this work the SMEs are particularly in focus. The research has been conducted as fulltime employed at IVF and all empirical studies have been made within actual research and development projects.

2.2 Research description

This thesis represents the first half in the total post-graduate training project. The main objective has been to learn about the chosen area and to set directions for future research. In other words the methodology has not been in focus but will be in the doctoral work. A general description of a doctoral research project could be described as:

3 Knowledge Foundation

4 IVF Industrial Research and Development Corporation is the Swedish engineering industry's research institute that has the mission to strengthen its customers' competitiveness by carrying out applied research and development in close conjunction with industry. See also the Internet: www.ivf.se.
• What is the problem, or/and the opportunities?
• What have others done, or/and not done?
• My solution to the problem or the opportunity.
• How well was the research performed?

The first three bullets are to be considered in this licentiate thesis and the latter, in combination with the prior, attended in the doctoral thesis. The approach in this thesis is a combination of the four with the focus on the first two bullets according to the figure 5.

![Diagram](image)

*Figure 5. Schematic distribution of the time and effort planned and spent so far.*

Regarding the objective and the following research questions they should be seen as guidelines in this thesis and to be assessed and reformulated in the “Future research” section.
2.3 Research working method

The research has been carried out as a research project within IVF’s ordinary activities and has been carried out according to the “Synopsis method”. The Synopsis method is, according to Gröndahl (2001), a simple method that helps you structuring your thinking, work and writing. The synopsis is basically from the beginning a report skeleton with chapter and section headings. In the beginning the synopsis is more of a project plan and in the end a complete report. The following repeating procedure has been used within this project.

1. Write a synopsis which concludes:
   a. A description of the problem.
   b. An objective formulation with corresponding research questions.
   c. A plan to carry out research activities that (hopefully) will answer the research questions.
   d. A report structure with chapters and sections.

2. Conduct research activities such as case studies and literature reviews.

3. Synthesise and formulation of report text. In the beginning of the work more questions where raised rather than solutions, and in the end there where more focus on solutions rather than new questions.

4. Assessment together with the supervisor, i.e. how does new findings fit into the current view.

5. Modify the synopsis continuously as the work proceeds and insights increases.

Changes and decisions during the work have been recorded, regarding traceability, by changing the file name and saving all the previous versions. This makes it possible to review the chain of thoughts during a long period of time.

2.4 Literature review

A literature review with the objective to seek current knowledge of knowledge transfer has been carried out. The process of knowledge transfer to SMEs
covers many research fields. The width of the area for this thesis requires a multidisciplinary approach were the process has been illuminated within different large research disciplines such as:

- Knowledge management
- Learning organisation
- Organisational learning
- Technology transfer
- Transorganisational development
- Organisational development
- Operations and productions management
- Education and training

The literature study was made as an information retrieval in three steps:

1. The first retrieval was made early in the project to become familiar with the research field and was carried out after the problem and the research questions were decided.
2. The second retrieval was more specific and the number of key words was increased. From the previous literatures, that have been reviewed, specific publications from the reference lists were also captured and studied.
3. The third retrieval was carried out in search for specific literature needed for certain questions or in areas where the existing material was not extensive enough or questionable.

Main sources of information have been research databases as: Emerald⁵ and Elsevier⁶, but also the Internet search engine Google⁷. Key words that have been used mainly are: knowledge, technology, transfer, management, sme, learning, and implementation.

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⁵ See Internet: www.emeraldinsight.com
⁶ See Internet: www.elsevier.com
⁷ See Internet: www.google.se
There has also been a special coverage of certain research journals during the research:

- The Learning Organisation
- Journal of Industrial Training
- Journal of Knowledge Management
- Journal of Small Business and Enterprise Development
- Journal of Intellectual Capital
- Journal of European Industrial Training
- International Journal of Operations & Production Management

The result from the literature review is mainly presented in the result chapters “Knowledge transfer models” and “The environment of knowledge transfer” but also in the “Introduction” chapter.

### 2.5 Studies and surveys

Different studies and surveys have been carried out within the scope of this research. The objective with each research activity has been to further illuminate a part of the knowledge transfer process or to investigate factors that influence it in its environment. Three different studies have been made:

- The PABIS\(^8\) project study, where the purpose was to develop and assess a knowledge transfer process.
- The TIME survey with the purpose to investigate the relationship between the knowledge creation and transfer processes in a research project.
- The DFA2 project assessment. The objective was to investigate how the need for knowledge in relation to the knowledge creation process has been considered in the DFA2 development project.

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\(^8\) The project name PABIS is a acronym from "Produktion Av Bränsleceller I Sverige – en möjlighet!" Translated: Manufacturing of fuel cells in Sweden – an opportunity!
2.5.1 The PABIS project study

PABIS, Produktion av bränsleceller i Sverige– en möjlighet!, was a research and development project that was designed in order to obtain a specific industrial effect. The objective was to identify and activate industrial companies in Sweden regarding fuel cell technology. A project plan and methods were formulated and developed together with the assignment customer. The project plan, which also became the general result from this project is assessed and further described in the “Empirical studies” chapter.

2.5.2 TIME – project assessment

The TIME project was a multi stakeholder industrial research and development project funded by VINNOVA and carried out during a three-year period. The objective was to develop a useful tool for disturbance elimination in order to improve the manufacturing performance and resulted in a handbook (IVF, 2004). The performance has been studied in an assessment survey regarding the factors that have affected the outcome from the project.

2.5.3 The DFA2 – project assessment

DFA2 is an engineering tool that has been developed at KTH in cooperation between IVF and WoxénCentrum as a doctoral research project. The research and knowledge transfer process has been reviewed and analysed in order to find specific and general factors to consider in this type of research and development projects.
Knowledge transfer models

In the literature many different ways to transfer technology and knowledge are found. Traditional ways are for example staff transfer, publications and seminars. In this chapter applicable different models, found in the literature study, will be presented, analysed and commented. The models that are presented are:

- Researcher taking employment in industry
- Consultant and advising assignments
- Courses, educations and conferences
- Participation in research project
- Creating and administrating networks
- Use of students and graduates
- Workshops
- Publications
- Instruction materials
- Industrially employed doctoral students
- E-learning
- Implementation
- Learning by doing with a coach
- Implementing a technology acquisition process
- The IVF model

The different models are not presented in a specific order but will be briefly analysed in the end of each section and in the last section of this chapter valued and ranked.
3.1 Researcher taking employment in industry

This way when a former research employee takes employment in industry is one of the most common ways of knowledge transfer (VINNOVA, 2004). The knowledge is bounded with the person. It is also suggested that persons from institutes and universities could take a short time employment in a company (Braun et al., 2000). The effects for the receiving companies are good, but from the viewpoint of the knowledge, the knowledge source is only working for one company.

The efficiency of this way is very low since the knowledge is connected to one person alone and only one company can benefit from it. The way does not influence dissemination to other companies. The quality of the knowledge transfer is very high though.

3.2 Consultant and advising assignments

Assignments as consultants are common today, perhaps more in the institutes than in the universities. There has from time to time existed “small company support” where SMEs have had possibilities to hire staff from institutes to a discounted fee. When consulting for an SME there are factors to consider. Alstrup (2000) suggests that, in order to create a climate of confidence, consultants hired as external coaches to support continuous improvement activities must, on one hand, respect the owner-manager’s need of sovereignty and the short-term “flexible” style of the small enterprise. On the other hand, their role is also to support the long-term learning process. This requires these consultants to strengthen their abilities not only to cope with different and often unforeseen situations, but also to balance short-term and long-term issues. Alstrup also argues that, to ensure a learning process, the coach must be willing to withhold the expertise until it is in demand.

Gustafsson et al. (2001) point out the risks of consultants. One common reason to use external help is a wish to implement the system as fast as possible. It is then an easy way to let the consultant do most of the tasks to hurry up the implementation. But there is a clear risk that the employees in such a situation are not sufficiently involved and that they are not sufficiently familiar with the system when the consultant leaves the company with his knowledge.

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9 In this case ISO 9000
Blake and Mouton (1983) suggest a number of ground rules for a catalytic consultant. He or she:

1. Starts an intervention with informal conversation to create an easy-going non-authoritarian atmosphere, an informal give-and-take situation. “How are things?”

2. Invites the client to describe the situation, and accept the needs described by the client as the only legitimate frame of reference to work within. As the consultant listens, he or she tries to formulate suggestions for gathering new information that may illuminate some aspects of the subject the client seems interested in pursuing.

3. Suggests procedures that might be followed to gather more information.

4. Gives encouragement whenever possible by supporting the client’s efforts at defining or redefining the problem at hand.

5. Avoids giving specific suggestions. Even suggestions regarding procedures for data gathering are offered in a very tentative way.

6. Encourages the client to make his or her own decisions. The consultant is graceful about it, but will not make them for the client.

Using a consultant is a fine way to transfer knowledge if the conditions are right. In general consultants have structured methods to accomplish results but there is a risk that the quality is moderate since consultants benefit from providing knowledge that is not common.

### 3.3 Courses, educations and conferences

Courses, educations and conferences are often used to transfer “theory” to the participants. This type of knowledge transfer has been developed much in pace with information technology. Today courses can be given over the Internet, in real time, but also be available through e-learning tools (see later section).

From a dissemination point of view the use of conferences is one of the best ways. It is also quite effective since one person can meet many others at the same time. The quality could vary a lot regarding the recipients’ ability to assimilate the knowledge in mind.
3.4 Participation in research project

Almost all applied research within production development funded by the Swedish authorities is financed in co-operation with the participating companies. In this way, results and the use of the results are meant to be assured. How much knowledge the participant gains from the project depends on the participant’s role. Different roles are:

- Active, where researchers’ from institutes and universities are used to solve company specific problems.
- Passive, where the company put their business to the researchers utilisation.
- Supplier, where the company let the researchers use their equipment.
- Customer, where the company assess new technology, methods or tool in a pilot project.

Depending of the role and the motivation that the participant has, different amount of knowledge could be transferred. To reach others, the result from the project needs to be disseminated. The effectiveness is low since there is a high sender input to a limited amount of knowledge.

3.5 Creating and administrating networks

Networks or virtual organisations can be used as a platform for knowledge and technology transfer, either through co-operation in knowledge acquisition processes or through benchmarking or benchlearning (Expowera; Fagerström et al., 2000). Terziovski (2003) concludes that networking practices have a significantly positive effect on business excellence for SMEs.

Caputo et al. (2002) suggest, in order to overcome limitations such as high cost, fear and modest information, with respect to public or private incentives, a model for innovation transfer to SME. The model contains in short:

- Networked architecture, which contributes to interaction of the different involved actors in order to increase transfer’s success chances.
- Introduction of an organisational unit – Innovation Centre – that collects knowledge on innovations.
• An organisational actor innovation promoter – who is the main interlocutor of the enacted SME willing to realise an innovation transfer.

In Sweden these types of networks exist in form of IUCs\textsuperscript{10} which objective is to link ideas, knowledge, capital and companies together to create new companies or products. They also, to some extent, have programs for competence development (Ylinenpää, 2001).

Ahlström-Söderling (2003) has studied factors in the creation process of strategic SME networks. The following recommendations focus on developing guidelines and practical tools to promote organisational learning in SMEs and SME clusters:

• SMEs need carefully targeted “formal” and “informal” training and support networking strategies. This need have to be in the context of the various types of learning behaviours they exhibit and in line with the three main constituent components of organisational learning: information gathering, knowledge acquisition and competence consolidation and development.

• There is a need to raise awareness amongst SMEs of the need to balance these three different components of ‘organisational learning’ in their human resource development planning and management.

• As a large proportion of SMEs are in ‘crisis management’ rather than pro-active learning situations they need to be encouraged to adopt a more participative style of collective learning. Support services need to be provided and resources pooled.

• The lack of competencies in marketing and multi-job skills in small enterprises needs to be addressed.

• The lack of expertise in skills auditing amongst SMEs, their support organisations and regional development agencies needs to be addressed by developing a ‘skills evaluation culture’.

• A European Skills Accreditation System should be established to homogenise the features and needs of SMEs.

\textsuperscript{10} IUCs = Industriella Utvecklingscentra (Industrial Development Centers) See Internet: www.iuc.se
• Local clusters should be encouraged to act as the “hub” of the European Accreditation System.

• SMEs should be encouraged to promote the value of capturing on the job experience; to promote competence standards for their local cluster and contribute towards the accreditation of informal competence development.

Networking is an effective way to transfer knowledge when a number of companies could be participating in knowledge transfer event together. They can share costs for education and also benefit from others experiences. Network is also a good way to disseminate experiences regarding methods.

3.6 Use of students and graduates

The use of students and graduates, with the intention to transfer knowledge, are described by several authors (Ylinenpää and Lassinantti, 1999; Stier, 2003; Mukhtar et al. 1999). Mukhtar et al.(1999) states that students tend to favour larger companies in favour for SMEs due to making career choices. They further conclude that graduates with personal former work experience tend to view SMEs more favourable. "The clear message from the results…. …is that increased student experience of SME work environments, better information on what SMEs are, how SMEs operate, and more resources to support transfer, will increase the flow of science students into SMEs, where the relationship formed will be beneficial to the firm, the graduate and the wider the UK economy.”

Since students do not have a lot of experience the quality of the knowledge transferred could be moderate and it is not a very effective way. It does not benefit dissemination either.

3.7 Workshops

Learning by doing, with reflections on what has been learned brings theory and practice closer to each other. Workshops where the participants learn and practice new theories in the same occasion are one way to obtain this. A good example of this is different business games such as “The Continuous Improvement Game” (Bradshaw, 1999) and the “Lean game”. One recent example is when the company, “Lars Höglund AB”, five months after the Lean game workshop has managed to accomplish good economical results due to changes inspired from the new knowledge. Stier (2003) also describes how
students have effectively learned lean manufacturing techniques through games and simulations.

Workshops seem to have a great impact on receiving companies. The quality is moderate though since the amount of knowledge is limited during the workshop.

### 3.8 Publications

There are a number of ways to publish research results and knowledge. Some of them are:

- Technical and business magazines
- Handbooks
- Popular scientific publications
- Research reports
- The Internet, e.g.: www.kunskapsformedlingen.se (The knowledge broker)

Almost every research or development project publishes its results in some sort of publication. It is the traditional way of reporting the project status since it is perhaps the most effective way to transfer knowledge – one person can reach millions. Since very few persons in industry read reports and books in the industry the quality is very low. To illustrate this, a very common statement in Swedish companies is that a report or memo must not exceed one page.

### 3.9 Instruction materials

Developing instructional materials is a formidable task. When learning new methods or establishing a standardised way of doing things instructional materials are tangible trainee-oriented resources to use. According to Campbell (1999) there are different types of instruction materials such as:

- **Job performance aids** such as procedural guides, worksheets, checklists, decision tables or flowcharts.
- **Instruction sheets** such as information, assignment or procedural sheets.
- **Modules** that are carefully structured documents, in printed form, through which instructional content is provided to individual trainees.
Time, effort, expertise and motivation are required to prepare engaging materials of good technical and pedagogical quality. Guidelines for this are presented in the appendix.

Instructions are a good way to transfer the essence of the knowledge but are limited to tools and simple methods. The effectiveness of instructions depends on how widely spread the instructions are.

### 3.10 Industrially employed doctoral students

An assessment of KK-stiftelsen’s program “Enskilda företagsdoktorander” (CMA, 2003) reveals that the level of knowledge and competence in the participating companies have enhanced. Some of the most important success factors were to have a good and working supervisor committee and that the conditions must be “right”, i.e. that the company has to be greater than 20 employees and have a former knowledge of Ph.D. students or have a Ph.D. employed. Wallgren (2003) illuminates the importance of the balance and mutual understanding of the Ph.D. students acting in the two arenas, the academic world and the company’s world.

This is not a very effective way of knowledge transfer but have high quality. Since the doctoral student publish papers and reports outside his or her own company it is quite good from a dissemination angle.

### 3.11 E-learning

E-learning is a forthcoming way to transfer knowledge. This method’s strength of is that learning could take place anytime and anywhere. Roffé (2004) states that e-learning is such an attractive opportunity for training providers to reconfigure delivery and support that it presents compelling reasons to engage with the practice. A broad range of provision is therefore available for every type of market segment, including small firms. Sambrook (2003) describes how utilisation of e-learning could create new forms of learning, particularly appealing to small organisations, to overcome traditional barriers such as lack of financial resources, time, expertise and facilities. She finds that SMEs can benefit from this type of learning. However, key findings from this research

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11 KK-stiftelsen (Knowledge Foundation) is a trust with objectives to support research at new universities and university colleges and competence development in industry (See also internet: www.kks.se).
suggest that there are significant barriers to electronic learning, including the lack of hardware and software, and employer attitudes.

E-learning has great potentials regarding dissemination and is also a very effective way. The quality of the knowledge transfer depends on the quality of the e-learning tool in mind.

### 3.12 Implementation

According to Merriam-Webster Online Dictionary *implementation* is “to give practical effect to and ensure actual fulfilment by concrete measures”. Implementation and learning has a direct connection to the knowledge creation process. If the method or subject is intangible the more effort is needed in the transfer process and vice versa. For example, Womack and Jones (2003) state that the most difficult step is simply to get started by overcoming the inertia present in any brown-field organisation. You will need a change agent plus the core of lean knowledge, some type of crisis to serve as a lever for change, a map of your value streams and a determination to kaikaku\(^\text{12}\) quickly to your value-creating activities in order to produce rapid results that your organisation cannot ignore. Womack and Jones also suggest an action plan for Lean Production implementation as help for planning and carrying out the organisational transformation. It consists of four major steps and a time frame that stretches during five years. The steps are in short:

- The first six months you need to get started by finding a change agent, get the knowledge, map your value streams and begin kaikaku.
- Six months through year two you need to create an organisation to channel your streams by reorganising your firm by product families and value streams and the creation of a lean promotion function.
- Years three and four you need to install business systems to encourage lean thinking, introduce lean accounting and introduce lean learning.
- Complete the transformation by end of year five through applying these steps to your suppliers and customers, develop global strategy and transition from top-down to bottom-up improvement.

Implementation in general needs a systematic approach to be successful. Lycke (2000) has studied driving forces and obstacles that occur when implementing TPM. After studying different improvement concepts she suggests a general

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\(^{12}\) Kaikaku, also known as kaizen blitz, is a major improvement activity lead by the management.
implementation plan for improvement concepts which consists of five general steps:

1. Senior management decision.
2. Information and training.
3. Organisation.
4. Policies and goals.
5. Master-plan for implementation.

Another model that can be used in general for production methods implementation is described by Ghobadian and Gallear (1997). After studying implementation of TQM in SMEs they suggest this 10-step-model technique:

1. Recognize the need of the need for the introduction of TQM.
2. Develop understanding among management and supervisors.
3. Establish goals and objectives for the quality improvement process.
4. Plan the TQM implementation.
5. Educate and train all employees.
6. Create a systematic procedure (ISO 9000).
7. Align organisation.
8. Implement the TQM concepts.
9. Monitor the implementation of the TQM concepts.
10. Engage in continuous improvement by going back to step 3.

The most important factor to succeed is the management commitment or as Ghobadian and Gallear (1997) states: “Unless the management in an SME recognizes that quality is an important competitive factor and that TQM concepts can improve the totality of operations as well as the product quality, then no significant change will take place.”

Other important factors, when carrying out a successful implementation, are described by Johansson (2002). He has in his study regarding implementation of flexible automatic assembly in small companies used implementation aspects for a successful implementation strategy. Factors that can be important in technology implementation are:
• Supplier-user relationship, i.e. that both the receiver and the provider of the technology are involved in the implementation process.

• Product-process dependency, i.e. whether it is the correct technology and what change that is required.

• User strategy, the key to this variable seems to be the planning horizon – the longer the better.

• Incremental implementation strategy, i.e. could the technology be implemented step-by-step?

• General management support, which is crucial.

• Participation, for the potential system users.

• Justification, i.e. how will the new technology be exploited?

• Size, structure and organisational culture of the company, determine the amount of resources for the implementation.

• Training and education, perhaps the most important factor in establishing a readiness for change and participation.

The attitude to the new method is also a factor to consider. Au and Enderwick (2000) have found that the attitude towards adaptation is influenced by six internal beliefs:

• Perceived difficulty.

• Adoption experiences.

• Supplier’s commitment to the firm.

• Perceived benefits.

• Perceived compatibility of the technology.

• Enhanced value.

Other factors to concern have been collected from literature by Löwstedt and Norr (1991) regarding dissemination of innovations between organisations. Some factors are:

*The origin of the technology* – domestic innovations tend to be used faster.

*The characteristics of the technology*, i.e. the experienced advantage of the new technology.
The company’s size since larger companies tends to implement new innovations earlier. The importance of the size seems to be more important for process innovations than product innovations.

Higher technological and scientific competence reduces the uncertainty connected to the new technology.

The organisation structure, i.e. more centralised companies have shown to benefit more from new innovations.

According to Lycke (2000) there are both driving forces and obstacles that need to be taken care of during an implementation process. She did identify a number of driving forces and obstacles when implementing TPM.

The main driving forces are:

- Visible and committed management.
- Information and education.
- Competence and understanding.
- Continuity and persistency.
- Long-term thinking.
- Communication.
- Visible results.
- Participation.
- Engagement and motivation.

There are also obstacles in the implementation process. The most important are according to Lycke (2000):

- Organisational changes.
- Lack of knowledge.
- Lack of support.
- Indistinct leadership.
- Earlier failures with improvement programs.
- Lack of time.
- Lack of confidence in management.
• Strong informal leaders.
• Individuals instead of teams.
• Satisfied with the situation of today.

The implementation is focused on transferring knowledge to practice that gives the way rather high quality but often demands a lot of resources.

### 3.13 Learning by doing with a coach

Alstrup (2000) states that courses at education centres fulfil their purposes in most cases. But in some cases the participants join a course, seem to learn new skills and gain new motivation without being able to use the results when back in the firm. The gap between theory and practice appears to be hard to overcome. The fact that the participants are learning theoretical subjects at a course away from the workplace, without being able to practice the new skills, does not bring the learning to an operational level. Learning by doing, with reflection on what has been learned, brings theory and practice closer to one another. Alstrup suggests that if an outside coach is used to ensure a learning process, the coach must be willing to withhold his or her own expertise until it is demanded and instead facilitate the reflection of the participants in the working group. It is important to promote knowledge in step with the time and occasion at which it is demanded.

Koruna (no year) has developed a model for this type of learning – “Action-enabling technology transfer” – for transfer of technological knowledge. It is divided in six phases:
• Modelling, i.e. the task of solving a problem is made visible to the student by the expert.

• Coaching, i.e. the expert offers the student help, make suggestions, and give hints and so on.

• Scaffolding and fading, i.e. that the experts need to engage students somewhere between what they already understand and what they do not know.

• Articulation, i.e. “learning by teaching” is considered to be of positive impact on the learner’s process of knowledge building.

• Reflection, i.e. the learner is facing the challenge to compare his own thinking and reasoning with the thinking and problem solving strategy of either experts or peers.

• Exploration, i.e. instructions from outside of the context or real problems lead to the accumulation of inert knowledge for the recipient.

This model seems to require a lot from the expert. It is unclear how many transfer processes that can be going on at the same time. This way seems very effective since the coach is bound to the process a lot. The quality of the transfer is very high though.
3.14 Implementing a technology acquisition process

Another way to accomplish technology transfer is to implement a technology acquisition process in the receiving company. Such a process is described in Baines (2004) and was developed to create a formal and rational decision process. The model contains nine steps with five decision gates:

1) Technology profiling, which is the starting point in a technology push case.
2) Establish requirements of technology, which is the starting point in a pull case.
3) Find a technological solution
4) Form an outline business case, with the following gate: “Present the outline case to gain management approval”.
5) Choose technology source, with the following gate: “Choose supplier(s)”.
6) Demonstrate the technology, with the following gate: “Confirm technology capabilities”.
7) Confirm business case, with the following gate: “Present the case to gain approval”.
8) Implement the technology, with the following gate: “Commission and hand over to manufacturing”.
9) Post-investment audit.

This is one way to create competence in “ordering” knowledge or technology. It is important to have a holistic view in a change process. Bradford and Childe (2002) suggest a re-design model for SMEs due to that they more often have to adapt the manufacturing systems to changing circumstances. The model that they suggest could be used as a “change platform” to handle known methods and technology.

The redesign methodology contains four steps:

2. Risk assessment.
3. Action, where the plan is carried out.
4. Evaluation of action against plans and outcome against risk assessment.

Figure 8. Methodology diagram (Adapted from: Bradford and Childe, 2002)

To implement a general acquisition model in companies as a first step is an interesting idea if the model also, to some extent, could answer where and what new knowledge or technology could be found.
3.15 The IVF model

A model used in IVF emphasises knowledge transfer from one part to many companies in the same knowledge transfer event. The general thought is to create a benchlearning situation between the different companies during the implementation. The model could be described in the following steps:

- Initial seminar to determine the different companies needs.
- Present state mapping, establishing of performance measures.
- Workshops at each company to develop new knowledge.
- Cluster meetings for benchlearning activities.
- Support activities:
  - Education
  - Training
  - Educational visits

This model is general and could be used systematically in organised knowledge transfer events facilitated by e.g. knowledge creators as research institutes or universities. It is also quite effective and the knowledge transfer is probably of high quality.

3.16 Analysis and conclusions

The different methods have different abilities to support knowledge or technology transfer. Which one is the best in this situation? If the problem areas presented in the first chapter are viewed, three of them concern the knowledge transfer process:
• There are many SME companies and few knowledge transfer teachers regarding newly developed methods. This problem implies that the knowledge transfer model must be effective regarding how resources are used during the transfer.

• “The Learning Paradox”, i.e. that the companies need to know about existing methods and their potentials. This problem demands that a transfer process also benefits dissemination of the knowledge.

• “The Swedish Paradox”, i.e. that little effect comes out from the research conducted in Sweden and the research and transfer processes must be more effective. This problem implies that the knowledge has low quality when it has been transferred, i.e. much of the knowledge never leaves the researchers.

A five-ranked scale was chosen\textsuperscript{13} to value each model for transfer where 1 is a low degree of impact and 5 is a high degree of impact. The results are presented in the Table 1.

\[\begin{array}{|c|c|c|c|c|c|c|c|c|c|c|c|c|}
\hline
& \text{Researcher employment} & \text{Consultants} & \text{Courses} & \text{Participation} & \text{Networks} & \text{Students} & \text{Workshops} & \text{Publications} & \text{Instructions} & \text{Employed doc students} & \text{E-learning} & \text{Implementation} & \text{Acquisition process} & \text{IVF model} \\
\hline
\text{Effect} & 1 & 3 & 3 & 1 & 4 & 2 & 3 & 5 & 3 & 1 & 5 & 3 & 3 & 4 \\
\text{Dissemination} & 1 & 1 & 5 & 1 & 4 & 1 & 2 & 4 & 1 & 3 & 5 & 1 & 1 & 3 & 3 \\
\text{Quality} & 5 & 3 & 2 & 4 & 4 & 3 & 4 & 1 & 4 & 4 & 2 & 4 & 5 & 3 & 4 \\
\text{Sum} & 7 & 7 & 10 & 6 & 12 & 6 & 9 & 10 & 8 & 8 & 12 & 8 & 8 & 9 & 11 \\
\hline
\end{array}\]

\textit{Table 1. Knowledge transfer models valued.}

The different factors have not been weighted in this analysis but imply that networks, e-learning, the IVF model, publications and courses are the more effective ways than the others for knowledge transfer to SMEs.

\textsuperscript{13} The author’s note: A three-grade scale seemed to blunt and a seven-grade to detailed for this purpose.

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4 The knowledge transfer environment

This chapter describes how factors in the environment affect the transfer process of production methods to SMEs. Findings from the literature study has been categorised into the following sections:

- The characteristics of production methods
- The knowledge creation environment
- SME characteristics

Figure 9. Outline of this chapter and how the different sections are connected to the general model.

4.1 The characteristics of production methods

Do all production methods have the same characteristics? If you use Toyota as an example, The Toyota way, Just in time and single-minute-exchange-of-die (SMED), that all are components in the Toyota production system (TPS), have different focuses and depths in the knowledge. The depth implies different degrees of complexity and can affect the knowledge transfer process.
4.1.1 A historic view of production theory movements

The objective with this section is to give a brief historic review from the perspective of major “movements” during the 2000th century in order to develop a model for categorising different levels of content within competitive production methods. The movements that are described are:

- Scientific management
- Human relations
- Sociotechnical systems
- Quality movement
- Human factors

Scientific management

Scientific Management started around 1900 and was a reaction of the “soldiering” in the industrial society. Soldiering was a sort of unspoken agreement between industrial workers not to work more than agreed. This was a threat to the society, thought the main advocate Fredrick Winslow Taylor. His main thoughts could shortly be described through two postulates:

- There is a best way.
- The best suited man on the right place.

The principles of Scientific Management were designed by industrial researchers of those days and were communicated through different publications. The origin of the principles was collected from different industrial case studies (Taylor, 1911). In short, the steps in the method are:

1. Develop a science for each element of a man’s work. In this step tools as Design-of-Experiment and mathematical analysis are used.
2. Scientifically select and then train, teach and develop the worker.
3. Insure that all work is being performed in accordance with the principles.
4. Share the work and responsibility (almost) between the worker and management. Management to managers and work to worker.
The core values could shortly be presented as follows:

- Improvement should be rewarded. –Win-win solutions are sought.
- The benefit of the worker’s health is in focus.
- Continuous improvement in efficiency gives a better society with cheaper products.

All improvement should be based on scientific findings. The essence of Scientific Management could be described as a set of rules formed as a method that was followed by core values.

**Human relations**

Elton Mayo and his colleagues have through the famous Hawthorne experiments (1924-1933) created knowledge known as Human Relations. The fundamental idea in this movement is that industrial workers were social animals whose productivity was a consequence of their attitudes toward work and their informal relationships. Four general conclusions were drawn from the Hawthorne studies (Gillespie, 1991).

- The skills of individuals are imperfect predictors of job performance. Although they give some indication of the physical and mental potential of the individual, the amount produced is strongly influenced by social factors.
- Informal organisation affects productivity. The Hawthorne researchers discovered a group life among the workers. The studies also showed that the relations that supervisors develop with workers tend to influence the manner in which the workers carry out directives.
- Work-group norms affect productivity. The Hawthorne researchers were not the first to recognise that work groups tend to arrive at norms of what is “a fair day’s work”, however; they provided the best systematic description and interpretation of this phenomenon.
- The workplace is a social system. The Hawthorne researchers came to view the workplace as a social system made up of interdependent parts.

From these conclusions an ideology was formed. An institute was founded which secured a source from which different methods and tools could be developed such as:
• Supervisory training program.
• Publications.
• Hands-on-advices.
• Interviewing techniques.

Sociotechnical systems

Sociotechnical system interventions are organisation development techniques that typically involve the restructuring of work methods, rearrangements of technology, or the redesign of organisational social structures. The objective is to optimise the relationship between the social and human of the organisation and the technology used by the organisation to produce output (Pasmore and Sherwood, 1978). This movement was developed as a reaction on the Human Relations that could be seen as focusing only on the social aspects (Thorsrud and Emery, 1969).

The knowledge has been built with the origin in coal-mining studies. Those led to three major concepts (Klein, 1994):

1. The technical and social systems are interdependent. They influence each other, in both directions.

2. There is a choice in the way one organises round any given technology. This choice will be influenced explicitly or implicitly, by values.

3. The work system is an open system.

Klein also added a fourth concept:

4. There is a choice in the way in which technology itself is designed.

Walton also described the Sociotechnical systems as *a set of core values and suggestion of solutions* (Pasmore and Sherwood, 1978). The core values are:

• Autonomy work groups.
• Integrated support functions.
• Challenging job assignments.
• Job mobility and rewards for learning.
• Facility leadership.
• “Managerial” decision information for operators.
• Self-government for the plant community.
• Congruent physical and social context.
• Learning and evaluation.

These values were to be used when designing and/or evaluating a sociotechnical system, hence a checklist but also as guiding principles.

Quality movement
After World War II the Americans supported the Japanese to rebuild their industry. In the USA they had practiced what we today call quality methods that was brought to and evolved in Japan for the next decades. The “Japanese Wonder” had its roots in this knowledge transfer. The Japanese industry had developed the knowledge to industrial methods that were very competitive. The threat to American industry was clear to men like Deming and through analysing the American management insights came up about that something must be done to meet the threat. As Deming (1986) puts it: “Only transformation of the American style of management and of governmental relation with industry, can halt the decline and give American industry a chance to lead the world again.” Deming formulated 14 points that are a collection of “to-do’s” and are more or less a sequence of events to a transformed state of the company that the company has to go through. The receivers – the managers in Americans industry companies – were the target group for the knowledge of how things ought to be done in American (and Western) companies.

The knowledge in this case could be characterised as aid to self-support with guidance from three action steps:

1. Learn how to change,
2. Understand the use of the 14 points, and
3. Cure yourself from diseases.

Human factors
Human factors, also known as ‘human engineering’ or ‘human factors engineering’, is the application of behavioural and biological sciences to the design of machines and human-machine systems. Despite the interest of this subject throughout history the Human factors as a discipline begun during the World War II – the new weapon systems needed explicit engineering of the interface between human and machine. Psychologists, physiologists and
medical doctors were brought to work with engineers and produce explicit system designs and to make laboratory experiments to develop guidelines for future systems. The knowledge that was built often ended up as guidelines in handbooks. There are not many theories built in a quantitative way but a lot in a qualitative way. Quantitative theories that exist represent mathematical models that generalise properties of ears, eyes and so on (Sheridan, 2002).

Conclusions

Most of the knowledge has been designed as philosophies or methods and in some cases as to-do lists. Often it has been up to interpreters to form methods and tools that correspond with the original thought. To summarise this section three levels of methods could be identified:

- Philosophy or ideology that gives guiding principles to the receiver.
- Methods or processes, which tell the user how to do things.
- Tools or guidelines, which tell the user both what to do and how to do things.

4.1.2 State-of-the-art of production methods

In a study where the best companies in the world were analysed some outer and inner factors that characterise this companies where found (“Bäst i världen”, 1991). The outer factors where:

- Cost focus.
- Competition willingness.
- High customer focus.

The inner factors were:

- Management and the employee’s awareness of the necessity of high productivity.
- Simultaneous renewal and cost effectiveness.
- High external interaction with customers, suppliers and others.
- Human relation issues are important.
- Large-scale advantages through e.g. modularisation.
- Time-to-market shortening through e.g. concurrent engineering.
- Active target management.
- Company managers ability to formulate visions.
4.1.3 Analysis of production methods

There are many philosophies, methods and tools that have been developed in order to improve the competitiveness. Grünberg (2003) has reviewed different production methods or improvement techniques. Using the above classification to describe some of the improvement techniques the following description appears:

- **Total productivity maintenance** (TPM) is a collection of methods and tools but needs a philosophy to give the context and guiding principles in order to work.
- **Just in time** (JIT) is a collection of methods and tools within the Toyota production system (TPS) but as TPM it needs guiding principles to fully work. At Toyota this philosophy level is represented by *The Toyota way* that is a collection of guiding principles.
- **Lean Production** is the western world name of systems similar to TPS and contains all levels of knowledge.
- **Total quality management** (TQM) has all three levels. As a guiding principle the customer is in focus. Methods like different improvement methods and tools, such as the 7 quality tools, that accompany the principles.
- **Business process reengineering** (BPR) and **Business process improvement** (BPI) are mainly methods and tools in order to obtain better processes.
- **Supply chain management** (SCM) is a collection of methods and tools but without a guiding principle.
- **Theory of constraints** (TOC), has all three levels but could be viewed at as a method, e.g. when it is used in a lean production system.
- **Read a Plant – Fast**, is a tool to measure the *leanness* of a production system.
- **Simulation** is a tool or a method depending when and how it is used.
- **Process mapping** is a tool.
- **5S** is a method and some tools but is usually used in a lean production system.

It seems that the three level method descriptions is a possible way to describe the complexity of the knowledge and connection to other methods.
4.1.4 Conclusions

To be able to develop methods and tools it is important to understand the context and environment. As shown above the tools and methods all belong to a system of production methods. In some cases the method could be used without knowing the context but there is a need to find out if the method is suitable in the company’s environment.

4.2 Knowledge creation

This section presents different aspects on the knowledge creation process such as:

- How knowledge is created.
- Diagnostic tools in order to connect the degree of company maturity to knowledge transfer activities.
- A market view of knowledge creation.
- How methods could be adjusted for SMEs.
- Learnings from the best research institutes.

4.2.1 How knowledge is created

Von Krogh et al. (2001) describes knowledge creation from a literature point of view and state that the aim for a knowledge creation process is to improve the potential of creating innovations and improvements within knowledge domains. A knowledge domain consists of relevant data, information, articulated knowledge, such as handbooks, manuals or presentation and a list of key people and groups with tacit knowledge based on long-term work experiences. Knowledge creation processes typically take place in five steps in a group of limited size (5-15 persons):

1. First the knowledge domain members start by creating collective tacit knowledge by jointly experiencing new work processes, tasks, technological characteristics, use of technologies, customer sites, etc.

2. In the second phase the team attempts to make these collective experiences explicit, through agreeing on proper, just and accurate descriptions of their experiences. These descriptions in turn are used in a brainstorming fashion to develop new concepts based on their experiences.
3. In the third step the concept is being matched against market needs, strategies, goals and so fourth. In this step customers could be invited to review the concept.

4. If the concept passes the third step it is transformed into a prototype.

5. The last step is to integrate the newly created knowledge in the existing knowledge domain.

4.2.2 Diagnostic tools in order to connect the degree of company maturity to knowledge transfer activities

How do you know if a company is mature enough for certain production methods? Somewhere in the knowledge transfer process the preconditions in the receiving company ought to be valued against the characteristic of the method or knowledge in question. A diagnostic tool can point out what to be developed in a company for it to be able to implement the method or to be used as a self-assessment tool during the implementation. For example Gullander (2004) has in the DAISY-project studied DES\textsuperscript{14} implementation and suggested a step-model for DES implementation with proposed activities to reach the next step.

\textsuperscript{14} Discrete event simulation
Figure 10. Suggested activities to reach the next level of maturity. An example from DES implementation.

This approach could be generally applicable for productions methods if a maturity index and activities to reach the next level is developed together with the method. If the SME in question has been measured to a certain level of maturity it is easy to advice or take proper activity steps.

Different types of diagnostic tools can be found in the literature with different aims and design. Based on the literature study three groups of diagnostic tools have been identified as relevant:

- General diagnostic tools that can be used to measure general aspects or to be used as a frame when developing new specific diagnostic tools.
- Knowledge management diagnostic and implementation tools. An organisation that has a knowledge management system implemented has good possibilities to implement competitive production methods.
- Specific diagnostic tools, such as to detect degree of continuous improvement (CI) or Lean production.
General diagnostic tools

Ylinenpää and Lassianntti (1999) have studied the effects of "SME-trainees" in SMEs. To measure the effects they have used a set of variables:

- **CONCEPT**: Whether the business concept and the firm’s vision are clearly defined.
- **POLICY**: Whether the firm has developed and documented its policies in different fields.
- **ROUTINES**: Whether procedures and routines for different operations are defined and rooted amongst the firm’s employees.
- **QUALITY**: Whether the firm has introduced an accepted quality system that was accepted by the organisation.
- **TEAM**: Whether cross-functional teams are utilised for decision-making and production planning.
- **PARTICIP**: The percentage of employees taking active part in the work of such teams.
- **DECISION**: Whether the decision-making process in the firm is a ‘one-man-show’ or involved in the organisation.
- **PROBLSOLV**: Whether the firm utilises any structured or systematic method for problem solving.
- **EFFMEET**: Whether meetings in the organisation are prepared in advance and conducted in a professional way.
- **INFO**: Whether information is given and shared in the organisation.
- **CLIMATE**: Whether the organisational climate could be characterised as closed or open.
- **EDUC**: Whether employees are given training in relevant fields for doing a professional job, including areas such as communication, problem-solving, teamwork etc.

These variables can be used together in a standardised self-reporting study (See e.g. Westlander, 2004).

No process will ever reach the point of absolutely perfect knowledge – but most processes can benefit from attempting to move towards it. Moreover, few if any processes operate under conditions of total ignorance. Most operations have at least some idea as to why the processes behave in a particular way. Slack et al. (2001) describes an eight-stage scale ranging from ‘total ignorance’ to ‘complete knowledge’ of the process:
1. Complete ignorance.
2. Awareness.
4. Control of the mean.
5. Process capability.
8. Complete knowledge.

Yamashina (2000) means that to become a world-class manufacturer, the organisation itself must be active. From the viewpoint of competence, any organisation can be classified into the following five levels:

1. People deny that there are problems or do not want to see them.
2. People admit that there are problems but find excuses for not being able to solve them.
3. People accept the fact that there are problems but are unable to solve them because they do not know how to attack them.
4. People want to see potential problems and for this try to visualize them. They will attack them by learning proper methods.
5. People know their problems, methods to solve them and how to involve all the people to attack them. They are ready to attack any problem and to change their organisation if needed after solving the problem.

Detection of knowledge management maturity

One way to measure the readiness of an organisation for new knowledge and methods is to establish how mature the knowledge management process is of the organisation. Darroch (2003) states that there is little guidance in the literature on how to measure knowledge management. She has developed a scale divided in three parts according to knowledge management’s different phases:

- Knowledge acquisition
- Knowledge dissemination
- Responsiveness to knowledge
If knowledge work is needed in competitive production methods Sveiby and Simons (2002) suggest that a collaborative climate is one of the major factors influencing effectiveness of knowledge work. They have developed a tool to measure knowledge work, consisting of a questionnaire with 20 statements divided into four sub-groups with five statements in each:

- Organisational culture
- Immediate supervisor
- Employee attitude
- Work group support

**Specific diagnostic tools**

In some cases it is necessary to develop specific diagnostic tools just to measure the impact from a specific method. Below some existing tool are presented.

**Continuous Improvement and Innovation**

Hyland et al. (2000) states that the level of CI maturity can be measured using a CI maturity index. Six core abilities have been identified as having an impact on the effectiveness of improvement programs. The six core abilities and behaviours are termed: strategic, systematic, sustainable, extensive, learning and values. (see also Caffyn, 1999; Bessant and Francis, 1999).

McAdam et al. (2000) uses the CENTRIM Innovation Model to measure and detect innovation activities in companies. The model comprises six main sectors that are each sub-divided into three segments. The main sectors are:

- Directing a creative business.
- Developing creative capability.
- Building creative culture.
- Managing learning for new ideas.
- Organising for creativity.
- Taking wise decisions.

**Learning Organisation**

How “learning” an organisation is could be used as a criterion to determine the readiness for adapting new methods. Moilanen (2001) has analysed different diagnostic tools for learning organisations and developed “The Learning
Organization Diamond tool”. The tool is a questionnaire composed of 40 statements. 20 of them focus on the organisational level and 20 on the individual level. The core of the questionnaire for the organisation is:

- Driving forces – Building the whole.
- Finding the purpose – Where and why?
- Questioning – Why not, what hinders?
- Empowering – In what ways?
- Evaluation – To know if succeeded?

Lean production maturity through Read a Plant - Fast

Read a Plant – Fast (Goodson, 2001) is a method that helps to assess how “lean” a plant is. The tool was developed to be able to assess plants just by making a short tour in the factory. Afterwards a rating sheet is filled in. It is based on eleven different categories:

- Customer satisfaction.
- Safety, environment, cleanliness and order.
- Visual management system.
- Scheduling systems.
- Use of space, movement of materials and product line flow.
- Levels of inventory and work in process.
- Teamwork and motivation.
- Condition and maintenance of equipment and tools.
- Management of complexity and variability.
- Supply chain integration.
- Commitment to quality.

There is also a questionnaire with 20 yes-or-no questions that are linked to each category that helps determine if the plant uses best practices in these categories (Goodson, 2002).
4.2.3 *A market view of knowledge creation*

It is important to know if the knowledge, that is planned to be created, is really needed. With a cost-benefit analysis it is possible to analyse the need. Machlup (1980) discusses a knowledge creation from a market point of view. This implies the presence of two groups, one that offers knowledge, the other desiring to acquire it and willing to pay for it. This model does not fit well for several areas of knowledge creation, but it may be helpful in some. Machlup also suggests making cost-benefit analysis for projects or government-action programs where market prices could have been corrupted. There are five types of benefit-and-cost comparisons:

- Type one has the intention of avoiding people's over-valuing of their favourite project.
- Type two may be seen in explicit propositions about the value of the program, in which you impose your own value judgments upon the people of the commonwealth.
- Type three is more like an imposition of your individual value judgments.
- Type four is based on theoretical analysis, where you at least state what kind of empirical information you would need to make a calculation or an estimate of the benefits and costs.
- Type five is the actual calculation of benefits and costs in which all or much of the required information is available and utilised.

4.2.4 *Methods adjusted for SMEs – some examples*

In the literature review a number of publications regarding method for SMEs were found:

- TUTTAVA, an adjusted 5S system (Alvarez et al. 2002)
- P-M-analysis, a systematic cause analysis (Nilsson and Wojtkowiak, 1996)
- 5steps, a method for establishing continuous improvement regarding lead time (Eriksson and Järneteg, 1993)
- DO-IT
Tuttava

Tuttava is designed as a manual in nine steps with guiding examples. The steps are:

1. Start work where a group is appointed and information to the employees is carried out.
2. Good working procedures are developed.
3. Procedure analysis, i.e. are the procedures able to comply with in the daily work?
4. Make a checklist to be able to measure the orderliness.
5. Measure the orderliness in the working places.
6. Inform that orderliness should be improved and how.
7. Continue measuring and publishing the orderliness level.
8. Follow up the checklist every three months.

There is also an even more compressed manual for micro\(^{15}\) companies – *Mikro-Tuttava*.

P-M-analysis

The P-M\(^{16}\) analysis manual describes some important information when to start using the method. The following points are brought up:

- What is P-M analysis?
- Why use P-M analysis?
- Guidelines for implementation.
- Step by step description of the 8 analysis steps.
- Common mistakes when using P-M analysis.
- How to adjust the method to the company’s own business situation

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\(^{15}\)Companies less than 10 persons.

\(^{16}\)‘P’ stands for Phenomena and the ‘M’ for Mechanism.
5steps – a method to implement lean production in SMEs

A guide for the implementation of lean production in SMEs has been developed at IVF in the early 90’s by Eriksson and Järneteg (1993). The developed model, 5steps, is based on Time Based Management (TBM) and is focusing on lead-time reduction and contain five steps:

1. Definition, where the fundaments for the intervention is made. A first analysis is carried out where problem areas are pointed out. A project group with sub-groups for different tasks is formed.
2. Initiate, where as many as possible of the co-workers are involved in solving problems found during the first step.
3. Maturation, where people are trained in systematic continuous improvement.
4. Transformation, where the plans for change are executed.
5. Stabilising, where the instable part of the fourth step is becoming more and more stable and builds the fundament on which further improvement could be build.

DO-IT

Another example of how competitive production methods are designed for easy assimilation is the “DO-IT-concept”\(^\text{17}\). It is a basic system adapted from Toyota Production System. It has five modules where the first one is a fundament for the others:

- Continuous improvement, how to gain understanding for elimination of waste.
- Go out walking – the way to a continuous flow and an optimal process lay-out.
- One-piece-at-the time – smaller batches through reducing set-up times.
- On demand – the way to a customer driven system through kanban\(^\text{18}\).
- 5S – the way to the systematic work place.

The pedagogical approach in DO-IT is based on that a message ought to be transmitted via many different channels to reach the receivers. The material is

\(^{17}\text{See Internet: www.utbildningshuset.se/utbdoit.html}\)

\(^{18}\text{Kanban is the classic signalling device for production pull systems.}\)
presented in a lecture with OH-slides, through simulations, through text in the workbooks and through video sessions.

Analysis

The different methods above are in a report format and quite short. Three factors are common:

- They answer the questions what is the method for? and why and where should it be used?
- The methods are built for stepwise implementation.
- The methods are all exemplified in a do-like-this manner.

These examples that many researchers and developers consider it important to design methods for SMEs that is easy to understand and to learn. A conclusion to draw is that it is important that the knowledge is designed for easy assimilation.

4.2.5 Learning’s from the best research institutes

It is important that the knowledge that is created in research institutes has its meaning and context. This can be obtained through a knowledge management system. Knowledge management should not be confused with information technology. IT is an important enabler, e.g. in providing document management solutions, but knowledge management is a far wider subject. Knowledge management is an active approach to identifying, using and enhancing the tacit as well as the explicit and embodied capabilities and experiences of an organisation. It represents a systematic and organised attempt to use knowledge within an organisation to fulfil organisational objectives and enhance its value to stakeholders. This will include transforming its ability to store and use information, and developing both the assets of the organisation and its processes. According to Braun et al. (2000) knowledge management in research can be structured in five domains:

- **Content**, where knowledge must be identified and captured. It is also important that the transfer knowledge itself must be separated from other knowledge.
- **Context**, where e.g. definition of a shared language is the key to success. It is also important to define clear objectives to deliver benefit.
• **Process**, where knowledge input and access to knowledge must be easy and part of the daily business process.

• The *culture* must encourage and reward sharing of knowledge within the research institute. The question of ownership and usage of knowledge must be carefully addressed.

• **Infrastructure**, i.e. computer technology provides the tools and infrastructure. The technology works as an enabler for fast knowledge storage and retrieval within the knowledge areas.

To get an effective and suitable knowledge management process, it should be general but also give guidelines to the persons who will work within it but also be able to be benchmarked (Braun et al., 2000).

### 4.3 SME characteristics regarding knowledge transfer

SMEs have different requirements than larger companies due to method adaptation. These requirements are important to consider in the knowledge transfer process. This section will describe how SMEs are described in literature.

#### 4.3.1 General characteristics of SMEs

Small firms are subject to greater external uncertainty and greater internal consistency of motivation and action than large firms. This stems from that small firms often have large firm customers and that the large gives small firms little bargaining power. This in turn leads to the fact that the SME should be more reactive to the business environment and will have to redesign itself more often (Bradford and Childe, 2002). Terziovski (2003) generalises and claims that SME generally lacks of knowledge and resources. Small businesses fail from lack of management ability. Effective training to improve manager’s knowledge generally is to encourage grater use of decision support systems (DSS) (Duan and Kinman, 2000).

In a study were the learning process in small organisations was explored the findings are according to (Penn et al., 1998), that small organisations are characterised by:

- A paternalistic culture.
- An informal approach to planning.
• The importance of an individual’s ideas and character.
• Learning by working with others (rather than formal training).
• Belief in the importance of growth.

Alstrup (2000) concludes that small enterprises have few resources to spend on activities beyond the daily short-term activities. Furthermore, small enterprises seldom have the expertise themselves to initiate and sustain developmental projects. Small firms often need external support if they want to implement new concepts, e.g. quality management.

It is generally recognised that size influences organisational behaviour. Large organisations are usually bureaucratic and SMEs are more organic. Some of the SME characteristics are (Ghobadian and Gallear, 1997):

• Flexible structure and information flows.
• Top management close to the point of delivery.
• Very few interest groups.
• Short decision making chains.
• Result-oriented.
• Individual creativity encouraged.
• Dominated by pioneers and entrepreneurs.
• Training and staff development is more likely to be ad hoc and small scale.
• No specified training budget.
• Negligible resistance to change.
• Limited external contacts.

Lindmark (1999) concludes, that methods such as TQM, have a positive impact on small organisations and that small organisations have advantages due to their size when implementing work with quality. These advantages due to flexible organisational structure, lack of hierarchical positions and a strong organisational culture.

4.3.2 SME issues of learning and competence

A small company has limited resources and does not have access experts of their own in many fields. It operates with small economic margins and the white-collar resources are limited and focused on operative productive work.
Due to lack of economical resources, but also not being exposed to new ideas from the world around, training and development are low prioritized (Forslin and Thulestedt, 1993). Kailer and Scheff (1999) states that SMEs, in general, usually depend on the collaboration with external know-how experts because of their limited personnel and know-how capacities. Ylinenpää and Lassinantti (1999) state that SMEs have a low level of formal qualifications. The problem in Sweden, as well as in many countries, has been that SMEs traditionally have been reluctant to employ graduates from the universities. According to Lagerholm and Axelsson (2002) 55 per cent of the SME firms in Sweden do not have any higher educated19 engineer employed.

SMEs often have no strategies or poorly developed strategies. This can be the case particularly regarding learning and strategies for knowledge capture and transfer. Even SMEs that have a strategic plan may not have developed a deliberate plan for learning (Hyland et al., 2000). This statement is supported by McAdam and Reid (2001) that state that the SME sector appears to need to develop their understanding of knowledge management further as a key business driver rather than as a resource-intensive additional initiative.

When a SME has the intention to learn a new method there are many factors to consider. According to Hugnell (no year) regarding knowledge acquisition and competence development there are some factors to consider:

- **Timing**, e.g. if a firm does not have a lot of orders there is always room for education.
- There has to be a **need** expressed.
- **Planning**. Many firms do not have a knowledge management-process and it seems that competence development has minor importance.
- **Educational form**. The firms usually want the education in their own facilities (which could be hard to manage for smaller firms).
- **Flexibility**, i.e. the possibility to adapt courses after the firms need is important.
- The **demands** vary a lot due to attitude.
- You have to be **specific** when addressing more than one company.
- Marketing, i.e. the firms often have little knowledge about educational options.

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19 Bachelor or master degree of engineers.
Yusof and Aspinwall (2000) state that training and education is one of the most important items on the agenda for small businesses in adopting TQM but small firms are unable to allocate sufficient funds for training and do not have the extra capacity to substitute people for periods of absence. Some conclusive advices are:

- Not to implement TQM all at once.
- A short-term payoff can have long-term benefits.
- Education, as well as training, from universities, local colleagues or sharing training resources from non-competitor small business through networking is a much cheaper option.
- Have realistic expectations.
- Have a well-organised implementation plan ready.
- Since profit is the main motive of all business it is not all wrong to ensure that the initiatives have an impact on the bottom-line.

### 4.3.3 Management in SMEs

The management in a SME is an important factor to consider. Ghobadian and Gallear (1997) claim that total quality management involves cultural change at all levels of an organisation. Once top management recognises the need of change, then it is easier to attain cultural change in SMEs than in large organisations. However, it is probably more difficult for SMEs’ management to recognise the need of change. This is due to the limited resources and external contacts, pressure on top management’s time and the style of management.

According to Forslin and Thulestedt (1993) it is easy for the manager to be absorbed by detail issues but the small company gives better conditions for a good overview. The type of management philosophy has great impact and importance for renewal possibilities in the small company.
4.3.4 Method implementation in SMEs

To be successful with implementation of methods in a SME there are many factors to consider. Some of the success factors are, according to Yusof and Aspinwall (2000):

- A systematic approach.
- Selective training.
- Establishing a good communication system.
- Having a continuous improvement system.
- An effective and simple implementation framework.
- Teamwork development.

Gustafsson et al. (2001) states that one of the most important factors in order to succeed with the implementation is the attitude to the system from the beginning. Education is also a factor to consider. SME implementation advantages are according to Ghobadian and Gallear (1997):

- Leadership – a SME CEO enjoys a high degree of visibility and can readily emphasise the importance of quality.
- A greater degree of vertical and horizontal visibility.
- Employees tend to be closer to the firm’s products and customers.
- A natural tendency for cross-functional training.
- Easier to create a holistic atmosphere.

Norén (1987) describes new technology\(^\text{20}\) success factors:

- The expected low degree of differentiation in a small company leaves great possibilities to co-ordination.
- A flat organisation and simple structures give good possibilities to cope with the necessary mental changes due to new technology implementation.
- Simple structure gives good possibilities to have a good general view over the company.

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\(^{20}\) In this study CAD/CAM-system implementation is in focus.
Much can go wrong in an implementation. Yusof and Aspinwall (2000) have in a study where TQM was implemented in a SME listed some problems and obstacles. The main problems were:

- Lack of human resources.
- Lack of involvement from non-production functions.
- Trying to achieve too much in a short time frame.

The most important problem with implementation, according Gustafsson et al. (2001), is that the resources in time and people were underestimated and that the implementation was experienced as very expensive. Ghobadian and Gallear (1997) also states that there are disadvantages such as:

- The owner’s or CEO’s personality tends to dominate the culture.
- Individuals are often responsible for a number of different functions with little back-up.
- Flat structures can leave employees frustrated since they are often unable to realize their short and mid-term career goals.
- “Resource paucity” is the most serious disadvantage faced by SMEs.
- SMEs are usually sceptical to outside help.

There are some implications in the implementation according to Ghobadian and Gallear (1997):

- Resource issues did not appear to preclude the implementation of TQM in SMEs.
- The closeness of the workforce could also cause difficulties.
- It is easy to be over-ambitious.

Lindmark (1999) has also observed difficulties that rise during implementation work such as limited resources and management change.

Other important factors are, according to Gustafsson et al. (2001), that, in general, a reasonable amount of external help is used with the time plan and the implementation and education.
5 Empirical studies

Three different studies and surveys have been carried out:

- The PABIS case study, which has given input to the knowledge model development.
- The TIME survey has given input to the preparation phase for knowledge transfer and conclusions regarding the knowledge creation process.
- In the DFA2 assessment study the coupling between the knowledge creation process and the industrial need has affected the knowledge transfer process.

5.1 The PABIS\textsuperscript{21} case study

This project has been used as a model for knowledge transfer. The project itself is described. But it is not the project’s result that is interesting but the project model itself.

5.1.1 Project background

“The hydrogen society” and fuel cell power has been pointed out as one possible path regarding energy supply in the future when the oil reserves are used up. The background to the PABIS project was that not many Swedish companies had considered the opportunities regarding fuel cell technology as a potential business opportunity. IVF and STEM\textsuperscript{22} decided together with Vinnova to create a project where Swedish companies were invited to get answers to the questions if, when and what should the companies invest in regarding fuel cell technology. In this case there was also some focus on PEMFC\textsuperscript{23} and the automotive industry.

\textsuperscript{21} The project name PABIS is a acronym from ”Produktion Av Bränsleceller I Sverige – en möjlighet!” Translated: Manufacturing of fuel cells in Sweden – an opportunity!

\textsuperscript{22} Swedish Energy Agency (Energimyndigheten)

\textsuperscript{23} Proton Exchange Membrane Fuel Cell
5.1.2 Project objective

The main objective was to create an interest and to activate Swedish industrial companies regarding business opportunities within the fuel cell technology area. A special characteristic about this project is that since the knowledge was very little in the companies the enthusiasm was expected to be low.

5.1.3 Working method

To meet the project objectives there were two tracks that had to be developed:

- Relevant industrial decision knowledge regarding if, when and what needed to be collected, analysed and designed for this specific target group.
- The process for dissemination, knowledge transfer and responses collection of the industry companies were also needed to be developed.

Together with a reference group a project plan, which also became the general results from this project, was developed. It contained the following activities:

- A contemporary study was carried out as a literature study.
- Technology study by analysing current designs.
- Demand specification due to component or process.
- Company identification.
- Workshops.

5.1.4 Solution

The knowledge regarding if (Is this a potential technology shift?), when (When is it going to happen?) and what (What processes and products will be needed?) was first collected and analysed, and later on designed as a slide presentation. The what-analysis gave input to which companies that were the target group. The what-analysis origin from known fuel cell engines and gave a list of components, subsystems and manufacturing processes. This list was matched with Swedish companies either on process or component/subsystem basis and a list of potential interested companies with contact persons was created.

The following procedure was built where the number of participants are decreasing when uninterested fall away.
1. Get companies’ interest via newspaper\textsuperscript{24} articles, the Internet and phone calls.

2. Send a personal workshop invitation to the persons on the list.

3. Step 1: Carry through the workshops with the slide show and discussions. The main objective with the workshop was to find “real enthusiasts”.

4. Step 2: Interested companies will further also get a specific SWOT-analysis and fuel cell technology activities implementation in business strategy in a workshop in their own company. This step is carried out in order to achieve a critical mass of employees with the same knowledge foundation.

5.1.5 Results from the project

Some 80 companies where identified and invited via mail. Another 200 were invited via e-mail. Approximately 40 persons from 33 companies participated in the workshops. 12 companies carried out the second step.

5.1.6 Analysis and conclusions

The procedure worked as planned. Of the 12 companies that participated almost everyone have had fuel cell technology related activities afterwards. Probably an additional implementation step would be necessary in some cases. The first step was to find the real enthusiasts. The second was to help the real enthusiast to get the knowledge into his company. A third could help to establish the knowledge inside the company. This step could be facilitated in many ways – by creating a network where mutual questions and problems could be processed.

The procedure seems to be generally applicable and could be used for any kind of knowledge transfer. But it has to be completed with an implementation model as well.

\textsuperscript{24} An article in the Swedish magazine “Underleverantören“ (Direct translation: The sub-supplier) and IVF external magazine “Teknik och tillväxt” (Direct translation: Technology and growth) was published.
5.2 The TIME assessment survey

In this study the TIME project has been assessed regarding how different factors affect the outcome from a research project through a survey. The following is a short version of the survey. A full version is found in the appendix.

5.2.1 Background

Industrial competitive manufacturing knowledge is created and transferred to SMEs in Sweden by, among others, research institutes and universities in cooperation with the industry. Industrial research institutes state that their mission is to convert results from research and development into industrial profit. This is done primarily by currently transferring results to existing Swedish companies through e.g. publications, education, training and consultancy but also, in some cases, through spin-off companies. The universities have other motives than the institutes such as possibilities to conduct research training and to give opportunities for academic publication. The industrial partners are often interested in solving current problems for the benefit of their own company.

This survey has assessed the TIME project, financed by Vinnova\(^\text{25}\) in the research program “IT-verkstad”\(^\text{26}\). The TIME project objective was to create an “aid for improvement” and a “tool kit” in the field Shop floor disturbance management. The main result was a handbook (IVF, 2004). The handbook was not fully verified within the project, which was a minor drawback and not quite ready for knowledge transfer activities.

5.2.2 Objective

This survey focuses on which factors that affect the results in a multi stakeholder industrial research project. The objective was to investigate how the knowledge creation projects’ results are affected by the attitudes and approaches by the different parties in an industrial research project. The research questions that were to be answered by the survey were:

\(^{25}\) Swedish Agency for Innovation System

\(^{26}\) Free translation from Swedish: Shop floor information technology
• How did the different project participants think when designing the handbook?
• Is there a difference between the different groups of parties?
• How does the project design affect the results?
• Has there been any critical incident that has affected the outcome of the project?

5.2.3 Conclusions

The survey reveals that it is not easy to carry out a multi-stakeholder research project were the different stakeholders have different views. Some conclusions are:

• Important when designing knowledge is the form, in this case a handbook, and when in the project it is decided. The earlier decision the more limited outcome.
• It is also clear that the project team assemble matters regarding the lead-time in the project. A more mature group could develop a handbook quicker.
• A third bullet is that searching for knowledge does not have to be a substitute for planning. The two can co-exist. It is a matter of finding the proper balance.

There were also some new questions that could be raised. They all consider the national innovation system that has been the context of this study:

• Should the resources determine the result or should the need determine the resources? Of course the resources are limited in the innovation system but how do we know if the project is worth doing?
• This survey reveals that the maturity of the project group is a factor to consider, but who wants to pay for the group development? And if you always use the same groups, is it not a risk that the group might be shielded from other influences?

In this case the industrial parties had little influence on the design of the end product – the handbook. The knowledge that is being developed must be needed by the end-users to have a real impact in the industry. How do we, in the best way and within the innovation system, balance actual today’s needs in the industry with the academic striving to search for the unknown?
5.3 DFA2 development – a qualitative assessment of the project

This study have had the focus of assessing a R&D project, that resulted in a engineering tool – DFA2 – in order to determine how the perceived need was connected to the actual dissemination and knowledge transfer. The following is a short version of the survey. A full version is found in the appendix.

5.3.1 Background

DFA2 is a technical design evaluation tool that has been developed in integration between IVF and WoxénCentrum\(^\text{27}\) at KTH. The work resulted in a doctoral thesis, research reports and a software embryo. Some four years after the DFA2 release the tool does not have that many users. Why? It is necessary to evaluate the knowledge creation and transfer process and how they correspond. This study assess the DFA2-project to gain understanding about which factors are enabling and which are being obstacles in these processes.

5.3.2 Objective

This project assessment had the ambition to investigate which factors that affect the knowledge creation and transfer process from academia and research institutes to industry. Enablers and obstacles were sought for together with transferable conclusions and advices.

5.3.3 Description of the DFA2 development process

Project background

The fundament of the project design and its objective was the answer to the question: What is the problem? In the problem description subjects like harder competition, needs for shorter product development lead times and issues concerning automatic assembly are presented. Another problem is brought up as well: “Why is not DFA used more?” A literature review was made in the project due to the question: “What is missing?” Eskilander (2001) states: “…there is a need for a method that uses qualitative evaluation in combination

\(^\text{27}\) WoxénCentrum conducts research and development within the field customer driven high performance production systems in cooperation between industry and university. (See also: www.woxencentrum.nu.)
with design rules that are general for any automatic assembly process.” which leads to the research question: “How can a method for use in early product development, that focuses design for automatic assembly and includes both product evaluation and cost estimation, be structured and what information should it contain?” The objective, with the work that resulted in the licentiate and the doctoral thesis, was to develop a method – a Design Method for Automatic Assembly. Its origin was further development of a method developed earlier, “The Flowchart Method”, which is described in Byron Carlsson et al. (1998).

Project design

The development of the tool was carried out together with 18 industrial partners. Eskilander was the researcher and used the WoxénCentrum industry group as reference group and for verification activities. The need from the industry was described in the pre-study and was presented as nine suggested requirements of a tool where one requirement was to develop a software product. The DFA2 tool was developed in cooperation with the reference group of 18 companies.

DFA2 today

What has happened to DFA2 and how is it used? It is not a common tool in the industry today but the tool is still used to some extent. There are some users from the original project group and Eskilander has further developed the DFA2 product in his work at Ericsson. Regarding the software development first DELFOI was meant to be the developing partner of a DFA2 software tool but discussions about immaterial rights delayed and obstructed the process. A first edition was available for customers anyway. The vendor, who was a true enthusiast, left DELFOI and today they do not have the intention to develop it further because of lack of industry interest and/or marketing. Another software company, SOLME28, has developed a DFA2-module connected to their software platform. The DFA2-module is further developed due to user friendliness and functionality and will be released to the market around the turn of the year 2004/2005. They have pre-presented DFA2 but have only had a handful of contacts so far.

28 See Internet: ‘www.solme.se’
5.3.4 Discussion

One of the problems in the DFA area was that DFA is not used a lot. Even today DFA2 has few users. The goal was to create a DFA-tool, not to improve companies’ processes with a tool as means. The relevance and need for another DFA method could be questioned. There is no obvious demand for DFA-methods from Swedish industry today despite that the result of using DFA-methods show that the companies can benefit from them. There could be a so-called “learning paradox”. You could not demand knowledge you do not know exist. Many companies know about DFA but maybe not its potentials. But there was an academic need. There were no qualitative DFA methods for automatic assembly. The companies that participated in the project were very interested in the new tool. Maybe there is only a lack of knowledge by the Swedish industry or is it a true lack of need?

5.3.5 Conclusions

It seems that in order to be successful with knowledge creation and transfer, three parameters need to be fulfilled:

- A true industrial need.
- A well designed product (method).
- A well planned dissemination and transfer plan.

In the DFA2 case the product was well designed, but the need was questionable and the dissemination and transfer plan was fragile due to a too small critical mass. Other conclusions and advice that could be drawn from this project are:

- There is a need for a clear problem description and a clearly expressed need from the industry.
- It is important to view the problem or opportunity as well as an industrial as an academic problem.
6 Suggested model for knowledge transfer to SMEs

In this chapter different views, conclusions and demands that have appeared in the previous chapters will be systemised and presented. A model has been developed to correspond with the requirements.

6.1 Requirements of a knowledge transfer model to SMEs

Requirements that affect a knowledge transfer model for SMEs was presented in the introduction as a problem description. In chapter 3 different models of knowledge transfer where some could be better than others are presented. In chapter 4 different factors of “The knowledge transfer environment” that need to be considered are presented. In chapter 5 the different case studies and surveys have presented factors that also need to be considered. In this section a general knowledge transfer model is broken down and the different demands are connected to it. The following parts will be treated:

- The knowledge transfer process
- The knowledge transfer environment, which consists of:
  - The knowledge creation process
  - The subject – Production methods
  - The recipient – SMEs
6.1.1 The knowledge transfer process

From the introduction problem description the following problem addresses a knowledge transfer process to SMEs:

- Compared to the number of SMEs the resources in institutes and universities are limited. This implies that a transfer event must be effective and supply several companies.
- The “learning paradox” implies that there has to be an effective information and dissemination campaign to the target companies and that a positive attitude to the product is needed.
- The “Swedish paradox” implies that the quality of the transferred knowledge could be improved.
- Since different companies have different competence maturity, the model must be able to handle a width of demands.

6.1.2 The knowledge transfer environment

Knowledge creation process

From the problem description, surveys and the literature study it is concluded that:

- In many cases the methods need to be adjusted in order to fit SME prerequisites.
- There is a need of understanding regarding the importance of SMEs and their specific needs.
- A true industrial need is needed, which implies that the true needs from SMEs must be acquired.
- A well-designed product is a success factor.
- A well-planned dissemination and transfer plan is preferable.
- Manage a portfolio instead of looking for projects to fit a standard model. This implies that a “portfolio” organisation administrated by the knowledge developer exists.
- Get close to your partners, i.e. the knowledge transfer model must be described and be able to be benchmarked.
A factor to consider when designing knowledge is how the knowledge is designed, i.e. in which form and when it is decided in the project. Searching for new knowledge does not have to be a substitute for planning. The two can co-exist. It is a matter of finding the proper balance.

The project team designs matters regarding the lead-time in the project. A more mature group could develop knowledge faster but could be shielded from outer influences that could limit the outcome.

It is important that a method is connected to its context so that the recipient easily could determine if the method is interesting to use. There is also a time perspective at the different levels. A “tool” is probably developed in a shorter time than a “method” or a “process”. A “philosophy” has a very long developing time. For example: it took Toyota 40 years to develop the “Toyota Way”. This implies that tools and methods could be developed in single projects but philosophies need series of projects to be developed.

All these bullets address problems in the knowledge creation process regarding the knowledge transfer environment. An explicit and evident model for knowledge transfer and its environment could solve this problem.

**Production methods – the subject**

From the problem description, surveys and the literature study it is concluded that:

- Since different companies have different competence maturity, knowledge transfer needs methods developed for step-wise implementation.
- Maturity indexes must be developed in order to classify different potential users of the methods.
- For a SME it is important that the knowledge is designed for easy assimilation and adjusted to SME needs.
- How to get the tacit knowledge into the “product”? In some cases the tacit knowledge follow the knowledge creation actor into the knowledge transfer event.
SMEs – the recipient

The SMEs have different characteristics than larger companies such as limited resources and limited competence. Other factors to consider are:

- **Timing**, i.e. if a firm does not have a lot of orders there is always room for education. Support is needed “on demand”.
- There has to be a need expressed.
- Need for **planning**, i.e. many firms do not have a knowledge management process and it seems that competence development has a minor importance.
- When it comes to **educational form**, it is important with as little resistance as possible. The firms want the education in their own facilities (which could be hard to manage for smaller firms).
- **Flexibility**, i.e. the possibility to adapt courses to the company’s need is important.
- **Width of demand**, i.e. the demand varies a lot due to attitude.
- **Target group**, when addressing more than one company you have to be specific.
- **Marketing**, the firms have often little knowledge about educational options.
- As a large proportion of SMEs are in ‘crisis management’ rather than pro-active learning situations they need to be encouraged to adopt a more participative style of collective learning. Support services need to be provided and resources pooled.
- SMEs should be encouraged to promote the value of capturing on the job experience; to promote competence standards for their local cluster and contribute towards the accreditation of informal competence development.
6.2 Presentation of the DCT-model

To be able to perform an effective knowledge transfer different activities and knowledge need to be connected into a system or in a context. Once the knowledge is created it is transferable to companies. The DCT-model (Dissemination – Clustering – Transfer) is the author’s suggestion to a repeatable systematic approach that has three steps:

**Figure 11. The DCT model – a schematic view.**

### Step 1 – Dissemination

As a first step, dissemination, companies need to be aware of the existence of the current competitive production method. This can be done in many different ways such as:

- Publications
- Seminars
- Workshops
- Articles in newspapers
- Newsletters

A suggestion is that different methods are presented in a descriptive seminar where companies are invited to listen and view short presentations of different knowledge areas. An event like this could be annual or quarterly.
Step 2 - Clustering

The second step is to arrange an initial workshop in which the method is presented in order to give the companies a possibility to match their maturity with a maturity index. The companies are invited to join a cluster with companies with the same degree of maturity.

Choose some of the methods described in section 4.2.2.

Step 3 – Knowledge transfer events

The third step is aimed to carry out different knowledge transfer events where the implementation of the method is supported in the different clusters. Here it is important to choose transfer models that fit the method and the companies. Examples of supportive activities are:

- Education
- Courses and training
- Educational visits
- Workshops

The companies join the cluster until they have reached their pre-stated maturity level. The DCT-model is repeated with new target companies regularly.
6.3 The DCT-model environment

Figure 12 shows a model for knowledge transfer to SMEs. It contains two linked processes: knowledge creation and knowledge transfer in a knowledge portfolio management context.

![Knowledge portfolio management diagram](image)

Figure 12. Knowledge creation and transfer in a knowledge portfolio management environment.

6.3.1 Knowledge portfolio management

A knowledge portfolio is the composition of an organisation’s competence, educational material, publications and so on. To able the DCT-model it needs to be connected to a portfolio, i.e. other methods and tools that share the same philosophy or guiding principles. This is important for the receiving companies to be able to evaluate if the method fits into their business approach or organisation. This is also appropriate for the knowledge developer that enables the knowledge creation planning. It is within the portfolio the guiding ideas and philosophies are developed. Within the portfolio it is possible to analyse what methods that are missing and the need for development in order to build a system of methods, tools and plans for knowledge transfer events. Internal knowledge transfer within the knowledge development actor is probably also given better possibilities of continuity in the knowledge portfolio.
6.3.2 Knowledge Creation

Most of the knowledge creation is carried out in projects. According to the model, three areas are important to consider:

- How should the method be designed?
- How should the project be designed?

The two questions above are linked to the knowledge portfolio and the development needs in order to complete the portfolio.

**End result specification**

How the result should be designed is linked to how the knowledge is planned to be transferred. When the DCT-model is used there are some factors to consider:

- What are the method’s positions to the context and to the knowledge portfolio?
- What problems does the method solve?
- How is it measurable?
- How should a maturity index be developed?
- The effectiveness and value of instructional materials is necessary to confirm (see Appendix).

**Project specification**

The knowledge creation project is also an important factor to consider. The following questions need to be answered:

- What is the industrial need? In what way is it manifested? Is the need confirmed? If not use the Machlup model (see section 4.2.3)?
- Who are appointed to develop the knowledge?
- How mature is the development team?
7 Conclusions

In this chapter the overall findings are reviewed. Since this is only a part of the doctoral work guidance it is presented in form of suggestions to future research.

7.1 Overall findings – a summary

As previously stated, some of the general conclusions from this work are:

- The competition is getting harder. The knowledge of different competitive methods is now spreading over the world and over the supply chains.
- SMEs are different from large companies and have other prerequisites.
- There are limitations in the nation’s innovation system regarding production methods and SMEs.
- There are many different models of knowledge transfer where there are indications that networks, e-learning, the IVF model, publications and courses are more effective ways than others for knowledge transfer to SMEs.
- The knowledge transfer process is depending on its environment, in this case, the characteristics of production methods, knowledge creation process and the characteristics of SMEs.
- From the PABIS case study the embryo of the DCT-model was developed.
- The TIME project assessment has given insights of the importance of the knowledge creation phase.
- The DFA2 development assessment moderated the conclusion that three parameters need to be fulfilled in order to obtain a successful knowledge transfer: a true industrial need, a well-designed product and a well designed dissemination and transfer plan.
• As a solution to the problems and expressed and unexpressed demands the DCT-model has been developed. The model contains three steps:
  o Dissemination.
  o Clustering.
  o Knowledge transfer events.

7.2 Critical review

Is this research needed? Yes. Svensson et al. (2002) claims that this type of research is needed, but it is also needed because of the fact that the limitation in the national innovation system has been altered detrimental to the SMEs. The suggested solution to this change is the suggested DCT-model. It has been developed in order to effectively transfer industrial knowledge to many SMEs at the same time make them cost effective as well.

Is it valid? The DCT model is based on the requirement specification aggregated from this thesis work. The requirement specification in turn is based on findings in the literature outgoing from the problem description. But is the problem description valid? This question is also a fundament to the doctoral work and needs to be answered.

Are the objective and the research questions fulfilled? A model has been suggested based on state-of-the-art knowledge. The research questions have, though they only functioned as guidelines, all been considered and to some depth, been answered.

How effective is the DCT-model? The analysis in Chapter 3 implies that not all methods to transfer knowledge are efficient. Networks, e-learning, the IVF model, publication and courses are more effective than others. If the same analysis is used when assign the DCT-model it ought to have amongst the highest ranking.

7.3 Future research

This thesis is halfway to the doctoral thesis and its objective has been to suggest a model for knowledge transfer to SMEs. At the same time the work itself has been a collection of current knowledge. It has also been an opportunity to share the thoughts and findings with other researchers, stakeholders and interested parties. Some reflections on this work will not be available until it is assessed during the licentiate presentation act.
The objectives of this thesis have been to learn, reflect around knowledge transfer to SMEs and suggest a model. There are many steps left before the model is both valid and verified (if now the model is a solution to the problem). Following activities are planned in the doctoral work:

- The background and problem description must be verified and validated. One way to do this is to perform a workshop with a number of persons within the innovation system. Hence, is the problem description in this thesis valid?

- Once the problem description is verified the model probably needs to be further developed. Does the DCT-model need to be further developed regarding eventual changes in the problem description?

- One new problem will occur when the model has to be tested: What type of method shall be used in order to verify the DCT-model? This will be one of the major research questions in the doctoral work.

- The next research questions will be: How does the DCT-model work? And: How effective is it?

- An optional research question will be: How shall the DCT-model be implemented in knowledge developers’ organisations?

Other possible research questions that can be drawn from this work are:

- This thesis only considers knowledge transfer from knowledge developers to SMEs. But if the process is considered the other way it leaves the question: How could the actual need of methods be detected in a secure and effective way?

- Is the “Learning paradox” really a paradox or is it only an indication of the “Swedish paradox”?

- One hypothesis to be examined is: To establish effective knowledge transfer three prerequisites need to be fulfilled: A true enthusiast sender, a true enthusiast receiver and a well-designed model. If this thesis is correct: How do you find the true enthusiasts?
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Appendix 1 – Preparation and evaluation of instruction material

Job performance aids

**Procedural guide** which present task steps with or without illustrations and precautionary information. The task steps are performed in sequential order.

**Worksheet** which present short, simple directions along with blank space, on a line or in a box, where responses are entered. Items appear in a functional order.

**Checklist** where list questions, actions, etc. to consider or perform when planning, observing, comparing, inspecting, etc. Items appear in a logical progression and generally include a line or box to be checked.

**Decision table** where lists in table form all the conditions and possible decision or actions resulting from those conditions. Used when a problem includes multiple conditions that influence the proper decision.

**Flowchart** which graphically presents a series of ordered action steps and questions with “yes” or “no” answers. Movement through the flowchart is self-explanatory. Users follow the answer path to actions steps until the end point is reached.

Instruction sheets

The term instruction sheet refers to several types of related sheets that are provided to trainees as an aid to the teaching/learning process. There are some different types:

**Information sheet** which purpose is to provide a clear, understandable explanation of facts and/or data on a particular topic.

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29 This section is a summery of Campbell (1999) - “Instruction materials: Their preparation and evaluation”
Assignment sheet direct trainees to read and study material before or just after the instructor presents it; answer questions in a book or put to use information presented by the instructor; review and follow rules; practice the application of principles, as well as skills; collect data and record information; and/or analyze and solve problems.

Procedure sheets purpose is to guide trainees in their initial performance and later practice of manipulative (hand-on) activities in classrooms, workshops, laboratories, and other training settings.

Modules

Modules are carefully structured documents, in printed form, through which instructional content is provided to individual trainees. They have been variously called training, learning, or instructional packages, guides, or modules. Modules deliver clear and concise instruction on one or more learning objectives. They facilitate self-directed learning and self-pacing and are used mainly for individualized instruction.

Confirming the effectiveness and value of instructional materials

Instructional materials need to be confirmed due to its effectiveness and value. A procedure for this process has been developed and is presented in five steps:

1. **Self-review** due to content coverage, technical accuracy, legibility, grammar and so fourth.
2. **Expert-review** due to technical, editorial and judgmental matters.
3. **Individual tryouts** where correct and incorrect performance and difficulties concerning the materials is recorded.
4. **Small-group tryout** where notations are made where the group have difficulty or questions.
5. **Operational tryout** where further feed-back is collected from a representative population.
Appendix 2 - The TIME assessment survey

In this study the TIME project has been assessed regarding how different factors affect the outcome from a research project through a survey.

Background

Industrial competitive manufacturing knowledge is created and transferred to SMEs in Sweden by, among others, research institutes and universities in cooperation with the industry. Industrial research institutes state that their mission is to convert results from research and development into industrial profit. This is done primarily by transferring the results on an ongoing basis to existing Swedish companies through e.g. publications, education, training and consultancy, but also in some cases through spin-off companies. The universities have other driving forces than the institutes such as possibilities to conduct research training and to give opportunities for academic publication. The industrial partners are often interested in solving current problem for the benefit of their own company.

This survey has assessed the TIME project, financed by Vinnova30 in the research program “IT-verkstad”31. The TIME project objective was to create an “aid for improvement” and a “tool kit” in the field Shop floor disturbance management. The main result was a handbook (IVF, 2004). The handbook was not fully verified within the project, which was a minor drawback, and not quite ready for knowledge transfer activities. The project had a project group of eight people from one research institute and two different universities, a company group of three different companies and a steering group with members from the three groups. The project was carried out during a three years period.

30 Swedish Agency for Innovation System
31 Free translation from Swedish: Shop floor information technology
Objective

This survey focuses on what factors that affect the results in a multi
stakeholder industrial research project. The objective with the survey was to
investigate how the knowledge creation projects results are affected by the
attitudes and approaches by the different parties in an industrial research
project. The research questions that were to be answered by the survey were:

- How did the different project participants think when designing the
  handbook?
- Is it a difference between the different groups of stakeholder?
- How does the project set-up affect the results?
- Has there been any critical incident that has affected the outcome from
  the project?

Method description

Choice of population for the survey

A stakeholder analysis was carried out and there was an estimation made of
how much influence over the result the different stakeholder might have had.
The following stakeholders were identified:

- The project leader, much influence.
- The project group (both academia and institute), much influence.
- The project steering group, some influence.
- The financer, little influence.
- The industrial partners, little influence.

From this mapping the decision was to interview a number of actors in project;
the project leader, the project group, and one from the project steering group
and the industrial partner combined, a total group of eight persons.

Choice of survey method

Possible survey methods in this case are, according to Westlander (2000), four
principal models:
- Unstructured personal interview.
- Semi-structured personal interview.
- Structured interview.
- Printed questionnaire.

Since the number of interviewees in this survey was only eight persons, the benefits of a questionnaire were limited. The quality of the answers was more important than the quantity. A totally unstructured personal interview would probably give too much side information and a structured interview could have a lot of biases if it is designed poorly. It fell out natural that a semi-structured interview around specific themes would probably be the best in this case.

To choose themes that could answer the research questions a pilot interview was carried out. This procedure is suggested by Bell (1993) and the pilot interview was performed as an unstructured interview with one of the project participants. One theme regarded critical incidents that have affected the result of the project. This theme was inspired by the Critical Incident Technique, Chell (1998) and could also catch interesting issues that the themes do not focus.

**Survey design**

In line with Westlander (2000) the investigation process has been conducted in seven operational steps where the two first ones govern the design of the survey and the latter four steps show how the data is to be processed and used.

- The choice of conversions themes.
- Planning.
- Conducting the interviews.
- Transcription.
- Analysis.
- Verification.
- Writing a report.

The choice of themes and the interview planning were designed as a checklist.
Choice of themes
The themes were selected through the pilot interview. The themes were:

- The project plan.
- The design of the project team.
- The projects working conditions.
- The competence and references when designing the result (a handbook).
- Critical incidents (good, bad or interesting) that have affected the result.
- Degree of satisfaction.

Conducting the interviews
The interviews were conducted partly over telephone but also face-to-face. First a quick introduction was held about the objective with the survey, the themes and a project up-date. Notes were taken during the interview. The main interview strategy was to get the interviewee to be interested and talk freely around the different themes. The interviews varied in time from 30 to 60 minutes.

Transcript and verification
After transcription of the notes the files were structured and organised as statements and sent to the interviewees for verification. The interviewees were asked to assess if the transcript did correspond with the interviewees picture of what was said? If not the files were altered.

Analysis
The statements were first structured in the different themes and coded with role, seniority and organisation. It was then analysed according to:

- Concordance?
- Differences?
- Same type of statements within the different subgroups?
Results

The transcript of the material contains approximately 150 statements within ten themes or sub-themes. Some of the statements were:

- The design of the project has great importance for the outcome of the project. The interviewees did not agree whether more target control would have given a better result. The academic sub-group is in favour of more “loose” steering, but almost all agreed that there has to be balance between “academic freedom” and target steering.

- It was clear that when the project was planned the budget was not decided. Later on when the budget was decided (less funds than expected) the project was not thoroughly re-planned due to the new circumstances.

- The survey revealed that the group was well designed regarding number of persons (eight) and the width in competence areas. Less successful was the geographical spreading of the group that led to some lonely-workers.

- The project group questioned the relevance the steering group of the project because it did not deliver much input or directions.

- The group had little formal management. Some of the interviewees believe that the project result would have gained on a more hierarchical organisation or at least appointed sub-project leaders.

- The most expressed critical incident in the survey was the decision to make a handbook. It gave the participants a clear goal. Half of the group had designed handbooks or similar earlier but only one had more extensive knowledge about handbook design.

- Most of the project members were satisfied with the handbook prototype that was developed and they all agreed that it was a pity that it was not fully verified within the project.
Conclusions

The survey reveals that it is not easy to carry out a multi stakeholder research project were the different stakeholders have different views. Some conclusions are:

- Important when designing knowledge is in which form it should have, in this case a handbook, and when it is decided in the project. The earlier decision the more limited outcome.

- It is also clear that the project team assembly matters regarding the lead-time in the project. A more mature group could develop a handbook quicker.

- A third bullet is that searching for knowledge does not have to be a substitute for planning. The two can co-exist. It is a matter of finding the right balance.

There were also some new questions that could be raised. They all consider the innovations system that has been the context of this study:

- Should the resources determine the result or should the need determine the resources? Of course the resources are limited in the innovation system but how do we know if it is worth it?

- Since this survey reveals that the maturity of the project group is a factor to consider, who wants to pay for the group development? And if you always use the same groups, is it not a risk that the group might be shielded from other influences?

In this case the industrial parties had little influence of the design of the end product – the handbook. The knowledge that is being developed must be needed of the end-users to have a real impact in the industry. How do we, in the best way and within the innovation system, balance actual today’s needs in the industry with the academic driving force to search for the unknown?
Appendix 3 - DFA2 development – a qualitative assessment

This study has had the focus of assessing a R&D project, that resulted in an engineering tool – DFA2, in order to determine how the perceived need was connected to the actual dissemination and knowledge transfer. The following is a short version of the survey. A full version is found in the appendix.

Background

DFA2 is a technical design evaluation tool that has been developed in integration between IVF32 and WoxénCentrum33 at KTH34. The work resulted in a doctoral thesis, research reports and a software embryo. Some four years after the DFA2 release the method does not have that many users. Why? It is necessary to evaluate the knowledge creation and transfer process and how they correspond. This study assess the DFA2-project to gain understanding about what factors that enable and which are being obstacles in these processes.

Objective

This project assessment had the ambition to investigate which factors that affect the knowledge creation and transfer process from academia and research institutes to industry. Enablers and obstacles were sought together with transferable conclusions and advices.

32 IVF Industrial Research and Development Corporation

33 WoxénCentrum conducts research and development within the field customer driven high performance production systems in cooperation between industry and university. (See also: www.woxencentrum.nu.)

34 The Royal Institute of Technology in Stockholm
Method

The method used for collecting data and information was a combined literature review and interview survey. The literature review contained mainly papers and reports concerning the DFA2 development process. The interviews were held with key persons connected with the DFA2 development. The interviews were performed as unstructured interviews (See Westlander (2000) for example).

Description of the DFA2 development process

Project background

The fundament of the project design and its objective is the answer to the question: What is the problem? In the problem description subjects like harder competition, needs for shorter product development lead times and issues concerning automatic assembly are presented. Another problem is brought up as well: “Why is not DFA used more?” A literature review was made in the project and on the question: “What is missing?” Eskilander (2001) states: “…there is a need for a method that uses qualitative evaluation in combination with design rules that are general for any automatic assembly process.” which leads to the research question: “How can a method for use in early product development, that focuses design for automatic assembly and includes both product evaluation and cost estimation, be structured and what information should it contain?” The objective with the work that resulted in licentiate and doctoral. thesis’ was to develop a method – a Design Method for Automatic Assembly. Its origin was further development of a method developed earlier, “The Flowchart Method”, which is described in Byron Carlsson et al. (1998).

Project design

The development of the tool was carried out together with 18 industrial partners. Eskilander was the researcher and used the WoxénCentrum industry group as reference group and verification. The need from the industry was described in the pre-study and was presented as nine suggested requirements of a tool:

- Support cross-functional teams.
- Transfer of knowledge.
- Cost analysis.
• Quality assurance.
• Geometric product evaluation.
• Design suggestions.
• Software.
• Prohibit unnecessary variants.
• User friendly.

The DFA2 tool was developed in cooperation with the reference group of 18 companies.

**DFA2 tool development**

The tool was during the project developed regarding its functional design, the fundamental logic. The results were presented in several publications (Eskilander, 2000 and 2001) and on conferences (e.g. CIRP 2002). Shortly after his disputation Eskilander ended his employment at IVF and started to work for Ericsson. DFA2 was not quite finished due to the software requirement but a software embryo was developed. Contacts with DELFOI were taken regarding software developing.

**DFA2 today**

What has become of DFA2 and how is it used? It is not a common tool in the industry today but the tool is still alive though. Different trails have been developed. There are some users in the original project group and Eskilander has further developed the DFA2 product in his work at Ericsson. When Eskilander left IVF the DFA2 product management was transferred to a consultant colleague (who is now working as a self employed consultant with product development and still uses DFA2) and together with the author the DFA2-method was assessed together with its users and further developed. This work is published as an IVF-report (Rapp and von Axelson, 2003). Connected with this work a newspaper article (von Axelson and Rapp, 2003) was written with the message in short: DFA gives great potential to your products. The article did not lead to any contacts at all. Little effort in further marketing was made. Some colleagues at KTH was trained in DFA2 and now it is used it in the education in the Master of Science program at KTH.

Regarding the software development first DELFOI was meant to be the developing partner of a DFA2 software tool but discussions about immaterial rights delayed and obstructed the process. A first edition was available for
customers anyway. The vendor, who was a true enthusiast, left DELFOI and today they do not have the intention to develop it further because of lack of industry interest and/or marketing. Another software company, SOLME\textsuperscript{35}, has developed a DFA2-module connected to their software platform. The DFA2-module is further developed due to user friendliness and functionality and will be released to the market around the turn of the year 2004/2005. They have pre-presented DFA2 but have only had a handful of contacts so far.

**Discussion**

One of the problems in the DFA area was that DFA is not used a lot. Even today DFA2 has few users. The goal was to create a DFA-tool, not to improve companies’ processes with a tool as means. The decision to create this tool had its origin in the answer to the research question: “what is missing?”. In an interview Eskilander explains that one of the main reasons that DFA is not used was that the present methods like Boothroyd and Dewhurst’s DFMA and the SONY method DAC were either poorly developed due to user support according to user criteria (see Eskilander, 1999 pp.68) or too specific. To develop a new tool that responded to the user criteria would probably solve the problem.

The tool was not finished as it was planned with a software application. When the DFA2 development project was finished the method was designed and tested with good results but it was not designed as software. Eskilander (2001) states: “If DFA2 is available as commercial software it is likely that even more companies will try the method and hopefully start applying it. The interest from companies for consultancy within DFAA has proven to be huge. … … If product designers and system designer can use DFA2 to eliminate misunderstandings, shorten development times and lower costs, then this thesis is very valuable. One goal as a researcher is to find something that may increase the competitiveness of industry.” Another interviewee has a different view of software support and states that for the support in the product development process software is not needed. One good thing with software is that it helps marketing and sales of the method. It gets a higher price and something that costs also gets a value. Free knowledge tends to be rejected. The relevance of a DFA method for automatic assembly is questioned because the fact that only the product is in focus in the assembly system product interface. The assembly system could also be improved. DFA for manual

\textsuperscript{35} See Internet: ‘www.solme.se’
assembly on the other hand is focused on the product and a standard machine—humans. It is said that a DFA method that focuses automatic assembly also could be used for manual assembly but not the other way around which points out that DFA2 could be used for manual assembly as well.

Several of the key persons in the transfer process changed their employment during the dissemination phase in the project that made it slow down. Maybe the project group was too small with too few people involved that it became too fragile.

The relevance and need for another DFA method could be questioned. There is no obvious demand for DFA-methods from Swedish industry today despite that result of using DFA methods show that the companies can benefit from them. There could be a so-called “learning paradox”, that you could not demand knowledge you do not know exist. Many companies know about DFA but maybe not its potentials. But there was an academic need. There were no qualitative DFA methods for automatic assembly. The companies that participated in the project were very interested in the new tool. Maybe there is only a lack of knowledge by the Swedish industry or is it a true lack of need?

**Conclusions**

It seems that in order to be successful with knowledge creation and transfer, three parameters need to be fulfilled:

- A true industrial need
- A well designed product (method)
- A well planned dissemination and transfer plan

In the DFA2 case the product was well designed, but the need was questionable and the dissemination and transfer plan was fragile due to a too small critical mass. Other conclusions and advice that could be drawn from this project are:

- There is a need for a clear problem description and a clearly expressed need from the industry.
- It is important to view the problem or opportunity as both an industrial and an academic problem.