Product Innovation Knowledge Transfer for Developing Countries

Towards a Systematic Transfer Approach

Jan Carel Diehl

Product Innovation Knowledge for Developing Economies

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Johan Carel DIEHL

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Preface

Directly after my graduation as an Industrial Design Engineer at Delft University of Technology it was expected that I would focus the next years in supporting Small- and Medium-Sized Enterprises (SMEs) in the Netherlands in becoming more sustainable and competitive. For this purpose, together with friends we founded the 'Tria Center for Sustainable Entrepreneurship'. By accident there was an 'in between opportunity' to do an internship in New York at an NGO called East Meets West, which looked after the exchange of knowledge and skills between the 'Western' and 'Eastern' world. The focus of the project was on how to create sustainable and competitive advantage by applying product innovation methods for locally produced natural materials such as jute and coir fibres. And here the journey started… After New York, India was the first next destination outside Europe to work with local entrepreneurs on a fusion of Western and Eastern product innovation approaches. Since then I had the chance to visit 60 other countries, which extended the East-West learning with North-South learning. Each new place introduced me to new secrets about how to do business, new ways of working, new habits, new cultural embedded design aspects, and above all how to develop collaboratively local sustainable and competitive products. Consequently my career, life, interest and research moved from SMEs in the Netherlands to developing and emerging economies, and I found myself back to where I started my journey, at Delft University of Technology.

The section MPO (Milieugerichte Product Ontwikkeling, English translation: Environmental Product Development), which became later the Design for Sustainability (DfS) research program at the Faculty of Industrial Design Engineering offered me and my colleagues a unique playing ground to explore and research product innovation for and in developing countries. Product innovation projects were initiated all over the world and international students and researchers were encouraged to come over to Delft to share their experiences. After several years of running around the world providing workshops, train-the-facilitator sessions, guiding in-house company demonstration projects and other knowledge transfer activities the opportunity arose to do a PhD research on this topic. And this time not running, but sitting behind my desk and analyzing and reflecting on how the transfer of product innovation to developing countries takes place and how it can be improved. Excited with this challenge I thought it would just take a few summers and winters to do so. In practice it took some more time… But here it is!

Even though this dissertation mentions my name on the cover, it has been a work of hundreds of others as well. First of all I would like to thank the local partners in the case studies. It was great pleasure to work with Dr. Elias, Dr. Majaja and Prof. Moshoro from the University of Dar es Salaam in Tanzania. Together we explored the need for product innovation knowledge in Tanzania and how the knowledge transfer could be adjusted to the local characteristics and needs. Especially the development and implementation of new problem-based product innovation courses was impressive. In Delhi, India, it was an enormous pleasure to work with Soumitri and his team. Together we explored bottom up approaches as well as teaming up with multinationals. We have been active in the field during days and reflecting in the evenings on the role of

innovation and sustainability in India as well as the rest of the world. Last but not least Central America. The Cegesti crew always could find the perfect balance between work and practice - make things happening in industry in combination with enjoying nature, food and music. Within all these projects a crucial element in the knowledge transfer and research activities has been the input of Dutch and local students!

During this research journey some people stayed on board from the beginning until the end. First of all I would like to thank Marcel Crul. Together we worked in Central America and afterwards in several other international product innovation knowledge transfer projects. Collaboratively we edited the UNEP Design for Sustainability for Developing Economies Manual, one of the main outcomes of this thesis. It was, and is, great pleasure to work with you in a pragmatic way in combination with fun and reflection. Most grateful I am to my two promoters who did have the patience and knowledgeable input to make this PhD research happen: Han Brezet and Henri Christiaans. Every Tuesday Henri was available to discuss research approaches, to go through in between results, challenge and provoke my research work, and to reflect on our collaborative work in Tanzania and Croatia. Thanks to your support I could make the needed breakthroughs in the research approach, as well as find the balance between practice and theory. Your weekly, daily and sometimes weekend support is highly appreciated! Finally I owe a great deal of thanks to Han. From the beginning on you have opened the pathways for me to explore the world and especially the role of (sustainable) product innovation in developing and emerging economies. What I have learned from you is countless! Explore the world, be open minded, be creative, follow your intuition, act and reflect in parallel, encourage and inspire others, be professional, but show as well your emotions, and above all: make things happen! And luckily you allowed me to do the same with my PhD study. And yes a lot of things happened during this PhD study!

This PhD study took place at the Faculty of Industrial Design Engineering. The multidisciplinary thinking and acting of our Faculty supported me a lot in doing my research. Especially the section Design for Sustainability (DfS) provided to be a creative, flexible, convenient, reflective and social working space to execute this research. Former and current DfS Crew: thanks a million!

Finally, family and friends: Pety and Carel (my parents) and Annemiek (my sister), thanks for your support in my choices of life and listening to my sometimes confused and chaotic talks about my PhD research. You were there all the time! Jaarclub Glasnost (1987) and Biljart Club Maurits Toverballetjes (1984): None of you intended to do a PhD… so I 'had' to do it. It was a pleasure! Thanks for all the relaxing times in between.

Duygu, thanks for your endless love and care and trust and support in my PhD research and life. I know I was sometimes disconnected of the world and you. But now it is time for the next steps and projects in our collaborative journey! And much more…!

Rotterdam, November 2010

Summary

There are different strategies towards economical development for developing countries. One of them is to increase the local capacity and implementation of product innovation. According to the World Bank, OECD, and other financial and research institutions, the transfer of product innovation knowledge to developing countries is expected to be one of the key drivers for competitiveness and economical growth, and part of the solution to environmental and social challenges. However, at the moment, the majority of this knowledge is generated in developed countries. Because of the local deficiency in the coming decade in regional knowledge on product innovation, companies and universities in these countries have to (partly) rely on the acquisition of knowledge from outside sources until sufficient local capacity has been built up. The current transfer of product innovation knowledge is considerably finance and staff intensive and its content and transfer mechanisms do not always fit the needs and characteristics of the knowledge recipients in developing countries. Subsequently, in order to answer this increased need for knowledge on product innovation in developing countries, more efficient and appropriate knowledge transfer methods will be needed. Although interest in the transfer of product innovation knowledge to firms and universities in developing countries is increasing significantly, there is a general lack of systematic interest of knowledge institutions and international organisations in how the current transfer takes place and how it can be improved. The present study focuses on this underexplored research area.

The objective of this study was, therefore, to improve the transfer of product innovation knowledge to developing countries, in particular to companies at the SME level and local knowledge institutions such as universities. The main research questions were:

Research question 1: How does product innovation knowledge transfer to knowledge recipients in developing countries currently take place in terms of content (What) as well as didactic principles/transfer mechanisms (How)?

Research question 2: How can the product innovation knowledge transfer to knowledge recipients in developing countries be improved?

At the start of the study it was expected that a systematic approach could facilitate the decision making process for the selection of the proper knowledge content (What) and the knowledge transfer mechanisms (How). In answering the two research questions, a three-stage design-based research approach was applied: stage 1) preliminary research, stage 2) prototyping and assessment, and stage 3) reflection. Within each stage different research methodologies were employed.

Stage 1: Preliminary research
The first stage of the study was an exploration and description of how the current transfer of product innovation knowledge to developing countries takes place, along with the development of a conceptual framework, a list of focal points and a list of expectancies. This stage began with

a literature review (theory) and was completed with case study research (empirical study). The result was an answer to Research Question 1.

Chapters 2, 3 and 4 present the literature review. Chapter 2 discusses the process of knowledge transfer. Knowledge transfer is a multi-staged process and all stages are essential in order to make the knowledge transfer successful. Different types of knowledge can be distinguished, ranging from tacit (implicit) knowledge to explicit (codified) knowledge. These knowledge components can be transferred to a knowledge recipient (i.e. an individual or organisation) by means of two types of transfer mechanisms: people-based and information-based transfer mechanisms. People-based knowledge transfer mechanisms make use of personal contacts, direct communication and training to transfer knowledge. Information-based knowledge transfer mechanisms employ electronic and written documents, databases, and various artefacts to transfer knowledge. The type of knowledge and type of transfer mechanisms are often interdependent. In this case, the product innovation knowledge transfer is often dominated by tacit knowledge components, which are most optimally transferred by people-based transfer mechanisms (i.e. personal exchange of skills and competences). As a consequence, product innovation knowledge transfer is habitually staff intensive (and as such cost intensive). Two other elements play an essential role in the success of the transfer of product innovation knowledge: absorptive capacity and learning approach. The absorptive capacity of an individual or organisation is an important moderating factor for the effective acquisition and utilisation of new knowledge. This ability affects the degree of innovation as well as the speed and amount of new knowledge, which can be absorbed within a certain period by the knowledge recipient. Learning is the core of the knowledge transfer process. Product innovation education in developed countries is often based on constructivist approaches, which can be characterised by problem-based learning and a focus on the students. Traditionally, schools and universities in developing countries apply the opposite: more teacher oriented educational approaches within a traditional classroom setting (objectivism).

The first part of the literature review resulted in an overview of a substantial amount of factors that can describe and influence the process of knowledge transfer. They can be grouped into six clusters: knowledge, knowledge transfer, knowledge source, knowledge recipient, relation between knowledge source and recipient, and the broader context. The two consequent literature review chapters discuss the factors within these clusters in greater detail.

Chapter 3 reviews the content of the knowledge transfer process: product innovation. Different types and levels of product innovation can be distinguished, varying from incremental to radical. To be successful in either level, different types of thinking, ways of working, and taking risks are required. Consequently, different types of knowledge and tools have to be transferred to the knowledge recipients in order to build up the appropriate competencies and skills. In general, incremental innovation approaches (with less risk) fit better with the characteristics of SMEs in developing countries since fewer skills, competences and resources are needed.

Product innovation itself is closely connected to the profession of industrial design. Industrial design is a generalist discipline in which the industrial designer has to develop basic competences and knowledge regarding a wide range of topics. To support the industrial designer in the product innovation process, many design methodologies and tools have been developed (such as the Delft Product Innovation Model). Within the knowledge domain of industrial design three different types of knowledge can be recognized: domain specific basic and design knowledge, and domain independent process knowledge. In order for the knowledge recipient to be skilled and

competent enough to properly carry out a product innovation process, he or she will need all three types.

Chapter 4, the final part of the literature review, focuses on the characteristics of the knowledge recipient and the context in which he or she operates in developing countries. Numerous factors can be identified that can help to describe the characteristics of the knowledge recipient as well as how they can influence the transfer of product innovation knowledge. In this study they have been split up into three levels: national, organisational, and individual level. At a national level, the national income (GDP) is a quick indicator for other economical, industrial and social indicators. Many factors are correlated to the GDP. For example, in low income countries one can expect that agricultural and food related industries dominate the national income (labour intensive and capital/knowledge extensive), that the staff within companies will have a low educational level (with a low absorptive capacity), and that there will be a relatively large informal sector and low local support by knowledge institutions for product innovation. Next to socio-economical factors, a nation can be characterised by its cultural dimensions. These cultural dimensions can have a direct influence on the teamwork within the knowledge transfer project, as well as on the knowledge transfer within the organisations and the way of teaching the local knowledge recipients. At an organisational level this study focuses on SMEs in developing countries. They are often the backbone of the local economy; however, they face major challenges in strengthening their human and institutional capacities. They frequently lack the in-house knowledge and skills and as such depend on external knowledge support. In addition, they suffer from problems such as the lack of capital, access to markets, finances and qualified staff. As a result they are in a decisive position. SMEs can be grouped according to their technological capability and motivation to change. Accordingly, different types of support can be provided to lift them up to greater economical and sustainable growth. At an individual level the knowledge recipient can be characterized based upon his or her professional background, level of experience and attitude and motivation towards the particular transfer of product innovation knowledge. Subsequently, knowledge recipients have different ways of absorbing new knowledge, other ways of handling product innovation in practice as well as preferences for specific tools and methods.

Together these three literature review studies provide theoretical insight into how the transfer of product innovation knowledge takes place. It is a complex and dynamic system that is influenced by many factors that are often interrelated. In order to reduce the level of complexity and to provide a comprehensive overview, a preliminary conceptual framework that builds upon the literature review is presented in Chapter 5. The goal is to offer a framework for more efficient and appropriate product innovation knowledge transfer. In addition, a list of focal points and expectancies were derived from the literature, which support the conceptual framework in describing the process of product innovation knowledge transfer. It was concluded that the literature review did not result in sufficient insight on how the product innovation knowledge transfer takes place in practice in order to function as a base for the next stage of the research study: the development of a systematic approach to improve the process of product innovation knowledge transfer. One of the arguments was that many interrelated factors simultaneously do have an impact; however most literature describe them in isolation while a comprehensive view of all factors together is needed. Consequently, it was decided that further empirical studies taking the preliminary conceptual framework as a starting point were needed. A case study research would provide the possibility to (partly) evaluate and elaborate this conceptual framework and the identified factors in practice as well as to observe the numerous factors simultaneously within the same situation (multidimensional perspective). Four product innovation knowledge transfer cases were selected, which covered all of the facets of the conceptual

framework, in order to explore and describe how the knowledge transfer takes place in practice. The selected cases were situated in different regions of the world with different levels of economical development (Tanzania, India, Central America and Croatia).

Subsequently, the case studies were set up on the basis of the preliminary conceptual framework and the lists of focal points and expectancies, resulting in four case descriptions (Chapter 6, 7, 8 and 9). The goal was to study similarities and differences regarding transfer mechanisms, effectiveness and appropriateness among the cases, and to elaborate on the draft of the conceptual framework. The case studies describe in detail the common knowledge transfer activities such as workshops, demonstration projects, curriculum development, train-the-facilitator sessions and dissemination activities. In addition they highlight the particular learning experiences within these projects as well as their best practices.

One of the clear outcomes of the case studies was the mismatch that regularly occurs between the knowledge components offered by the knowledge source and knowledge facilitator, and the particular knowledge need of the knowledge recipient. In addition it was frequently observed that during the knowledge transfer projects, an increased (better) insight in and understanding of the knowledge recipient and his or her context was gained, and accordingly the knowledge content and transfer mechanisms were adjusted in order to make a better fit (more tailor made).

Next to the individual case studies, a cross case analysis (Chapter 10) was performed. Similar to the case descriptions, the cross case analysis was carried out in two steps: deductive and inductive reasoning. As expected from the literature review, the transfer of product innovation knowledge turned out to be a dynamic and complex system in practice. The case studies illustrated how the different factors take place simultaneously and how they interact with each other. The majority of the list of focal points demonstrated to be functional in describing the process and the majority of the expectancies were encountered in practice. In addition, the empirical research led to new focal points and expectancies, which not had been identified in the previous literature review. They provide particular insight into how product innovation takes place within SMEs in developing countries (one of the knowledge gaps identified in the literature review). The original Research Question 1 and the outcomes of the literature review emphasised the What (content) and How (way of knowledge transfer) components of the knowledge transfer process. The case studies demonstrated that in practice the knowledge recipient (Who) and the project conditions are highly influential as well. Based upon these findings, a refined conceptual framework was proposed. Together, the conceptual framework and list of focal points and expectancies provided an answer to Research Question 1.

Stage 2: Prototyping and assessments

The second stage of the study was the design, development and assessment of a systematic approach and associated tools that could improve the transfer of knowledge on product innovation to developing countries in practice. This stage provided an answer to Research Question 2.

As a consequence of the complexity and the many (interrelated) factors involved in the knowledge transfer process, knowledge sources and knowledge facilitators have to make many decisions with regard to the selection of the knowledge recipients, knowledge content and transfer mechanisms within a limited time span. Because of this and other reasons, as observed in the case studies, a mismatch between what has been offered and what was needed in practice within a knowledge transfer project can occur. As a result, the efficiency and the appropriateness of the knowledge content of the process decreases. These mismatches can occur for example by

not selecting the proper knowledge recipient (Who), offering knowledge on a too high innovation level (What) or transferring too much knowledge at once to a knowledge recipient with a low absorptive capacity (How). Based upon the insights acquired from the literature review and especially the case study research, it was assumed that to a large extent these mismatches can be prevented by applying a systematic approach for identifying and selecting the proper components. In Chapter 11 a systematic step-by-step approach is presented, building upon the elements of the conceptual framework. The systematic approach has a strong focus on the characteristics of the knowledge recipients (individuals and organisations) and their context because of their crucial impact on the selection of the different elements of the knowledge transfer process.

Next, in order to make this systematic approach operational, two types of tools as an intervention have been proposed: a needs assessment tool and a design manual. Accordingly, three propositions were formulated in order to determine whether the developed systematic approach, needs assessment tool, and design manual prove to be appropriate and efficient in practice. The systematic approach and accompanying tools have been mainly developed upon the outcomes of the first part of the research study (conceptual framework and list of focal points and expectancies) and the best practices from the empirical study.

First the Insight, Understanding and Selection (IUS) tool (a needs assessment tool) was developed in a series of loops of developing, testing and improving. This needs assessment tool guides the user (knowledge source and/or knowledge facilitator) through the process of identifying and selecting the proper knowledge recipient (Who) and the main knowledge content elements (What). In order to make a proper decision and selection of the knowledge recipient, the user first needs to gain proper insight and understanding of the characteristics at a national and regional level. Next, in order to decide upon the proper content, a better understanding of the knowledge recipient at an organisational and individual level is required. Based upon the earlier outcomes of Chapter 4, the IUS tool was developed. Subsequently the IUS tool was tested by practitioners in a real setting of an EU product innovation knowledge transfer. In practice, the use of the IUS tool led to the intended result: it efficiently provides the knowledge source and knowledge facilitator with good insight and understanding of the context in which the knowledge will be applied, and also facilitates the selection of the proper elements. The tool demonstrated to be efficient in use and leading to the selection of the appropriate knowledge recipients and the accompanying knowledge content. In addition, when used in teams it created a shared vision within the knowledge transfer process.

The needs assessment tool represents the first part of the systematic approach. In order to make the second part of the systematic approach operational, it was decided that a design manual would be developed. As observed in the case studies, a design manual demonstrated to have a wide employability within different product innovation knowledge transfer activities. Since the goal of this research is not only to contribute to a theoretical contribution but as well as to test an intervention in practice, a real setting was sought for developing and applying a design manual. The opportunity arose to develop a design manual as a commission of the United Nations Environment Program (UNEP): The Design for Sustainability for Developing Economies (D4S-DE) Manual. The D4S-DE manual embodies in detail the proper knowledge content (What) for a specific target group (SMEs in developing countries) as well as in which way it can be transferred (How). The earlier developed and improved needs assessment tool was incorporated in the design manual. Together, they compile the product innovation knowledge transfer package and encompass all of the earlier insights from the empirical study and the literature review. The D4S-DE manual is characterized by a focus on incremental innovation

(benchmarking and redesign), including modules on the basics of product innovation and other domain specific design knowledge, and a step-by-step checklist type for the approach to fit to the needs of the knowledge recipient. The developed D4S-DE manual was evaluated in two different settings. First, 16 practitioners from developing countries tested the design manual in a workshop setting, applying it in their own local context. The practitioners positively appreciated the main structure, content, and the 'learning by doing' interaction between the manual and worksheets. The manual provided them in a short time with clear insight into the different product innovation approaches while also making clear what and how to apply it in their own context. A few suggestions for improvement were provided and incorporated in the next version of the manual. This version was evaluated on its content and face validity by an academic review board.

Stage 3: Reflection
Chapter 11 concludes with reflections on the three propositions and provides an answer to Research Question 2: a systematic approach, made operational by the combination of a needs assessment tool and a design manual, illustrated that the transfer of product innovation knowledge can be improved (in the sense of efficiency and appropriateness).

The last stage of the study, reflection, is discussed in Chapter 12: a retrospective analysis of the study detailing the main research findings, theoretical contributions, scope, and limitations and recommendations.

This thesis presents a systematic approach to improving the transfer of product innovation knowledge to developing countries. By following such an approach, the proper knowledge recipient and the accompanying knowledge content and knowledge transfer mechanisms can be identified and selected, leading to a more efficient and proper product innovation knowledge transfer process. Hence, more knowledge recipients (i.e. SMEs and universities) can be supported, as well as provided with product innovation knowledge that fits their needs and characteristics. The results are an illustration of how a systematic approach and accompanying tools can improve the transfer of product innovation knowledge to developing countries. The conclusions and results are indicative and restricted to the field of design for sustainability. More research and testing is needed in order to implement the developed systematic approach on a large scale in developing countries.

List of frequently used abbreviations

CA	Central America
CR	Croatia
D4S	Design for Sustainability
DUT	Delft University of Technology
EU	European Union
GDP	Gross Domestic Product
IDE	Industrial Design Engineering
IIT	Indian Institute of Technology
IN	India
IUS	Insight, Understanding & Selection Tool
MNC	Multinational Corporation
NCPC	National Cleaner Production Center
NGO	Non-Governmental Organisation
RQ	Research Question
SME	Small- and Medium-sized Enterprises
TtF	Train-the-Facilitator
TZ	Tanzania
UDSM	University of Dar es Salaam
UNEP	United Nations Environment Program
UNIDO	United Nations Industry and Development Program


Blue
Diamond

1 Introduction

In this chapter the setting of this PhD research is described. After a short introduction on the background of this research (1.1) and several essential definitions (1.2), the problem context (1.3) that has led to this dissertation is explored. Why is the transfer of product innovation to developing countries of importance, what makes it so special, and why should it deserve special attention? Based upon this discussion the research objective and research questions will be formulated in section 1.4.

1.1 Background

Since the 90's the Faculty of Industrial Design Engineering (IDE) of the Delft University of Technology (DUT) in the Netherlands has been intensively involved in product innovation knowledge transfer projects in and to developing countries. The main goal of these projects is to support the capacity building in the field of (sustainable) product innovation within the local industries as well as in local higher education institutions. Examples of such kinds of projects are the Environmental Product Development project in Central America (1998-2002), the Indian European Ecodesign Program (1999-2002), the Industrial Design Engineering in Tanzania (2000-2004) project and the Product Innovation in Croatia (2004-2005) project.

During the last decade, the interest in and attention to the role of knowledge on product innovation in developing countries has remarkably increased. As a consequence, DUT-IDE is increasingly being approached to provide support to these kinds of international product innovation knowledge transfer projects, such as the EU-CP4BP project (2007-2009) in Vietnam, Cambodia and Lao PDR, the EU-UNCHAIN project in the Middle East and North Africa (2009-2012) and the SPIN project in South East Asia (2010-2013).

From this perspective a growing interest exists at knowledge institutions (i.e. Delft University of Technology) and relevant international organisations such as the United Nations Environment Program (UNEP) and the United Nations Industry Development Organisation (UNIDO) to get a better understanding of the transfer process of product innovation knowledge in and to developing countries and how it can be improved. Improved in the sense that the knowledge transfer will become more effective (transferring and embedding the proper knowledge) as well as more efficient (less financial and staff resources intensive). This has been the starting point for this PhD research.

1.2 Definitions

The main topics of this thesis are explored and defined in the literature review found in Chapters 2, 3 and 4. The essential definitions as an outcome of this literature review are:

Knowledge: Knowledge is the ability to connect external information with already acquired information, and experience, skills and attitudes leading to new action or understanding (Weggeman 2000).

Knowledge transfer: The act of transferring knowledge from one individual or organization to another by means of mentoring, training, documentation, and other collaboration. As a result knowledge created within one context is re-created and utilized effectively in another context. Knowledge transfer is a multi-stage process and can be split up into four sequential stages: initialization, inter-relation, implementation, and internalization (Inkpen and Dinur 1998; Szulanski 1999; Haghirian 2003; Abou-Zeid 2005).

Product innovation: The development and successful introduction into the market of new products that have characteristics that differ from existing products in the market. In this thesis the word 'product innovation' covers product as well as market innovation (Smulders, Kiers et al. 1998; Cummings 2003; Olofsson 2003).

Developing countries: All countries that are not labeled as developed countries. The United Nations Statistics Division considers Japan, Canada, USA, Australia, New Zealand and Europe as being developed economies. Developing countries in this definition include 'emerging countries', 'newly industrialising countries' and 'countries in transition' (UN 2009).

Sustainable development: A socio-economical development which meets the needs of a current generation without compromising the ability of future generations to meet their needs (Brundtland 1987).

Design for sustainability: A product innovation strategy which takes environmental and social concerns as a key element by incorporating environmental and social factors into product development throughout the lifecycle of the product, throughout the supply chain, and with respect their socio-economic surroundings (from the local community for a small company, to the global market for a trans national company) (Diehl and Brezet 2004; Crul and Diehl 2006).

1.3 Problem context

Before discussing the research objective of this thesis in more detail, some underlying questions will be discussed. The context in which the transfer of product innovation knowledge towards developing countries takes place will be critically explored. Why is knowledge, especially in the field of product innovation, of increasing importance for developing countries? What makes product innovation knowledge transfer to developing countries different from developed countries, and why should it deserve special attention?

1.3.1 The importance of knowledge

During last decade an increased interest can be observed in the contribution of knowledge in general to sustainable economic development (Chen and Dahlman 2004). Knowledge, and its application, is now acknowledged as one of the key sources of growth in the global economy. According to the World Bank Institute (WBI 2004), we are in the midst of a 'knowledge revolution'. This knowledge revolution can be distinguished by:

I. Faster creation and dissemination of knowledge
II. Increasingly competitive global environment
III. Increased importance of knowledge and innovations for economic performance and improvement in welfare
IV. Increased importance of education and updating skills to keep up with and make effective use of knowledge.

In addition, knowledge is becoming obsolete at a much faster rate than before. Weggeman (2000) refers to a 'half-life' time of knowledge. Only a part of the earlier acquired knowledge by

a person is still relevant after a certain period. The time that a specific type of knowledge is relevant depends on its kind and application. Like the lifecycle of a product, the life cycle of knowledge for example in the field of high-tech and innovative technologies, is becoming shorter and shorter. This situation in which on one hand the creation and dissemination of knowledge increases rapidly and on the other hand the time during which knowledge is relevant decreases, implies that in order to function well, knowledge workers (i.e. industrial designers, engineers, and business consultants) will have to learn and obtain new knowledge continuously (life-long learning) (Weggeman 2000). As such, knowledge workers have to be equipped with skills to identify, gather, absorb, adapt and apply knowledge from a wide range of disciplines which they need to apply in an efficient and effective manner. Consequently, specific educational models such as constructivism and problem-based learning will generate increasing worldwide interest as a result of their capacity to develop these skills, thus replacing traditional teaching methods.

1.3.2 Why transfer 'product innovation' knowledge to developing countries?

In its recent report "Less pretension, more ambition" (WWR 2010) the Dutch Scientific Council for Government Policy (WRR) suggests that offering care to people in developing countries may be noble, but does not in itself lead to self-sufficient countries or improve the prospects for future generations. Creating opportunities for development and economic growth should be the main objective of international aid. Improving living circumstances often leads to short term improvements. Knowledge, however, is expected to be the one of the key drivers of economical development, income and job generation and as a result, self sufficiency (Lieshout 2010; WWR 2010). Within this context, knowledge on product innovation is expected to play an important role in this development since it contributes to economical as well as social development. Many politicians, economic actors, and economists consider innovation as the key to achieving competitiveness in today's globalized world (Voeten, Haan et al. 2009). Knowledge on product innovation can be generated within an organisation or alternatively transferred from outside. According to the World Bank, the OECD and other economical research institutions, the transfer of product innovation knowledge is a key driver for competitiveness and economic growth (EU 2009). Several research reports indicate that companies in Europe with product innovation knowledge and competencies grow faster and contribute more to the national growth rate than others (OECD 2004; Lentz and Mortensen 2005; Lederman 2007; EU 2009). Product innovation knowledge is not only regarded as one of the most important resources in the process of economic development in developed countries but increasingly also in developing countries. In current debates about globalization and competitiveness, innovation is often represented as providing opportunities and conditions for developing countries to participate in the world economy (Voeten, Haan et al. 2009). More and more attention is being paid to the promotion of (product) innovation in developing countries (Aubert 2004).

Next to economic growth and increased competitiveness, 'sustainable development' is one of the main issues on the international agenda. For instance, the Commission on Sustainable Development of the Dutch Social-Economic Council (SER) considers today's financial and economic crisis a strong indicator of the need for a structural change in the world's economic system (SER 2010). The council claims that there is a need for a drastic transition towards a more sustainable society in which economic growth fits within the limits of sustainable development. This society should be achieved by focussing on the quality of growth and its contribution to the wellbeing of mankind and the earth in the long run. From an ecological perspective, this includes a reduction of pollution and of the loss of biodiversity, a significantly higher efficiency of energy and material systems and improved re-use of waste. Production and consumption patterns should fit within the limits of sustainable development (SER 2010).

In the perspective of sustainable development, developing countries are often in a situation in which they do not only strive for economical growth and environmental protection but also for social development. In this context, knowledge transfer, technology cooperation and especially product innovation have been recognized as a part of the solution to environmental and social growth challenges (EU 2009). According to the World Business Council for Sustainable Development (WBCSD) and the United Nations Industry Development Organization (UNIDO), the creation of sustainable enterprises in developing countries is a vital instrument for eliminating poverty and ensuring sustainable development (WBSCD and UNDIO 2002). Product innovation, especially 'design for sustainability', is seen as a main tool to develop these capabilities within local firms in order to address local social needs and environmental protection (Clark, Kosoris et al. 2009).

In short, product innovation knowledge can play an essential role in the economical as well as the sustainable development of developing countries. However, at present the majority of (product innovation) knowledge is produced in developed countries. Currently, developing countries contribute to only a small fraction of the world's knowledge. This disparity in the production of (product innovation) knowledge per capita between developed and developing countries is even greater than the disparity in income (Chen and Dahlman 2004). As a result, there is a risk of a growing gap between advanced and developing countries. For the near future, therefore, these countries will have no choice but to acquire most of their product innovation knowledge from outside (Watson 1993) and as a result product innovation knowledge transfer is expected to play a crucial role.

The expectation that product innovation can play a vital role in sustainable economical growth in developing countries in combination with a local deficiency of product innovation knowledge, has resulted in numerous knowledge transfer projects. Many of these projects have been initiated by national and international bodies (i.e. UNEP, UNIDO and the EU), charity foundations and knowledge institutions (i.e. universities and research institutes).

1.3.3 What makes product innovation knowledge transfer to developing countries different?

Expressions such as digital, technological and knowledge divides have become common and seem to imply that there are unutilised opportunities for knowledge transfer between the North and the South (Jensen, Johnson et al. 2004). It is clear that in order to support the growth of their competitiveness, and economical and sustainable development, developing countries should tap into the tremendous knowledge and technology available worldwide by adapting these resources to their needs and capabilities (Aubert 2004). The World Development Report from 1998/99 (World-Bank 1999), which is devoted to the role of knowledge in development, begins with the following promising words:

> "Knowledge is like light. Weightless and intangible, it can easily travel the world, enlightening the lives of people everywhere. Yet billions of people still live in the darkness of poverty – unnecessarily (Johnson and Lundvall 2001)" (Page 1).

Such a picture of many low-hanging fruits ready to be picked in a process of accelerated development can of course be regarded as exaggerated and overoptimistic. More cautious discussions tend to argue that even if such unutilised opportunities exist, there are also other factors limiting their utilization (Jensen, Johnson et al. 2004).

One of the reasons for which the 'low hanging knowledge fruits' are not picked is the limited absorptive capacity within firms and individuals. Cohen and Levinthal (1990) introduced the concept of 'absorptive capacity' to label the ability of a firm or an individual to evaluate, assimilate and use outside knowledge. They suggest that absorptive capacity is an important moderating factor for effective acquisition, utilisation and assimilation of new knowledge. Inadequate infrastructures, institutions and levels of education are often thought to result in a low 'absorptive capacity' in developing countries (Al-Ghailani and Moor 1995). In such situations, information and knowledge will fail to flow from developed to developing economies and catching-up will not occur (Jensen, Johnson et al. 2004).

Another reason is the fact that the developing world represents very diverse situations in terms of levels of development, culture, etc. Consequently, knowledge transfer programmes have to be tailored to countries' specific characteristics in line with the fact that 'one size does not fit all' (Aubert 2004). Similarly, at the micro (or firm) level, it is crucial to take into consideration the traditional values and practices for improving the management of enterprises. According to Aubert, culture specificities do not disappear with globalization, and it is by tapping into their potential, and possibly correcting their weaknesses, that modernization is possible. In addition Srinivasa and Sutz (2008) claim that in order to meet the local needs, innovation should be undertaken as a contextual process taking in consideration the socio-economic condition in which it is embedded.

While there is considerable experience accumulated in the field of (industrial) product innovation in developed countries, much of this is not directly applicable to developing countries because of the circumstances the latter are facing. Innovation climates in developing countries are, by nature, problematic, characterized by unfortunate business and governance conditions, low educational levels, and mediocre infrastructure. This raises a particular challenge for the promotion and implementation of innovation in these contexts (Aubert 2004).

As a consequence, numerous international development aid projects aiming at knowledge transfer have failed because of knowledge asymmetries: a given body of knowledge does not work in the same way in the South as in the North. Johnson and Lundvall (2001) claim that there are many reasons for the frequent failures of knowledge transfer, but very often they have to do with the complexity and context dependency of knowledge. Often the knowledge source in the North lacks insight into and understanding of the characteristics of the knowledge recipient in the South. If the knowledge source, be it a university, consultant or a development organisation, knows details about the context in which the knowledge will function and about the character of the context dependency, it will have better opportunities to support the necessary knowledge transfer (Jensen, Johnson et al. 2004).

Cultural and context differences may be a significant obstacle for knowledge agents to transfer and implement product innovation knowledge in a foreign company or knowledge institution (Polak 2001). Er (1997) examined the obstacles which product innovation consultants from Western offices encounter while consulting companies in developing economies. They identified some common problems on the part of their clients with respect to certain issues e.g. the clients' approaches towards business, product innovation practice and more generally thinking patterns as well as influencing context factors such as the pattern of industrialisation, the nature of domestic demand pattern, nature of education and cultural factors.

1.3.4 Why should product innovation knowledge transfer receive special attention?

As can be concluded from the above paragraphs, the transfer of product innovation knowledge to developing countries is expected to be a key driver for competitiveness and economical growth, and part of the solution to environmental and social challenges. At the moment the majority of the product innovation knowledge is produced in developed countries. Meanwhile, the support of product innovation by local intermediates such as universities is still regularly limited in developing countries. In the coming decade, knowledge recipients in developing countries have to (partly) rely on the acquisition of knowledge from outside until sufficient local product innovation capacity has been built up. The transfer of product innovation knowledge will play a crucial role in this process.

The current transfer of product innovation knowledge is considerably finance and staff intensive (low efficiency). Present product innovation knowledge transfer projects can be characterized by high investments in outside expertise (i.e. external facilitators such as consultants and experts) (Crul 2003). Since the current time and money investments per company are too high for widespread multiplication, only a limited part of the enterprises in developing countries can been reached. In addition, its content and transfer mechanisms do not always fit the needs and characteristics of the knowledge recipients in developing countries. Subsequently, in order to fulfil the increased need for knowledge on product innovation in developing countries, more efficient and appropriate knowledge transfer methods will be needed. It is assumed in this study that the transfer of product innovation knowledge will be more efficient and appropriate if it is tailor made to the specific characteristics and needs of the knowledge recipient.

Although the interest in the transfer of product innovation knowledge to firms and universities in developing countries rapidly increases, there is a general lack of systematic interest of knowledge institutions and international organisations in the matter of how the current product innovation knowledge transfer takes place and how it can be improved. Even though many studies have been directed at improving product innovation knowledge transfer in developed economies, not many studies have considered the specific context of developing countries. The few known studies are focussed on knowledge transfer within Multinational Corporations to developing countries and not to SMEs and other small local organisations. Given the increasing importance of and interest in the role of product innovation in developing countries, it is remarkable that this topic is still underexplored. The limited examples are either focussed on one specific region or sector, or treat the different issues (i.e. absorptive capacity, socio-economic development, innovation level) separately (in isolation). One of the few exceptions is the comprehensive study made by Crul (2003) with regard to the introduction and facilitation of Ecodesign as well as capacity and network building in Central America. One of the conclusions of this study is that design manuals and other product innovation knowledge transfer materials developed in Europe have to be adjusted to the needs and characteristics of local firms in order to be effective. For example, adjustments can be made by focussing the knowledge content on benchmark (copy) and redesign approaches (incremental innovation levels) and by simplifying the tools and methods (preference for checklist type of tools by local SMEs). Consequently, Crul recommends further research on the optimization of the product innovation knowledge content and transfer mechanisms to the characteristics and needs of knowledge recipients in developing countries.

The present study focuses on this underexplored research area. The following paragraphs will introduce the research objective and research questions of this PhD research.

1.4 Research objective and research questions

Companies and universities in developing countries rely largely on the import of product innovation knowledge from abroad. The amount of available product innovation knowledge in developed countries is tremendous. Without a solid understanding of the needs and capabilities of the knowledge recipient (in developing countries) a mismatch with the transferred (offered) knowledge can easily occur. In this way financial and human resources are being wasted at both sides of the knowledge transfer process while the foreseen (proposed) knowledge transfer might not be achieved. Many studies have shown the limited success of knowledge transfer in different areas, including health, agriculture and product innovation. The objective of this research is, therefore, to improve the transfer of product innovation knowledge to developing countries, in particular to companies at the SME level and local knowledge institutions such as universities. This objective is based upon the assumption that current knowledge transfer in the area of product innovation is not optimal as it lacks insight into the factors involved in this process. It is expected that a systematic approach can facilitate the decision making process of the selection of the proper knowledge content (What) and the knowledge transfer mechanisms (How).

The proposed systematic approach will be designed and developed based upon earlier experiences reported in literature (theory) combined with experiences in developing countries of the researcher and his colleagues at Delft University of Technology (practice). The systematic approach will be made operational by developing methods and/or tools that can be used in the daily practice.

The central research questions based upon the above research objective are:

Research Question 1: How does product innovation knowledge transfer to knowledge recipients in developing countries take place, in terms of content (What) as well as didactic principles/transfer mechanisms (How)?

Research Question 2: How can the product innovation knowledge transfer to knowledge recipients in developing countries be improved?

The primary research objective of this project is to improve the product innovation transfer knowledge transfer (RQ 2). In order to do so the researcher first aims to understand and carefully describe the product innovation knowledge transfer process (RQ 1). Thus, Research Question 1 serves the objectives of Research Question 2.

Research methods

The two research questions posed have a different focus and hence require different research methods. While question 1 aims at *exploring* and *describing* current practices of knowledge transfer, Research Question 2 is focused on *developing* knowledge transfer methods and techniques. Exploring current practice can be done by means of literature study, interviewing and questioning experts, and case study research. This part of the research study should lead to a conceptual framework that creates a basis for the development of methods. For the development of transfer methods and techniques, a proper research method has to be identified that can support this 'design and develop' function. This last function requires a design-based approach in which the following elements play a key role (Van den Akker, Gravemeijer et al. 2006):

- *Interventionist:* the research aims at designing an intervention in a real world setting;
- *Iterative:* the research incorporates cycles of analysis, design, development, evaluation, and revision;

- *Involvement of practitioners:* there is active participation of practitioners in the various stages and activities of the research;
- *Process oriented:* the focus is on understanding and improving interventions;
- *Utility oriented:* the merit of the design is measured in part by its practicality for users in real contexts; and
- *Theory oriented:* the design is (at least partly) based on a conceptual framework, whilst the systematic evaluation of consecutive prototypes of the intervention contributes to theory building.

In our view the development of methods and techniques also asks for a systematic approach. By a systematic approach it is intended that methods will be developed, by means of guidelines or didactic tools, that (1) map the relevant factors involved, such as the characteristics of the recipient, the knowledge source and the transfer process; and (2) when applied according to these methods will lead to more efficiency and effectiveness in the transfer process. The systematic approach and the research methods for the design and development of the tools will be introduced and discussed in Chapter 11.

To begin with the exploration part of this research project, the following three chapters report the literature review. The three fundamental elements – knowledge transfer (process), product innovation (content) and the knowledge characteristics of the knowledge recipients in developing countries – will be explored and described. Based upon the outcome of this literature review a conceptual framework will be constructed in Chapter 5 as a starting point for the empirical part of the study.

1.5 Outline of this thesis

The study consists of three parts: preliminary research, prototyping & assessment, and reflection (see Figure 1.1). This chapter has introduced the topic being explored, the problem setting and the research questions. The first part of the study, preliminary research, will commence with a literature review in Chapters 2, 3, and 4. These chapters will explore, describe and discuss the knowledge transfer (process), product innovation (content) and characteristics of the knowledge recipient. Chapter 5 will introduce the conceptual framework and list of expectancies as well as the research method for the next steps of the study. Chapters 6, 7, 8, and 9 describe four cases of product innovation in practice. Conclusions on the four case descriptions are discussed in Chapter 10: cross case analysis. The second part of the study, prototyping and assessment, begins with developing a systematic approach in Chapter 11. In the same chapter, the systematic approach is made operational by designing, developing, testing, and evaluating two tools: a needs assessment tool and a design manual. The study is completed with conclusions, reflection, discussion and recommendations in Chapter 12. For those who are interested in the main findings of this PhD research, it is advised to focus on Chapters 1, 5, 10, 11 and 12.

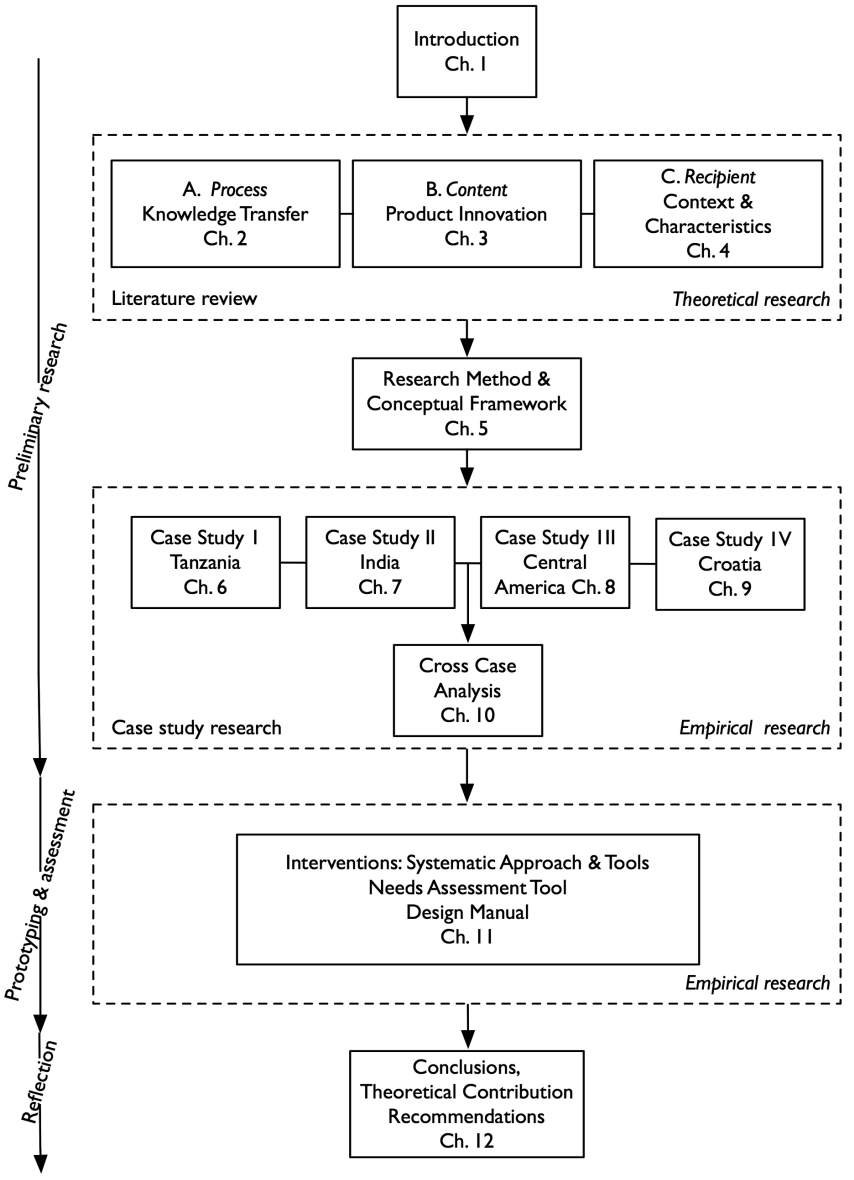

Figure 1.1: Outline of the thesis.

2 *Knowledge transfer*

The previous chapter has laid the foundations for this research. It introduced the problem context, the research objective and the corresponding research. As a first step in this research a literature review regarding three main topics (knowledge transfer, product innovation, and developing countries) will be carried out. This chapter will start with an introduction to the literature review (2.1) followed by an exploration of the first topic: What is knowledge and how does the transfer of it take place (2.2-2.7). At the end of this chapter factors that can affect the content (what) and the way (how) of knowledge transfer will be identified and clustered (2.8).

2.1 Introduction to the literature review

The first stage of this PhD research is a literature review after how product innovation knowledge transfer to knowledge recipients in developing countries takes place (Research Question 1). This will be done by reviewing traditional research literature (i.e. journals, academic books and conference papers) which address similar questions as within this study. The objective is to obtain a rich understanding of how the knowledge transfer takes place as well as to make the first steps towards the development of a first version of the conceptual framework.

The literature review will explore, describe and explain the three main knowledge topics as highlighted in both research questions. The three main relevant topics for this research are (see Figure 2.1):

- The process: knowledge transfer (Chapter 2);
- The content of the knowledge transfer: product innovation (Chapter 3);
- The knowledge recipient: companies and individuals in developing countries (Chapter 4).

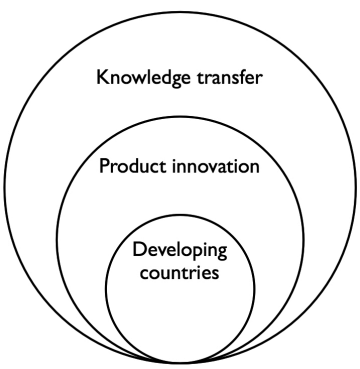

Figure 2.1: The three knowledge topics for the literature review.

By this sequence of topics, the literature review will be narrowed down each chapter. Starting from knowledge transfer in general it will narrow down to knowledge transfer specifically in the

field of product innovation, and next particularly to knowledge recipients in developing countries.

The first topic of the literature review, knowledge transfer, will be reviewed in this Chapter 2 in order to get a good understanding of the process, knowledge transfer, itself. First knowledge will be defined and the different classifications and characteristics of knowledge will be described. Next the process of knowledge transfer will be defined and divided into sub-processes. The distinct knowledge transfer mechanisms (information- and people-based) are explored and their applicability for the different kinds of knowledge will be discussed. Subsequently the two main learning theories, objectivism and constructivism will be characterised and compared. Constructivism and the connected problem-based learning approach will be discussed in more detail because of their relevance for product innovation learning. Next industrial design education approaches will be examined. The chapter will be concluded with a research after factors that can influence the knowledge transfer process.

The second topic of the literature review, product innovation, will discuss the 'knowledge content' that will be transferred. It will start by defining innovation and product innovation, followed by an exploration of the different levels of (product) innovation as well innovation strategies that take place in enterprises and will discuss the distinction between them. Next the discipline Industrial Design and the connected design methodologies and theories will be discussed. In daily practice industrial designers carry out a large part of the product innovation projects within companies. Subsequently the body of knowledge of product innovation will be classified into domain-independent and domain-specific knowledge. At last the concept of Design for Sustainability will be introduced as well as the role of product innovation in developing countries will be dealt with.

The last part of the literature review is dedicated to the knowledge recipient, especially in developing countries. Based upon an extensive literature review a range of factors related to the knowledge recipient that can influence the knowledge transfer process have been identified and clustered in three sub-clusters: factors at 1) national, 2) organisational and 3) individual level. National economical and development indicators will be introduced and their impact on the product innovation knowledge transfer will be discussed. Subsequently, literature related to the national absorptive capacity as well as the potential impact of cultural dimensions on the knowledge transfer will be reviewed. Next, on organisational level, factors such as size and absorptive capacity and other characteristics are being explored. In addition the specific role and characteristics of SMEs and the informal sector in developing economies will be debated. Methods will be collected to provide insight in the need and capabilities for absorbing new product innovation knowledge in these kind of companies. The chapter finishes with describing individual characteristics. Three design profession sub-domains (Industrial Design, Industrial Design Engineering and Design Engineering) will be distinguished. Each sub-domain will be further characterized by their working methods and problem solving approaches. In addition, the characteristics of young (novices) and more experienced professionals (experts) will be compared. An overview of the main topics of the literature review is provided in Figure 2.2.

The literature review will contribute to several stages of this research. At the first place it attempts to provide an answer to the first research question: how does product innovation knowledge transfer to developing countries takes place. In order to do so the several elements of the product innovation knowledge transfer process will be explored and described and a conceptual framework will be constructed to provide a comprehensive overview of the system. This conceptual framework will be presented in Chapter 5. In addition the literature review also

will contribute to the second research question: how to improve the transfer of product innovation to developing countries. In Chapter 5 a list of expectancies will be presented which can support the knowledge source and/or knowledge facilitator in identifying the proper elements of the product innovation knowledge transfer process. This list is derived from the literature review. The content and structure of the systematic approach and accompanying needs assessment tool and design manual as an answer on research question 2 (Chapter 11) are to a certain extent based upon the literature review as well. In the coming three literature review chapters after each section a short reference will be made to its relevance with regard to the above mentioned elements of this research.

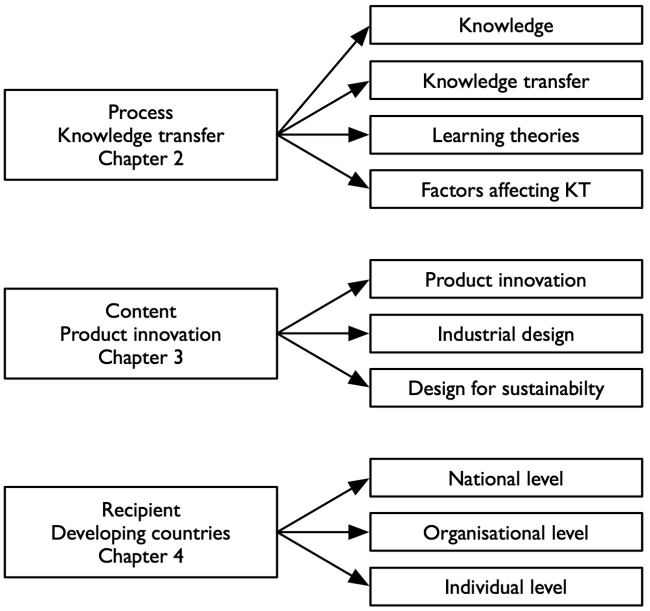

Figure 2.2: Overview of the topics for the literature review.

This chapter will further continue with the first part of the literature review: knowledge transfer. This will help to describe how the process of knowledge transfer takes place in general and is a first step towards the development of the conceptual framework.

2.2 Knowledge

A still increasing interest in knowledge and its transfer and management is stimulated by the possibility of resultant benefits, such as increased creativity and innovation in products and services, improved quality and process management and the development of knowledge workers (Moffet, McAdam et al. 2002). Knowledge is being recognised as a primary resource of organisations (Drucker 1992) and has became one of the most strategically-significant resources of advantage in an increasingly competitive world (Teece 2000; Birkinshaw 2001). The competitive advantage of firms and organizations depends on their ability to create, transfer, utilize and protect knowledge asset (Teece 2000).

Definition of knowledge

Researchers dealing with knowledge and the related terms are facing various definitions about the terms data, information and knowledge and their strong tie. Although these terms are often

interchangeably, we should clearly differentiate between them. Knowledge is broader, deeper, and richer than data or information. Data reflect discrete, objective facts about events in our world, while information is organised around a body of data. Davenport and Prusak (1998) differentiate data, information and knowledge as:

1. Data: a discreet and objective group of facts of a certain event (i.e. temperature of the atmosphere);
2. Information: a message containing an originator and a receiver and whose meaning involves a new interpretation based on a group of data (i.e. due to the temperature and the atmospheric pressure it should rain within one hour);
3. Knowledge: a mixture of experiences, values, contextual information and intuition, forming a framework in a person's mind that enables him/her to evaluate and obtain new experiences and information.

According to Weggeman (2000) knowledge is the capacity to enable a person to do a certain task by selecting, interpreting and valuing available data by which (new) task relevant information can be created. Knowledge is the ability to connect external information with already acquired information, and experience, skills and attitudes leading to new action or understanding. In his opinion knowledge is the result of a learning process and can be seen as a function of (task) related Information, Experience, Skills and Attitude at a given moment of time:

$$K=f(I*ESA)$$

The two components 'I' and 'ESA' can be distinguished but cannot be separated. This emphasises that knowledge is always a combination of the hard and soft factors. The explicit, codified knowledge is captured in 'I' and the tacit knowledge is placed within the 'ESA'. The last knowledge component (ESA) exists of a number of sub-components:

- The in the time constructed collection of personal Experiences;
- The repertoire of Skills one has to his of her disposition; and
- Attitude, a set of (un)conscious basic assumptions on which the personal norms and values are based.

Experiences and skills particularly affect the 'to be capable of', while the attitude especially affects the 'willingness or desire to do'. It is clear from this definition that knowledge is not just data or information but a combination of information, experiences and a context. Since the daily practice of product innovation for a substantial part is based upon a combination of information, experiences, skills and attitude, the definition of knowledge as provided by Weggeman (2000) will be used in this research.

Different kinds of knowledge

It is important to distinguish the different forms of knowledge, since the likelihood of successful knowledge acquisition and knowledge transfer depends on the form of knowledge being transferred (Davenport and Prusak 1998). Knowledge can be classified into various categories. In the literature one can find a multitude of different classifications with regard to knowledge. This paragraph unites the most common approaches. Three of the more frequently used knowledge classifications are discussed shortly:

A. Tacit versus explicit knowledge;
B. Know-what, know-why, know-how, know-who;
C. Procedural versus declarative knowledge.

A. Tacit versus explicit knowledge

The most common used classification for knowledge is explicit versus tacit knowledge (Nonaka and Takeuchi 1995; Weggeman 2000):

- Explicit (or codified) knowledge which can be documented and delivered as 'stand-alone' information or data;
- Tacit (or implicit) knowledge which can be regarded as the sum of individual knowledge and skills related to a person.

As first stated by Polanyi (1958; 1967), individuals know more than they can explain, this is because individuals have knowledge that is non-verbalized, intuitive and unarticulated. Polanyi defined such knowledge as 'tacit'. Tacit knowledge is linked to a person. This knowledge is less quantifiable and cannot be captured, codified and stored so easily. When the person leaves, the knowledge is lost. However, when tacit knowledge has been made explicit, it has become transferable. 'Knowledge explicitness' refers to the extend of which knowledge is verbalized, written, drawn or otherwise articulated.

Nonaka and Takeuchi (1995) asserted that four modes facilitate the conversion between tacit and explicit knowledge (see Figure 2.3). Through these processes existing knowledge can be converted into new knowledge. Tacit knowledge can be transferred through two processes; socialization, which maintains the knowledge in its tacit form, and externalization, through which it is transformed into explicit knowledge. Explicit knowledge can be transferred through two other processes: combination, which retains its explicit nature, and internalization, a process through which explicit knowledge is converted into tacit knowledge (Inkpen and Dinur 1998). This is explained in more detail in textbox 2.1.

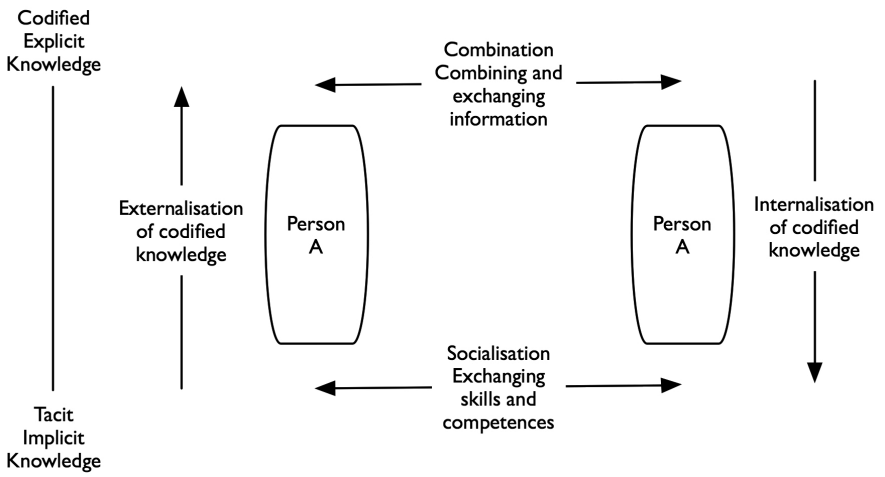

Figure 2.3: Four modes of knowledge conversion between tacit and explicit knowledge (Nonaka and Takeuchi 1995; Weggeman 2000).

Socialization: tacit → tacit knowledge. This is the sharing of tacit knowledge between individuals. In this mode, social processes (e.g. apprenticeship, imitating, developing common understanding) play an important role in the transmission of knowledge.

Externalization: tacit → explicit knowledge. This is the articulation of tacit knowledge and its capture in forms that are easier to understand. Words, images, modelling, reasoning and

reflection are typically used to translate expert knowledge into a mode, which makes it understandable, by others (e.g. classroom teaching, presentations, articles).

Combination: explicit → explicit knowledge. Explicit knowledge can then be combined with other explicit knowledge into more complex knowledge. In this mode, formal processes are used to assemble, validate, standardize, simplify, maintain and automate externalized knowledge and turn into documents, repositories and databases. Combination contributes to knowledge in different workgroups, cross-functionality, and at different levels in an organization (e.g. best practices databases, procedures).

Internalization: explicit → tacit knowledge. Explicit knowledge must then be internalized, or learned, in order to be effectively used to grow new knowledge. In this mode, individuals acquire knowledge by reading, listening or experiencing explicit knowledge in their own context or organisation. They must be able to identify relevant knowledge, acquire it and then turn it into action and practice.

Textbox 2.1: Four modes of knowledge transformation (Nonaka and Takeuchi 1995; Weggeman 2000; Smith and McKeen 2005).

The distinction between explicit and tacit knowledge as well as the four modes of knowledge conversion can help to describe the current knowledge transfer content. In addition to the provide consideration for alternatives. This categorization will be used later on in this thesis in Chapter 10 in the cross case analysis.

B. Know-what to know-who

A second knowledge classification is proposed by Lundvall et al. (1994). They distinguish four categories of knowledge:

- 'Know-what', refers to knowledge about 'facts'. Here, knowledge is explicit and close to what normally is called information;
- 'Know-why', refers to explicit scientific knowledge of principles and laws of motion in nature, in the human mind and in society. But it may also refer to implicit interpretative frameworks based upon experience and intuition;
- 'Know-how', refers to skills – i.e. the capability to do something. Applied to both practical an theoretical skills know-how is close to what is often referred to as 'competence';
- 'Know-who', refers to a mix of different kinds of skills including social skills.

These four types differ in respect of how easily they can be transferred from one application to another and/or from one group or place to another. Learning the four kinds of knowledge takes place in different ways and through different channels. Generally, 'know-what' and to some extent 'know-why' knowledge can be more readily formalised, written down or reproduced as explicit information. As a result they can be obtained through reading books, attending lectures and accessing databases (Jensen, Johnson et al. 2004). By contrast know-how and know-who types of knowledge are more socially embedded (tacit) and rooted in practical experience. They are acquired in social contexts such as the work place, apprenticeship-relations, or in clubs or associations or conferences or in real-life market places (Arnold, Allinson et al. 2005).

C. Procedural versus declarative knowledge

At last, cognitive psychologists generally distinguish procedural knowledge and declarative knowledge. Declarative knowledge deals with the 'knowing what' (facts and information) whereas procedural information deals with the 'knowing how' (know-how and application). Declarative knowledge has much in common with explicit knowledge in that declarative

knowledge consists of descriptions of facts and things or of methods and procedures. Procedural knowledge can be compared with tacit knowledge (Nickols 2003).

Others expand on this by including situational (or conditional/contextual) knowledge and strategic (or meta cognitive) knowledge (Veenselaar and Christiaans ; Geerlings and Veen 1980; Tennyson 1991; Christiaans and Dorst 1992; McGilly 1994; Nickols 2003; Pieters 2004; Breunlin Unknown):

- Declarative knowledge (factual information) 'know-what': is the knowledge of strategy and can be divided into semantic facts and the episodically own experience knowledge;
- Procedural knowledge (how to deal with it) 'know-how': is skills, knowing how to carry out the strategy, the best way to acquire experiences is by frequent exercises and feedback;
- Strategic knowledge (conditions for appliance): meta-cognitive, knowledge of evaluating and assessing of one's own skills, capacity and the complexity of the problem. Also refers to knowledge of processes that are effortful, systematic, and consciously invoked to facilitate the acquisition and utilization of knowledge. The term also refers to the algorithms and heuristics that are involved in planning the sequence of actions from problem to solution;
- Situational knowledge (when to apply it): 'know-where and know-when' is the knowledge of the situation of the problem in which the knowledge will be applied.

The three knowledge classifications, explicit versus tacit, know-what to know-who and declarative versus procedural do have in common the aspect that they all three distinguish explicit kinds of knowledge and tacit kinds of knowledge. This has been visualised in Figure 2.4.

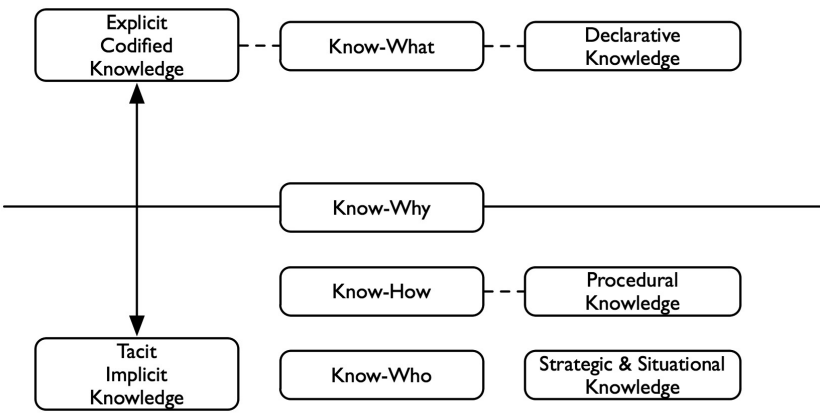

Figure 2.4: Relation between the three knowledge classifications (Diehl 2010).

As can be concluded there are different ways to distinguish forms of knowledge. In general they have two extremes in common: explicit or codified knowledge which can be delivered as stand alone information and data, and tacit or implicit knowledge which is embedded in a person or organisation. Both extremes ask for different ways of knowledge transfer. In general the transfer of product innovation knowledge is dominated by tacit knowledge. This will be discussed in more detail in section 2.6.

2.3 Knowledge transfer

A transfer begins when both a need and the knowledge to meet that need coexist within an organisation or system (Szulanski 1996). The base of knowledge transfer is a simple communication model. The communication model transfers information from one individual or organisation to another (Haghirian 2003). Two components of the communication are essential: The source (or sender) that sends the message, and a recipient to receive the message. The knowledge can be transferred directly from the source to the recipient or can be facilitated by an intermediate like for example a consultant, teacher or trainer (as in most of the case studies in this thesis). In literature several different nomenclatures are being used for the involved stakeholders and or means in the knowledge transfer process (see Figure 2.5). Within this thesis we will use the terms 'knowledge source', 'knowledge facilitator' and 'knowledge recipient'.

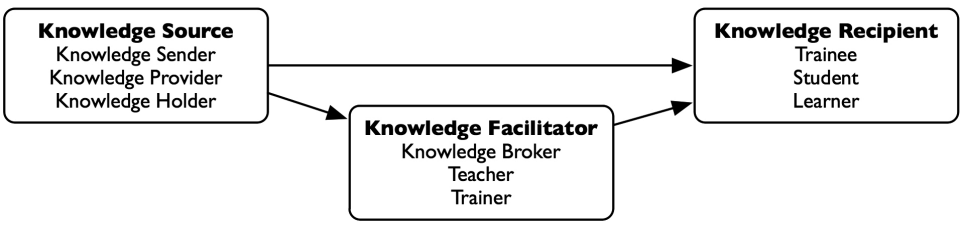

Figure 2.5: Terms for the different stakeholders in the knowledge transfer (Diehl 2010).

The knowledge transfer process

Knowledge transfer is not just an act, as typically modelled (as in Figure 2.5 above), but in addition can be described as a multi-stage process (Inkpen and Dinur 1998; Szulanski 1999; Abou-Zeid 2005). Within this multi-stage process knowledge created within one organizational context is re-created and utilized effectively in another organizational context (Abou-Zeid 2005). Like with knowledge, there is no consistent definition of knowledge transfer. Several scholars have proposed multi-stage models for the knowledge transfer process.

Szulanski (1999), for example, distinguishes in his model four stages within the process of knowledge transfer (initiation, implementation, ramp-up and integration):

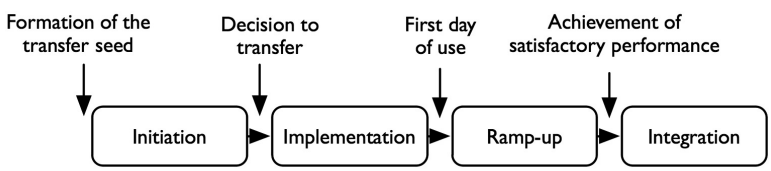

Figure 2.6: The four-stage knowledge transfer model of Szulanski (1999).

Inkpen and Dinur (1998) also propose a four-stage projection of the knowledge transfer process: initiation, where transferred knowledge is recognized; adaptation, where knowledge is changed at the source location to the perceived needs of the recipient; translation, where more alterations occur at the recipient unit as part of the general problem solving process of adaptation to the new context; and implementation, where knowledge is institutionalised to become an integral part of the recipient unit.

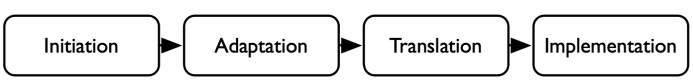

Figure 2.7: The four-phase knowledge transfer model of Inkpen and Dinur (1998).

The model proposed by Abou-Zeid (2005) fits the most to the setting of this research and will be described in more detail. Building upon the work of other scholars Abou-Zeid conceptualised another four-stage model for inter-organisational knowledge transfer existing of four sequential steps: initiation, inter-relation, implementation, and internalization.

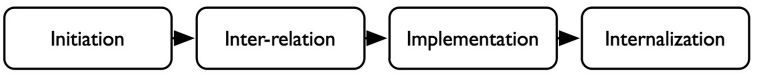

Figure 2.8: Four-stage knowledge transfer model of Abou-Zeid (2005).

Accroding to Abou-Zeid (2005) the *initiation* stage represents the period in which the prospective knowledge recipient becomes aware of the knowledge gap, that is, what the recipient must know versus what the recipient actually knows, or when the knowledge source recognizes the knowledge gap and the trying to convince the intended recipient. This stage involves activities such as identifying the type of knowledge to be transferred, evaluating expected outcome and potential source, together with the type of arrangement to be established with the source of required knowledge. Once these factors are identified, the feasibility of the transfer is explored. The outcome of this stage is the knowledge transfer decision, which includes the selection of the knowledge source and the type of collaborative arrangement.

The second stage, *inter-relation,* follows and constructive dialogues begin between the source and the recipient in order to specify what knowledge is to be transferred, when and to whom, and to identify and solve problems resulting form incompatibility of language, cultural conventions and other dissimilarities between the recipient and source. The outcome of this stage is the establishment of the necessary knowledge transfer conduits and mechanisms. Since knowledge includes both explicit and tacit dimensions, its transfer process has to include both personal and non-personal conduits.

The third stage, *implementation,* starts when a 'transfer coalition' at the recipient organisation, a selected group of staff who are in charge of the transfer process, unpack the newly acquired knowledge, reinterpret what they acquire. It is also during this stage that the transfer coalition will be predominantly concerned with identifying and resolving unexpected problems that may impede the integration and application of the newly acquired knowledge. At this stage the use of knowledge is more mechanical than reflective.

In the final stage, *internalization,* the knowledge acquired achieves a 'taken-for-granted' status. This status is reached when the recipient achieves satisfactory results with the transferred knowledge and the use of it gradually becomes routinized. Therefore, this step is a more reflective one in which the new knowledge is routinized and institutionalised.

It is clear that the transfer of knowledge can be described as a multi stage process. Each stage is characterised by different activities as well as a different focus.

Knowledge transfer mechanisms

To transfer knowledge from the knowledge source to the knowledge recipient one can make use of a wide range mechanisms for knowledge transfer. Most scholars distinguish between two kinds of knowledge transfer mechanisms (Uygur 2003; Abou-Zeid 2005):

1. Information (technology)-based (or non-relational or non-social) mechanisms: the usage of (electronic) documents, indirect communication, written media, databases, intranets, and various artefacts to transfer knowledge;

2. People-based (or social or relational) mechanisms: the usage of personal contacts, apprenticeships, direct communication and training to transfer knowledge.

In general explicit knowledge can be transferred more efficiently by information-based transfer mechanisms whereas tacit knowledge often requires more people-based, habitually individual, transfer mechanisms (Inkpen and Dinur 1998; Petersen, Pedersen et al. 2001; Uygur 2003). If tacit knowledge has to be transferred without people-based mechanisms, rich information and communication technologies like videos and interactive multimedia will be needed in order to be successful (Petersen, Pedersen et al. 2001). A misfit in the characteristics of knowledge type and transfer mechanism will result in poor transfer performance (Petersen, Pedersen et al. 2001).

As stated above, people-based mechanisms are more effective in transferring tacit knowledge but they are often more costly than information-based mechanisms because of the intensive involvement of staff. An alternative is to make the tacit knowledge first explicit. Knowledge codification (or externalization, see Figure 2.3) – the process of conversion of knowledge into messages, which can then be processed as information – changes some fundamental aspects of the economics of knowledge generation and distribution (Cowan and Foray 1997).

The codification process entails high initial, fixed costs but allows organizations to carry out distribution/transfer at very low marginal costs (Petersen, Pedersen et al. 2001). The economic value of codification is expected to increase continuously because of advances in information technology resulting in lower costs of codifying knowledge. Also, the costs of storing it once codified, and the costs of bringing it into practical use are likely to decrease as a result of ICT advances. The economic value of codification may also increase through ease of diffusion since it can be transmitted over long distances (e.g. via Internet) and within complex networks at very limited costs and high speed. These changes in the information infrastructure clearly increase the potential value of information-based knowledge transfer mechanisms (Petersen, Pedersen et al. 2001).

With this advent of vastly improved communication technologies, the traditional views of how global organizations transfer knowledge across geographic boundaries are undergoing rapid changes (Bhagat, Kedia et al. 2002). Nevertheless, there are also still many drawbacks related to information-based mechanisms. Nabeth et al. (2002), for example, mention that most of these information-based systems have emerged from document-centric approaches and are able to support (very efficiently) only a fraction of the whole knowledge cycle (classifying, storing, and retrieving knowledge).

It can be concluded that both knowledge transfer mechanisms (information- and people-based) have their own advantages and limitations. Consequently each knowledge transfer project has to consider the right balance between the two kinds of knowledge transfer mechanisms. Product innovation knowledge transfer projects are often characterised by tacit knowledge transfer (see section 2.6) and consequently by people-based knowledge transfer mechanisms. As such it can be expected that people-based knowledge transfer mechanisms will dominate the knowledge transfer process.

2.4 Knowledge management

Once the information has been transferred from one person or organisation to another it has to be maintained and managed: knowledge management. Nonaka and Takeuchi (Nonaka and Takeuchi 1995) describe the purpose of knowledge management as to seek optimisation of information flows and knowledge creation through tools and human relationship. The American

Productivity and Quality Center (1999) has defined knowledge management as a conscious strategy of getting the right knowledge to the right people at the right time and of helping people to share and put information into action in ways that strive to improve organizational performance.

However, according to Nabeth (2002), knowledge management systems do not usually take into account the specificity of the user, and in particular they usually provide the same interaction mode for all the users. When some form of personalization (tailor made) exists, this customization is very shallow and superficial: for instance the user is able to specify some preferences in the presentation of the information (such as the position of the information displayed in a portal), and in more advanced cases is able to specify some interest that the systems will take into account to filter the information to be displayed. According to them knowledge management systems should be user centric and try to build a deeper understanding of the user (Nabeth, Angehrn et al. 2002). More concretely, user-centred & personalized knowledge management systems should:

1. Support more efficiently the current activity of the knowledge worker by knowing his/her current focus, his/her goal and his/her role in the organization (Who);
2. Select and deliver knowledge in a way that maximizes its impact (How) (for instance a conceptual user will feel comfortable with a book, whereas a more down to earth user will prefer a story or a case delivered in voice form, a very sociable person will prefer a conversation with a peer, and an engineer the access to a mock-up);
3. Exploit the individual and social motivation and attitude of the user (people are driven by personal goals and believe that they have some strong influence on their commitment and therefore the quality of their work).

As suggested by the literature on knowledge management, a user centric approach and a deep understanding of the end user is one of the preferred approaches to identify and select the proper knowledge content and knowledge transfer mechanisms. This will be the main principle of the needs assessment tool, which will be developed in Chapter 11.

2.5 Absorptive capacity

Firms in many industries rely on knowledge generated outside of the firm as an input to their own research and (product) development process (Markiewicz 2004). Since most of the knowledge that companies use in (product) innovation comes from outside (see section 1.3.2) the ability to exploit external knowledge is a critical component of innovative capabilities (Cohen and Levinthal 1990; Arnold, Allinson et al. 2005; Forfas 2005).

Cohen and Levinthal (1990) introduced the concept of 'absorptive capacity' to label the ability of a firm or an individual to evaluate, assimilate and use outside knowledge. They suggest that absorptive capacity is an important moderating factor for effective acquisition, utilisation and assimilation of new knowledge. This ability, in turn affects the degree of innovativeness and capability of the firm to its changing environment, culminating in sustained competitiveness (Zahra and George 2002). Lack of absorptive capacity of the recipient has been found a strong barrier to the knowledge transfer process (Szulanski 1996; Davenport and Prusak 1998; Kostova 1999; Timbrell, Andrews et al. 2001).

Building absorptive capacity within a firm, according to Daghfous (2004), consists of two phases: First, the firm's ability to access external knowledge, which requires a knowledge sharing culture. The second phase emphasises the ability of a firm to utilise external knowledge, which is essentially the firm's ability to transform and implement external knowledge within the company

to enhance its core competencies. Absorptive capacity tends to develop gradually (Szulanski 1996; Lane and Lubatkin 1998).

The absorptive capacity of an organisation is dependent on the absorptive capacity of its members (Daghfous 2004). However Cohen and Levinthal argue that "A firm's absorptive capacity is not simply the sum of the absorptive capacities of its employees". Absorptive capacity at the individual level has two important elements, prior knowledge and intensity of efforts. The accumulation of prior knowledge enhances the ability to acquire new knowledge. Similarly, the diversity of prior knowledge facilitates novel associations and linkages and helps deal with uncertainty. Intensity of efforts refers to the fact that individuals should have both the ability and willingness to absorb transferred knowledge. The performance will be likely poor if motivation is low or absent.

As such the ability and the willingness (motivation and attitude) play a crucial role in the successfulness of knowledge transfer. The absorptive capacity and ability of knowledge recipients in low-income countries is expected to be lower than in developed countries, and consequently an important factor to take in consideration. Chapter 4 will elaborate on this.

2.6 Learning theories

As discussed, knowledge transfer is the combination of transmission and the absorption of new knowledge by that person of group. Knowledge that not has been absorbed has not really been transferred (Davenport and Prusak 1998). Through knowledge transfer and absorption, members of an organization learn. Learning is the core of the process of knowledge transfer (Spender 1994). Since learning is the core of the knowledge transfer process, the main learning theories will be discussed.

There are different approaches towards learning. In general, two traditions of learning theories can be distinguished: the objectivist and the constructivist tradition. The focus of the former, objectivism is to understand that which already exists. According to objectivists knowledge exists independently of the knower and particular contexts. Teaching is about transmitting this knowledge to learners who receive, store and apply it. Thus the road to better education is through better teacher instructions (teacher-oriented). To perceive learning as being dependent on instructions, however, could lead to a situation where the students look upon 'received' knowledge as final.

This would poorly equip the students and knowledge workers for a changing world, in which new skills have to be learned and new concepts to be integrated into their thinking, and in whichever greater demands are placed on individuals to evaluate situations and deal with unexpected (see section 1.3.1). The expanding knowledge base of most professions means that it is impossible to include all the knowledge that is required for the beginning practitioner in the pre-service curriculum (Christiaans and Diehl 2002). It is more important for students to be able to learn quickly, effectively and independently when they need it, than it is for them have assimilated (at graduation) all the information that their teachers believe is desirable. As a result it has become more important for students to learn how they can acquire in an efficient way relevant information to solve problems and how to transfer this information into competences (professional skills) (Christiaans and Diehl 2002).

In light of this the educational approaches at Western universities and schools moved during the years from knowledge instruction (objectivism) to knowledge construction (constructivism)

(Veen 2001) and the focus shifted from teacher-oriented towards more student-oriented education. The differences between both approaches are highlighted in Table 2.1.

Table 2.1: Characteristics of objectivism and constructivism learning theories (Eneroth 2000).

	Teacher's role	**Student's role**
Objectivism	To know the truth.	To receive information passively.
Constructivism	To act as a guide and source of expertise.	To identify the conditions and choose the best ideas.
	Knowledge	**Answers to problems**
Objectivism	All knowledge is known.	Either right or wrong.
Constructivism	Different knowledge is needed in different contexts.	Any answer is good.

From a constructivist point of view, learning is seen as an active process by reflecting on our experiences, solving cognitive conflicts and by trying to understand the world around us (Brooks and Brooks 1993; Eneroth 2000; Veen 2001). In this way each person creates its own rules and mental models to use to give meaning to experiences, rather than memorising someone else's meaning. Emphasis is placed on analytical abilities – the possibility of seeking and selecting information, clarifying problems, formulating assumptions, confirming and assessing evidence, and finding solutions. This typically represents the daily practice of professionals in the field of product innovation. As such constructivism is the more appropriate learning method for product innovation.

Within the context of the topic of this research three specific ways of learning will be will be highlighted:

- 'Problem-based learning' since it is one of the more popular ways of constructivism learning;
- 'Industrial design learning' in view of the fact that most product innovation education takes place within the context of industrial design schools;
- 'Distance learning' because of the often large physical distance between the knowledge source and the knowledge recipient.

Problem-based learning

Problem-based learning is in many ways an implementation of the constructivist and collaborative models of learning. Barrows and Tamblyn (1980) define problem-based learning as "...the learning which results from the process of working towards the understanding of, or resolution of, a problem". Problem-based learning is a way of constructing and teaching courses using (professional) problems as stimulus and focus for student activity. Problem- based learning moves students towards the acquisition of knowledge and skills through a staged sequence of problems presented in context, together with associated learning materials and support from teachers (Christiaans and Diehl 2002). Students meet an 'ill-structured problem' before they receive any instruction. In this way, students themselves identify, and search for the knowledge that they need to obtain in order to approach the problem. In this approach, groups of students have become their own learning forum (self activation) and are engaged to involve themselves in a problem and in the best case to become 'problem owners'.

The main learning methods of problem-based learning are learning by doing, learning in context and learner as the main focus (Chen 2008). This is similar to the Industrial Design teaching approach (Roozenburg and Eekels 1995; Buijs and Valkenburg 2000) as being taught at Delft University of Technology and many other design schools.

Constructivist educational approaches, problem-based learning and learning by doing are

expected to be the proper way to transfer product innovation knowledge to knowledge recipients. This will be discussed in more detail in the case studies as well as the development of the design manual.

Industrial Design Learning

Industrial design education plays an important role in teaching product innovation. Industrial Design learning is typically based upon constructivist and problem-based learning approaches: action and reflection. According to Christiaans and Venselaar (2005) industrial design education is about three main aspects. First, if learners are to become competent designers they need to gain an understanding of how the various stages of design fit together in the design process. They need to progress through the entire event and receive feedback on it. Only after demonstrating competence, they can successfully conduct more complex forms of design. Second, designing asks for the integration of many disciplines such as engineering, aesthetics, psychology and sociology, environmental studies etc. (Christiaans 1992). And third, in design education another form of integration is also important: integration between the application of theoretical knowledge and the final physical embodiment.

Within that perspective, acquiring industrial design knowledge and skills is, for several reasons, a complex and multidisciplinary activity. Novice designers (see section 4.4.3) need learning experiences composed of a knowledge component and a task performance or skills development component (Kirschner, Vilsteren et al. 1997). When taught in isolation this knowledge could be compartmentalised instead of integrated as in the design activity. Experiential learning approaches like problem-based learning and 'learning-by-doing' are widely accepted as a means of enabling learners to blend knowledge components with skills development (Tynjala 1998).

The emphasis during the first years of industrial design education is often focussed on declarative knowledge (see also section 2.3). Over time the focus switches over to more general procedural knowledge. The industrial design activity itself is usually thought to be a valuable teaching tool for general procedural knowledge. By 'learning by doing' students experience not only the problem and information needed but also the problem solving strategy. There is a consensus in literature that competence in designing can only be gained through experiencing the design process as a problem-solving event (Christiaans and Venselaar 2005). Practical exposure is essential to the learning of design methods, and the experience should be as real as possible. Tacit knowledge plays an important role in the design process. As a result, design education is focussed for a large part on transferring such tacit, non-described, knowledge from experts to novices (people-based knowledge transfer) (Poelman 2005). As a tacit form of knowledge, design expertise has to be built through social contact and personal experiences (Ashton ; Schön 1983; Bertola and Teixtera 2003; Ashton 2004).

Consequently it is expected that the transfer of product innovation knowledge will be dominated by tacit knowledge and primarily socialization and externalisation types of knowledge transfer will take place.

Distance learning

E-learning or distance learning using elements of multimedia, Internet and interactivity, has changed the educational world and has created the potential to use transportable course materials to teach and trans-national communication to support learning (Sz_cs 2001). This new situation with the availability of e-learning has led to new opportunities for education in developing countries. Not only local students in the developed countries can have access to the

international education system, but the Internet also can provide course materials to local teachers in less developed countries to give them a leapfrog start (Hoof 2001).

Meacham and Zubair (1992) note that an appropriate distance education model should take into account cultural factors, in addition to historical influences, geography and infrastructure, the technological environment, and the political dimension at all levels. They view that the best models of distance education involve situational analysis to identify significant environmental (including cultural) characteristics and the relationships between such factors and their relationship with the functions of distance education. Granger (1995) points out that there are multiple 'distances' to be navigated in distance learning programmes. These 'distances', which might also be relevant in long distance knowledge transfer, are related to knowledge, prior skills, language, culture, context, learning patterns and styles and learning goals and motivations.

Summarized product innovation and industrial design teaching is typically based upon constructivist and problem-based learning. Learning by doing is a key element in this and the tacit knowledge of teachers plays an important role. E-learning can be an efficient solution for the explicit part of the knowledge transfer, however only if taking into considerations the characteristics of the knowledge recipient.

The role of local higher education institutions

The important strategic role that institutions for higher education can play in helping nations to meet public goals has been extensively recognized. This role has a multifaceted nature, including such diverse aspects as public safety, quality of life, health care, environmental protection, sustainable development and economic competitiveness. The specific ways in which universities played this role is dominated by activities associated with the creation and distribution of knowledge. This has been translated, for example, in improved competences and skills in labour force, and in development and commercialization of new technologies (Conceicao and Heitor 2002).

Higher education systems in developing countries, however, are under great strain. They are chronically underfunded, while facing escalating demand - approximately half of today's higher education students live in the developing world. Faculty members are often under-qualified, lack motivation, and are poorly rewarded. Students are poorly taught and curricula underdeveloped (typically objectivistic and not based upon problem-based learning approaches) and outdated (World-Bank 2000). Collaboration between universities and industry and the transfer and implementation of the available knowledge is of key importance. The link between universities and industry varies strongly per country. In some countries the collaboration between universities and industry is stimulated by national policy and initiated by special institutes. This is, however not always the case, especially in developing countries there is often a big gap between academics and industry (Zaky and El-Faham 1998).

2.7 Factors affecting knowledge transfer

In the preceding paragraphs of this chapter, knowledge and the transfer of it has been discussed. Different types of knowledge as well as the distinct knowledge transfer mechanisms, learning theories and some initial factors that can influence the process have been described. Together they provide a first theoretical insight in how knowledge transfer takes place. This is, however, an 'isolated' picture of the knowledge transfer process since it is presented disconnected from the context in which it takes place in practice. In order to get a more accurate and comprehensive insight in the knowledge transfer process, the last two paragraphs of this chapter will investigate all factors that affect the knowledge transfer in practice. It is expected that in

addition to the outcomes of this first chapter of literature review, several factors will influence the knowledge transfer while being implemented in workaday reality.

Factors that influence the knowledge transfer

Many researchers in the field (Sagafi-Nejad 1990; Meacham and Zubair 1992; McDonough and Shaw 1993; Inkpen and Dinur 1998; Szulanski 1999; Polak 2001; Cummings 2003; Haghirian 2003; Abou-Zeid 2005) argue that a wide range of factors do have an impact on the knowledge transfer in practice. They indicate that these factors in theory can influence the knowledge transfer process in two ways:

1. The content of the knowledge transfer (What);
2. The way of knowledge transfer (How).

Abou-Zeid (2005) distinguishes two types of factors. On the one hand, there are knowledge specific factors that include elements such as tacitness and complexity (Bhagat, Kedia et al. 2002). On the other hand, as knowledge generation and utilization are constrained by the social, economical and cultural contexts in which they are embedded, the effectiveness of knowledge transfer is also influenced by context-specific factors such as prior experience, cultural distance and organisational distance (Szulanski 1996; Lane and Lubatkin 1998; Kostova 1999; Simonin 1999). Both type of factors will be discussed shortly in the next paragraphs.

Knowledge specific factors

Knowledge transfer is directly influences by the type of knowledge involved in the transfer process (Bhagat, Kedia et al. 2002). Garud and Nayar (1994) distinguished three dimensions of knowledge and indicated for each of them the potential impact for knowledge transfer:

1. The – simplicity versus complexity – dimension. A particular routine, practice, knowledge is more complex when it has a lot of components to it and these components are inter-dependent (Simonin 1999). Complex knowledge evokes more casual uncertainties, and, therefore, the amount of factual information required to completely and accurately convey such types of knowledge. Simple knowledge can be captured with little information and is, therefore, relatively easy to transfer.
2. The independent versus systemic character of knowledge – that is, the extent to which the knowledge is embedded in the organizational context. Knowledge that is independent can be described by itself, whereas knowledge that is systemic must be described in relation to a body of knowledge existing in the transferring organisation.
3. The third dimension of knowledge deals with the explicit versus tacit dimension as discussed in section 2.3.

Context specific factors

Next to the knowledge specific factors, successful knowledge transfer is depending on context specific factors (Szulanski 1999; Abou-Zeid 2005). Since the knowledge source and knowledge recipient are usually located in two culturally and economically different contexts, the questions arise, whether cultural, societal and economical differences between knowledge source and knowledge recipient influence the knowledge transfer process. Christaans and Venselaar (2005) point out that individuals and organizations share several dimensions of context e.g. climate, nationality, education, political, justice, economic, and other systems; corporate governance; management styles, and incentives schemes and each of these dimensions can influence the knowledge transfer process. Inkpen and Dinur (1998) in a similar way, suggest that contextual elements stand at the core of knowledge utilization and transfer. Every organizational practice, routine, or piece of information is deeply embedded in its context. Organisations develop specific capabilities in specific contexts. Many other scholars (Sagafi-Nejad 1990; Meacham and

Zubair 1992; McDonough and Shaw 1993; Inkpen and Dinur 1998; Szulanski 1999; Polak 2001; Cummings 2003; Haghirian 2003; Abou-Zeid 2005) agree with this statement that contextual factors do have an indispensable affecting impact on the knowledge transfer.

2.8 Clusters of factors

As concluded above and earlier in this chapter, a wide range of knowledge and context related factors influence the knowledge transfer process. Numerous studies have been executed after these factors. However, our current understanding of what contributes to successful interorganizational knowledge transfer is still quite limited for a variety of reasons. According to Perez-Nordtvedt (2008) extant research has examined the impact of these factors from unidimensional, rather than from multidimensional perspective. They often focus on one single isolated factor (i.e. culture or economics). Secondly the majority of studies on knowledge transfer focus on either the factors related to the relationship between the source and the recipient, the recipient itself, the source itself or the type of knowledge being transferred. Only a few studies, however, have addressed a more comprehensive view of all those factors that influence the knowledge transfer process simultaneously.

The objective of the first research question of our study, how does product innovation knowledge transfer take place, is to acquire an overall picture of the knowledge transfer process. From this perspective it is of importance to incorporate at first instance all factors in this research. As mentioned, only a few studies have sought to test models that incorporate all these factors simultaneously (Pérez-Nordtvedt, Kedia et al. 2008). Some examples are Inkpen and Dinur (1998), Szulanski (1999), Cummings (2003), and Sagafi-Nejad (1990) which have been trying to identify clusters of critical factors that influence the entire knowledge transfer process.

According to Inkpen and Dinur (1998) four clusters of related factors can be identified: source related factors, recipient related factors, factors related to the relationship and distance between the two units, and factors related to the nature of the knowledge transferred. Szulanski (1996) pointed out several groups of factors which influence the difficulty of the knowledge transfer. The most significant are according to Szulanski the characteristics of the knowledge transferred, the characteristics of the source, the characteristics of the recipient and the characteristics of the context. Cummings (2003) identified five clusters that can affect successful knowledge sharing implementations, including the relationship between the source and the recipient, the form and location of the knowledge, the recipient's learning predisposition, the source's knowledge-sharing capability, and the broader environment in which the sharing occurs. Finally, Sagafi Nejad (1990) synthesized the literature and identified four clusters of factors affecting knowledge transfers. These clusters include the characteristics of the technology and knowledge being transferred, the activities and modes through which the transfer occur, organizational profiles of the parties involved in the transfers, and broad environmental factors such as the level of the development and technological absorptive capacity of the host country.

To a large extent the above various proposed clusters of factors affecting the knowledge transfer process and the earlier identified factors in this literature review chapter coincide with each other. They combine the earlier mentioned knowledge related and context related factors. As a result the following six clusters of affecting factors can be defined (see Figure 2.9). Factors related to the:

A. Knowledge (Sagafi-Nejad ; Szulanski ; Inkpen and Dinur ; Cummings).
B. Knowledge transfer process (Sagafi-Nejad).
C. Source (Sagafi-Nejad ; Szulanski ; Inkpen and Dinur ; Cummings).

D. Recipient (Sagafi-Nejad ; Szulanski ; Inkpen and Dinur ; Cummings).
E. Relation and distance between the two units (Inkpen and Dinur ; Cummings).
F. Broader context (Sagafi-Nejad ; Szulanski ; Cummings).

Based upon these six clusters of factors a first picture can be made of how the knowledge transfer takes place and how it is being influenced (see Figure 2.9). This figure depicts the two main stakeholders, the knowledge source and knowledge recipient, and the four other clusters that are expected to influence the knowledge transfer process.

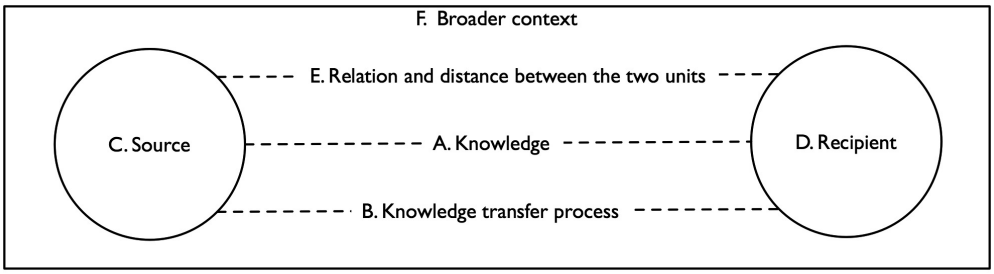

Figure 2.9: Overview of clusters of factors affecting the process of knowledge transfer (Sagafi-Nejad 1990; Szulanski 1996; Inkpen and Dinur 1998; Cummings 2003).

At this stage of the research this overview of the knowledge transfer process can be seen as a 'black-box'. Not much is known about its content. Chapter two has partly described knowledge (cluster A) and the knowledge transfer process (cluster B). In the next two chapters of literature review the black box will opened further, by exploring theory to examine underlying principles of the four other clusters as well. Chapter 3 will explore, describe and explain the phenomenon product innovation. This will provide more insight in the product innovation knowledge sources (cluster C) and the specific knowledge content to be transferred (cluster A). Chapter 4 will look into the characteristic of the knowledge recipient and the broader context, developing countries, in which he operates (cluster D and F). Based upon Chapter 3 and 4 a more detailed picture can be provided of the relation and distance between the knowledge source and the knowledge recipient (cluster E).

With this sequence, the focus of the literature review will be narrowed down from knowledge transfer in general to transfer of product innovation knowledge to recipients in developing countries specifically. Together they will provide a more systematic and comprehensive understanding of the transfer of product innovation knowledge to developing countries and will contribute to the development of a conceptual framework in Chapter 5.

2.9 Conclusion

The importance of knowledge and knowledge transfer is increasing tremendously. Knowledge itself is broader, deeper, and richer than just data or information. Knowledge is the result of a learning process and can be seen as a function of (task) related information, experience, skills and attitude at a given moment of time. Typically knowledge is sub-divided into explicit knowledge, which has been externalized and codified into for example documents, and tacit knowledge, which is implicit and linked to a person. Knowledge transfer is a multi-stage process existing of initiation, inter-relation, implementation, and internalization. All stages are essential in order to make the knowledge transfer successful. Two kinds of knowledge transfer mechanisms can be applied: information-based and people-based. Both knowledge transfer mechanisms have their own advantages and limitations. Consequently each knowledge transfer project has to

consider the right balance between the two kinds of knowledge transfer mechanisms. In general explicit knowledge can be transferred more efficiently by information-based transfer mechanisms whereas tacit knowledge often requires more people-based, often individual and personal, transfer mechanisms. The absorptive capacity of an individual or organisation is an important moderating factor for effective acquisition, utilisation and assimilation of new knowledge.

Nowadays it is more important to be able to learn quickly, effectively and independently when needed, than to assimilate a huge stack of information that teachers believe is desirable. To learn how to acquire relevant information in an efficient way to solve problems and how to transfer this information into competences (professional skills) has become more important. As a result educational approaches stimulating knowledge construction like constructivism and problem-based learning have become more prominent. Industrial Design education is often problem-based and learning by doing. Practical exposure by the design activity itself is seen as the best way to learn industrial design skills. As a result industrial design teaching should be focussed to a large part on transferring tacit knowledge by means of people-based knowledge transfer mechanisms.

The transfer of knowledge in practice is influenced by knowledge specific and context specific factors. Together they influence the process of knowledge transfer in two ways: the content (What) and way of the knowledge transfer (How). In total six clusters of factors have been identified related to: Knowledge, knowledge transfer process, knowledge source, knowledge recipient, relation between knowledge source and recipient, and the broader context.


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3 Product innovation

The previous chapter explored and explained the topic knowledge transfer. The second chapter of the literature review will focus on the content of the knowledge transfer: product innovation. The goal is to open up further the 'black box' of the product innovation knowledge transfer on clusters A (knowledge content) and cluster C (knowledge source). First a definition for innovation and product innovation will be provided (3.1). Subsequently the different levels of (product) innovation as well product-market innovation strategies (3.2) that take place in enterprises will be explored and the distinction in between them will be discussed. Next the discipline Industrial Design (3.3) and the connected design methodologies and theories (3.4) will be reviewed to explain how product innovation is being brought into the daily business practice. Finally, the concepts Ecodesign and Design for Sustainability will be introduced (3.5).

3.1 Product innovation

In recent years, there has been an increased interest to understand the process of product innovation that underlie corporate success and international competitiveness of states and firms (Goedhuys 2007). This is nowadays especially true for developing countries, as the knowledge intensity increased worldwide and competitiveness of firms active on the world market became increasingly determined by their ability to innovate (Mytelka and Farinelli 2003). Within this perspective, companies and other organizations that effectively manage the innovation of new products will gain significant competitive advantage and will survive on the long run.

What is innovation?

Innovation is a broad concept that is used in many different contexts. As a result, there are many definitions of innovation. The concept of innovation dates back to early studies on the capitalist system (Mutlu and Er 2003). During the first half of the 20th century, Schumpeter (1934; 1942) suggested that innovations are the imperative for economic growth, commercial profit, and thus, public wealth. According to Schumpeter innovation can be defined as "*the commercial or industrial application of something new– a new product, process or method of production; a new market or source of supply; a new form of commercial, business or financial organization*".

Most definitions of innovation emphasize 'newness' and 'successfulness'. Smulders et al. (1998) for example define innovation as: "*Innovation is the development and successful application of a new and useful idea"*. This states clearly that a brilliant new idea without a successful application is not an 'innovation'. In general a 'successful application' refers to 'successful to the market' (Olofsson 2003). However, there are different opinions about the 'newness' aspect of innovation. Cummings (2003) defines innovation as 'the first successful application of a product or process'. Not all scholars agree with this. Aubert (2004), for example, emphasizes that innovation should be understood as something new, however new to a local context. This relativity to the context is important and particularly relevant for developing countries (Aubert 2004).

Schumpeter's definition of innovation already pointed out that innovation is not just about product innovation. Scholars generally make a distinction between product and process innovation (Schumpeter 1934; Archibugi, Evangelista et al. 1994; Smulders, Kiers et al. 1998; Diyamett 2004) and in addition regularly also market, business and management innovation:

- Product innovation is the introduction into the market of new products that have characteristics and/or use applications that differ from existing products in the market.
- Process innovation is the introduction of a new method of production, that has not previously been used and/or a new way of handling a commodity commercially to make production more efficient or to be able to produce new or improved products.
- Market innovation involves entering new markets, new ways of serving customers, and/or market expansion.
- Business and management innovation involves developing new reward systems, organizational structure, ways of handling responsibilities and human resources etc. that positively affects (product) sales.

The focus of this research will on product innovation and to a lesser degree on market innovation. For the ease of reading the word 'product innovation' will cover both product and market innovation in this thesis. Process, business and management innovation are excluded from this research.

Innovation levels

Innovation can take place at different levels of novelty. Budworth (1996) proposes to categorize innovations into three levels: incremental, radical and fundamental. Each category is progressively more significant and more far-reaching. These three levels of innovation can be described as (see also Figure 3.1):

1. Incremental innovations: Entails step-by-step improvements of existing products and tends to strengthen the market positions of the established companies in the industry (Olofsson 2003).
2. Radical innovations: Discontinuous events which drastically change existing products or processes (Dicken 2003). The risk and required investments in radical innovation are usually considerably greater than those needed for incremental innovation but they offer more opportunity for new entrants to enter the market (Diyamett 2004).
3. Fundamental innovations: Depends on new scientific knowledge and open up completely new industries, causing a paradigm shift. In the early stage of fundamental innovations the contribution of science and technology are important (Rosenberg 1982; Coombs, Saviotti et al. 1987).

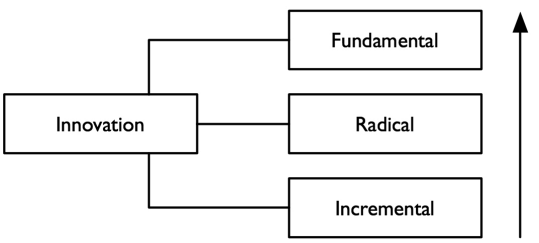

Figure 3.1: Three levels of innovation (Budworth 1996).

The majority of innovation efforts take place in companies that work from the incremental or radical innovation perspective. There is a wide range of innovation possibilities between these two extremes (Olofsson 2003). Fundamental innovations often only take place in large multi-national companies, company clusters or (inter)national research programmes. Fundamental

innovation levels are out of the scope of this research. The focus will be on range between incremental and radical innovations. To be successful in either incremental or radical innovations requires different kinds of thinking, ways of working, and taking risks. To get more insight and a better understanding of both types of innovation, they are discussed in more detail in the next paragraphs.

Incremental innovation

As the name suggests, this type of innovation makes small changes at one given time and is sometimes referred to as continuous improvement. A simple product may be improved (in terms of better performance or lower costs) through the use of higher performance components or materials (Abdul Ali, Kalwani et al. 1992). A complex product that consists of a number of integrated technical subsystems may be improved by partial changes at one of the sub-systems. User experience and feedback is important and may predominate as a source for innovation ideas. As an example, customer wants can be identified and added as features to the existing product. By undertaking an incremental innovation process the organization can exploit internal resources and rely on existing competencies of the in-house technology and the market (Berchicci 2005). Incremental innovation projects, due to the low levels of uncertainties are usually following a structured and predictable process and do not involve major investments or risks. Incremental innovation is sometimes also seen as copying or imitating (benchmarking) of products and processes of competitors (Arnold and Bell 2001).

Incremental innovations and redesigns of existing products are economically and commercially as important as radical innovations. Freeman (1982) argues that incremental innovations and design improvements are the 'bread and butter' of new product development for most of the firms. Many firms do not even attempt to seek radical innovations for a variety of reasons having to do with their size and resources, the nature of the industry, the level of research and development necessary, or the amount of risk involved (Dewar and Dutton 1986). Even firms that successfully introduce radical innovations do not do so very often (Freeman 1982).

Radical innovation

Radical innovation involves the development of key new design elements such as a change in a product component combined with a new architecture for linking components. The result is a distinctively new product that is markedly different from the company's existing product line (Camelo, Martin et al. 1999). A high level of uncertainty is associated with radical innovation projects, especially at early stages. Due to high levels of uncertainty, the process cannot be described as an orderly structured process. Radical innovations are confronted with uncertainties on different levels (Leifer, McDermott et al. 2000; Kotelnikov 2005). To be successful the uncertainty must be reduced on the following dimensions:

- Technical uncertainty: issues related to the completeness and correctness of the underlying scientific knowledge and the technical specifications.
- Market uncertainty: issues related to customer needs and wants.
- Organisational uncertainty: refers to organizational resistance that stems from a fundamental conflict between the mainstream organisation and the radical innovation team.
- Resource uncertainty: includes project discontinuities that influence the project's funding, staffing, and management requirements.

As such radical innovations need a number of enabling factors such as a high level of technological capability, strong R&D and a pool of multidisciplinary skills whereas the

incremental innovation adoption process needs less. The differences between incremental innovation and radical innovations are being summarized in Table 3.1.

Table 3.1: Differences between incremental and radical innovation processes (Berchicci 2005; Kotelnikov 2005).

	Incremental Innovation	**Radical Innovation**
Emphasis	Cost or feature improvements in existing products, services or processes	Development of new businesses, products and/or processes that transform the economies of a business
Technology	Exploitation of existing technology	Exploration of new technologies
Trajectory	Linear and continuous: evolutionary	Sporadic and discontinuous; revolutionary
Key players	Formal cross-functional team	Formal and informal cross-functional teams and individuals
Time frame	Short-term	Mid- till long-term
Risk and success	Predictable	Unpredictable and highly uncertain
Process	Formal, phase-gate model	Informal, flexible model at early stages due to high uncertainty. More formal at later stages after uncertainties have been reduced.
Market opportunities	Clear	Unclear
Market research techniques	Suitable	Unsuitable
Product attributes	Determinate	Indeterminate

Several authors have proposed different levels for product innovation. For example Ansoff (1968) suggests three product innovativeness strategies, notably (1) incremental new products, (2) moderately innovative products, and (3) really new products. Cooper (1979) identifies three dimensions that reflect the product innovativeness concept: (1) newness to the firm, (2) product uniqueness, and (3) product superiority. Lastly, Brouwer and Kleinknecht (1996) suggest that product innovativeness is reflected in two dimensions based upon: (1) product newness to the firm and (2) product newness to the sector.

Table 3.2: Overview of product innovation strategies.

Ansoff (1968)	*Cooper (1979)*	*Brouwer and Kleinknecht (1996)*
Incremental new products	Newness to the firm	Product newness to the firm
Moderately innovative products	Product uniqueness	Product newness to the sector
Really new products	Product superiority	

Product innovation levels in this research

For the purpose of this PhD study, based upon the previous paragraphs, four levels of product innovation have been defined for use in later stages of this research. For example, in order to describe and categorise the innovation activities of companies in developing countries in the case study research. The proposed innovation levels are to large extent based upon the definitions of Anssoff: product improvement (incremental new products), product redesign (moderately innovative products), new products (really new products), and new function fulfilment (see Table 3.3).

Table 3.3: Definition of innovation levels for this research.

Product innovation level 1	Product improvement
Product innovation level 2	Product redesign
Product innovation level 3	New product
Product innovation level 4	New function fulfilment

3.2 Product innovation strategies

Depending on amongst others the situation, vision and the competences of a company, different product-market innovation strategies can be developed. Generic categories of *product-market innovation* strategies exist that can be applied to a wide range of firms. In this paragraph two main product-market innovation strategy classifications are being described: the models of Ansoff (1968) and Porter (1980). These models can be helpful in describing the current innovation approaches within a company. In addition in business practice, companies and organizations can apply these models to analyse their current (and competitors') product portfolio and can provide directions to new product-market innovation strategies.

Ansoff growth matrix

According to Ansoff (1968), a company can address the need for innovation in four different ways based upon a combination of market and product innovation (see Figure 3.2):

- Market Penetration Strategy: Management looks for ways to increase the market share of its current products in their current markets.
- Market Development Strategy: Management looks for new markets for current products.
- Product Development Strategy: Management considers new product possibilities.
- Diversification is used when good opportunities can be found outside the present businesses (a combination of new products and new markets).

	Current Product	New Product
Current Market	Market Penetration Strategy	New Product Development
New Market	Mew Market Development	Diversification

	Current Product	New Product
Current Market	*Low Risk*	*Medium Risk*
New Market	*Medium Risk*	*High Risk*

Figure 3.2: Ansoff (1968) growth matrix.

Porter strategy matrix

The Porter strategy matrix (Porter 1980) describes common types of competitive strategy as 'overall cost-leadership', 'focus', and 'differentiation':

- Overall Cost Leadership: The business works hard to achieve the lowest production and distribution costs so it can have a lower price than its competitors and win a larger market share. Firms pursuing such strategy must be good at engineering, purchasing, manufacturing, and physical distribution. They have less need for marketing skills.
- Differentiation: The business concentrates on achieving superior performance in an identified customer benefit area valued by a large part of the market. It strives to be a leader in quality, technology, service, style, etc. The firm cultivates the strengths that will give it competitive advantages. Thus, the firm that for example wants to be a quality leader will make or buy the best components, put them together expertly, and inspects them carefully.
- Focus: The business focuses on one or more narrow market segments rather than going after a large market. The firm gets to know the needs of these segments and pursue either cost leadership or a form of differentiation within the target markets.

These three generic types of strategies can be combined (see Figure 3.3).

Competitive Reach	Competitive Advantage: Lower Costs	Competitive Advantage: Differentiation
Big Target Market	Cost Leadership	Differentation
Niche Market	Cost Focus	Differentation Focus

Figure 3.3: Porter strategy matrix (Porter 1980).

These product innovation strategies can be used to (re)consider which strategic directions do fit the best to the needs and capabilities of an enterprise or organization. The matrices of Ansoff and Porter will be used in the content of the design manual.

3.3 Industrial Design

Product innovation is closely connected to the profession of 'industrial design'. A big part of the product innovations projects are being carried out by (teams of) industrial designers. The next paragraphs discuss the industrial design profession as well as the industrial design methodologies and industrial design knowledge categorization.

The word 'design' has various definitions, which originate from a variety of perspectives. These perspectives lead to definitions at functional and strategic levels addressing amongst others to 'design' in general and 'product design' or 'industrial design' in particular (Mutlu and Er 2003). As a result, according to Lawson (1980), 'Design' is a word varying such a wide range of reference that we can no longer be really certain what it means. Though, for the purpose of this research the definitions for Industrial Design will be explored in more detail.

ICSID, the International Council of Societies of Industrial Design (ICSID 2005) defines Industrial Design as "a creative activity whose aim is to establish the multi-faceted qualities of objects, processes, services and their systems in whole life-cycles. Therefore, design is the central factor of innovative humanisation of technologies and the crucial factor of cultural and economic exchange". According to Heskett (1980), Industrial Design is a process of creation, invention and definition separated from the means of production, involving an eventual synthesis of contributory and often conflicting factors into a concept of three-dimensional form, and its material reality, capable of multiple reproduction by mechanical means. Finally IDSA (2005), the Industrial Designers Society of America describes Industrial Design as "the professional service of creating and developing concepts and specifications that optimize the function, value and appearance of products and systems for the mutual benefit of both user and manufacturer. They develop these concepts and specifications through collection, analysis and synthesis of data guided by the special requirements of the client or manufacturer. They are trained to prepare clear and concise recommendations through drawings, models and verbal descriptions". For the purpose of this thesis, the definition of IDSA will be applied.

Despite the fact that the representative bodies for industrial designers like IDSA and ICSID developed and communicate well-defined definitions of the Industrial Design profession, Industrial Design is still an often misunderstood concept. It is commonly seen, even by managers of companies, as the process of making products looking aesthetically pleasing or stylish (Murray 2004), not as managing the total product innovation trajectory. In developing countries, the

notion for the wide range of skills and impact of the industrial designers on the total product innovation process is even more limited.

The competitive advantage of Industrial Design

The role and the impact of Industrial Design in the western world is still increasing. Industrial Designers are nowadays called upon not only to design new products but also to manage the processes by which the products are produced and get involved in the strategic (Clark 2002). This expanded role for design has resulted in explosive growth among professional design firms and the corporate sectors associated with design in developed countries. Even though not always recognised, Industrial Design can be key factor in making a company and its products competitive, as it improves and strengthens company position in their markets and succeeds in making products convey a different, innovative image. Companies that invest in design tend to be more innovative, more profitable and grow faster than those who do not (EU 2009). The profitability of investing in Industrial Design in developed countries can be illustrated for example by the outcomes of the research of the Basque Design Center (DZDesign 1996). Investigating the impact of Industrial Design investments in enterprises in the Basque Countries concluded that:

- In 90% of the cases examined, product sales have increased;
- In 54,5% of these cases, manufacturing margins have improved, regardless of variations in sales prices and manufacturing costs;
- For 88% of the projects, the investment payback period is less than three years;
- For 92% of the projects, it is estimated that improvements in product quality and corporate image have caused the subject products to move to higher market segments;
- In 74.3% of the cases, producers have been able to gain access to new markets.

Likewise a recent (2008) survey of UK manufacturing firms showed that 55% of the firms see design and development as one of their most important sources of competitive advantage in five years (CBI 2008). Sixty of Swedish companies agreed with the statement that there is a clear positive correlation between design and profitability (EU 2009). These figures clearly state the significant contribution of Industrial Design to the competitiveness of industry.

Design methodology

Designing can be seen as a range of activities over time. To support the industrial designer in this process many scholars have been developing design methodologies. A common definition of design methodology is provided by Cross (1984): "*the study of the principles, practices and procedures of design in a broad and general sense. Its central concern is with how designing both is and might be conducted. This concern therefore includes the study of how designers work and think; the establishment of appropriate structures for the design process; the development and application of new design methods, techniques, and procedures; and reflection on the nature and extent of design knowledge and its application to design problems*".

Design methodology knowledge appeared only just in the 60's in the United Kingdom, partially as a response to the demands of industry and the military, and partially because of the advent of cognitive psychology. In those early days design researchers and design educators were interested in developing a systematic approach to product design, product development and product innovation, primarily to help the professionals in the field to structure and lighten their work, and also to find better ways of teaching new design professionals (Cross 1984; Buijs 2003).

Much of the early methodology was compiled by engineers who applied the same 'system thinking' they had used in designing their products to analyse the design process itself. The first

thing design researchers did, based on their own practices as professional product designers, was to cut the product innovation process into little pieces, which they ordered in a kind of logical way (Buijs 2003). This led to the development of phase-models and flow-diagrams of the design process (Archer 1974), and to attempts to rationalise and even automate the treatment of design problems. The technical positivist background of these theories led to design being seen as a rational process (Dorst 1997).

Criticism of these early models and methods came to the fore in the late sixties/early seventies (Lawson 1980). A different paradigm was proposed about fifteen years later by Schön (1983), describing design as a reflective practice. This constructivist theory (see section 2.8) was a reaction to the rational problem solving approach, and it attempted to address the blind spots and deficiencies Schön perceived in what by then had become mainstream design methodology. Schön rejected a theory of technical rationality that distinguishes professionals by the extent of their book knowledge and developed an alternate theory of the professional as reflective practitioner. Schön characterizes a reflective practitioner as one who emphasises problem setting (in addition to problem solving) activities, reasons about the problem and the solution through experimentation, and fluidly engages in a variety of representations (both inscription representations and language representations) to experiment with the problem (Adams, Turns et al. 2003).

The Delft Product Innovation Model (PIM)

At Delft University of Technology, Roozenburg and Eekels (1995) took the lead in the end of the seventies to develop an appropriate design methodology for Industrial Design. Roozenburg and Eekels analysed the different models of the product design process and came with the notion of a *basic design cycle* (see Figure 3.4). The basic design cycle encompasses all the phases a design process will go through at least once. It consists of a number of activities, each leading to a result. The cycle starts with a function, which is analysed, resulting in criteria; upon which synthesis takes place, resulting in a provisional design; that is simulated, resulting in expected properties; which are evaluated, resulting in an outcome; upon which a decision is taken whether or not to continue (Roozenburg and Eekels 1995). This analyse-synthesize-simulate-evaluate is still the kernel of the present 'Delft Product Innovation Model'.

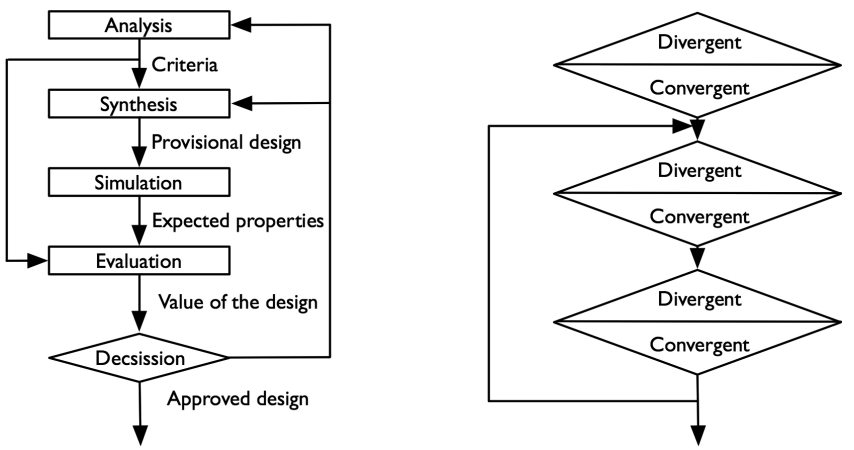

Figure 3.4: The basic cycle of design (Roozenburg 1977; Roozenburg and Eekels 1995) characterised by divergent, convergent, and iterative activities.

The product innovation process is frequently presented as a linear process. However, in practice it is often characterized as linear processes with iterative cycles, meaning that the design teams often go back to earlier stages and decisions in the product development process to re-evaluate previous decisions that have been made (see Figure 3.4). The basic idea is that every stage, phase or step has two different activities: first a divergent activity, followed by a convergent activity (Lopez-Mesa, Thompson et al. 2002; Buijs 2003). *Divergent* activities search for ideas and solutions and include searching for information, to explore the problem, to redefine it, to generate ideas and to combine concepts. *Convergent* methods impose value judgements and include methods to make sense of information, to prioritise items, to compare solutions, to assess ideas and to reject or select concepts (Lopez-Mesa, Thompson et al. 2002).

As a next step Roozenburg and Eekels developed the 'Delft Product Innovation Model'. They divided the total product innovation into four main stages (Roozenburg and Eekels 1995; Buijs 2003):

- *Policy formulation,* which results in a product policy;
- *Idea finding,* which results in a new business idea;
- *Strict development,* in which three parallel processes take place: product designing resulting in a product design, marketing planning resulting in a marketing plan and production development resulting in a production plan;
- *Realization,* in which three main activities take place; production, distribution and sale; and (product-)use.

Policy formulation and idea finding are considered to be part of *product planning;* product planning and strict development together form *product development. Product development* and *realization* form the total *product innovation process* (see Figure 3.5). This is inline with the general definition product innovation in section 3.1 stating that it should not only be a development of a product but also a (successful) introduction into the market.

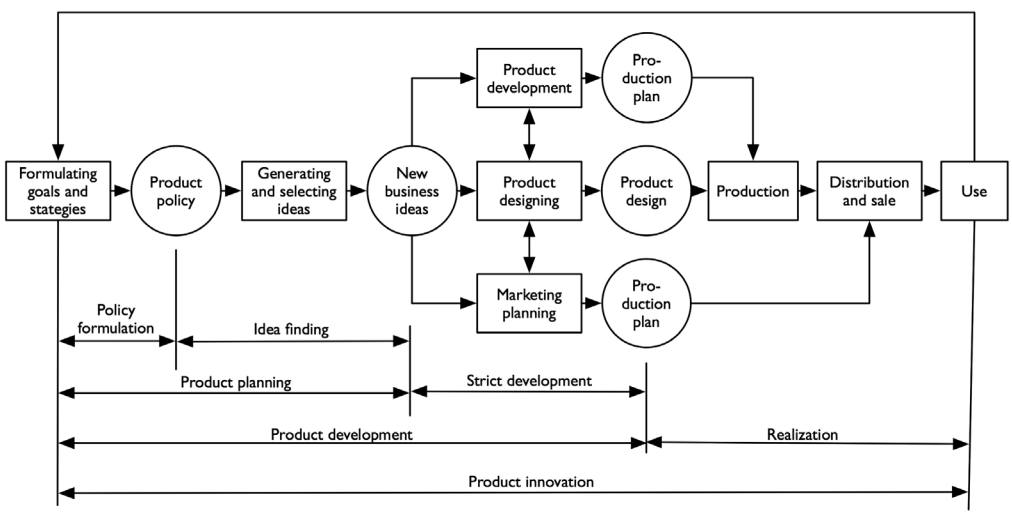

Figure 3.5: Delft Product Innovation Model (Roozenburg and Eekels 1995).

3.4 Industrial Design knowledge categorization

Industrial Design is a 'generalist discipline', i.e. the Industrial Designer has to develop basic competences and gain knowledge regarding a wide range of topics. Schön (1988) for example

recognised 21 applied sciences knowledge domains that could be of relevance for Industrial Design. Buijs (2003) mentions mechanical engineering, aesthetics, styling, marketing, consumer behaviour, ergonomics, economics, sustainability, management science and psychology as main disciplines. The challenge for an industrial designer is to observe other disciplines, gain relevant knowledge and to integrate them in them into the a design solution.In this perspective industrial design knowledge is not just seen as knowing facts, but also knowledge regarding how to apply and to integrate those facts, and which strategy in a certain situation can be followed the best. As such, according to Christiaans (1992) it is eminent for a designer (student as well as practitioner) to have knowledge (facts, experiences and processes) of these different domains at one's disposal during the design process in order to enable this knowledge to be integrated into the design solutions. To get a better understanding of the designer's knowledge base, which is used in solving design problems, requires a more detailed description of the relevant knowledge. Like with knowledge in general, also for the Industrial Design knowledge domain scholars have proposed several classifications. Christiaans and Venselaar (Venselaar, Hoop et al. 1987; Christiaans 1992; Christiaans and Venselaar 2005) developed a generally accepted classification of Industrial Design knowledge. They distinguish between *domain-specific* basic and design knowledge on the one hand and *domain-independent* general process knowledge on the other hand (see Figure 3.7). This leads to three categories of design knowledge:

1. Domain-specific *basic knowledge* in design refers to academic knowledge and skills of different disciplines like mechanics, ergonomics, materials, marketing, environment, sustainability or knowledge about human users etc.
2. Domain-specific *design knowledge* refers to knowledge and skills of the design discipline itself that is related to problem solving and how this knowledge should be applied. For example, the possibilities of specific materials to attain certain concept solutions, (the application of) design methods, knowledge of existing design solutions, design history, 2D and 3D modelling, aesthetics and user trials. Together with basic knowledge, design knowledge is specific to a certain domain, in this case Industrial Design.
3. Domain-independent *process knowledge* refers to domain independent knowledge – knowledge of managing and monitoring the solution finding process - part of it being called meta-cognitive knowledge. Often this kind of knowledge comes into play when heuristics, or 'weak methods' are needed. General process knowledge can also be regarded, in the main, as the monitoring function of memory that helps the student or professional to organize the problem-solving process as a whole. It refers to a reflection on the design process by way of knowing what stages are relevant in the problem solving process and what method can be used to facilitate it.

The *domain-specific* knowledge is *theoretical* and the *domain-independent general process* knowledge more *experience* based (Christiaans 1992). A good designer needs to have to his or hers disposal both domain specific knowledge and domain independent general process knowledge of the design process itself in order to come to a successful result. Additionally the problem solver needs sufficient knowledge of the process and strategy to identify the most efficient way of solving the problem for the specific situation. In other words, solving design problems is an integration of the various disciplines and general process knowledge (see Figure 3.6).

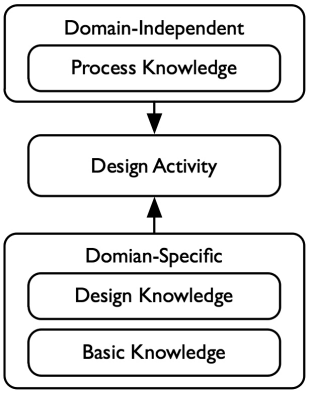

Figure 3.6: The three design knowledge components (Christiaans 1992).

As such it is expected that a knowledge facilitator and or knowledge recipient has to have all three industrial knowledge components in order to be capable and successful in carrying out a product innovation project.

3.5 Design for Sustainability (DfS)

As discussed in the problem context of this study (Chapter 1), often the objective of product innovation knowledge transfer to developing countries is to not only economical growth but also to improve the social and ecological conditions. From this perspective, one of the domain-specific design knowledge topics, Design for Sustainability (DfS), will be discussed in more detail in the next paragraphs.

Sustainable Development

The main goal of Design for Sustainability is sustainable development. The concept of a sustainable development was introduced and promoted for by the report 'Our Common Future' as a common aim for the whole world (Brundtland 1987). The Brundtland definition of sustainable development states: "*Development which meets the needs of a current generation without compromising the ability of future generations to meet their needs*". It is clear that the current patterns of consumption and production are unsustainable and not inline with the definition above.

Even though sustainability is widely accepted as a general goal, the concept is ambiguous and elusive. There are difficulties finding the balance between the needs for making environmental and social improvements on the one hand and the economically reality plus satisfying the demands of our consumer society on the other. In order to understand and manage the sustainability concept more easy and transparent, an approach illustrating the meaning of sustainable development has been formulated by Elkington (1998) known as the 'Triple Bottom Line' existing of the three sustainability components 'Economic Prosperity', 'Environmental Quality' and 'Social Justice' which further were developed into 'Economy', 'Environment' and 'Social Equity'. Nowadays these three key elements of sustainability are frequently referred to as the 'Triple P': *People, Planet and Profit* (see Figure 3.7).

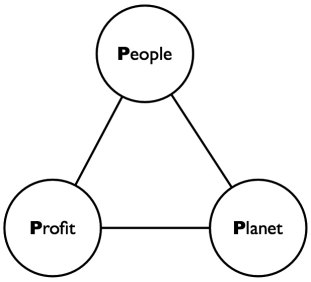

Figure 3.7: 'Triple P', the three key elements of sustainable development.

Improved product design, which applies sustainability criteria, can be a useful instrument to enterprises and governments to deal with these concerns. (Crul and Diehl 2006). Product innovation is directly linked to sustainability: both are oriented towards change and the future. To be sustainable, product innovation must meet a number of challenges linked to People, Planet and Profit: social expectations and an equitable distribution of value along the global value chain, and the innovation must work within the carrying capacity of the supporting ecosystems.

Ecodesign

Initially, sustainability (in Europe) largely was an environmental (Planet) issue. The initial impetus was directed at what is called 'Design for the Environment' or 'Ecodesign'. 'Ecodesign considers environmental aspects at all stages of the product development process, striving for products that make the lowest possible throughout the product life-cycle' (Brezet and Hemel 1997). 'Eco' stands here for *Eco*logy and *Eco*nomy by looking for improvement options that decrease the environmental impact of the product lifecycle and in the meantime offering opportunities for financial benefits (so called win-win situations).

The first larger scale Ecodesign initiatives started in North- and Central-Europe. In the Netherlands it started with the 'Million project' in the end 1980s followed by the PROMISE project in 1991-93, organized by the Dutch Technology Assessment Organization (Brezet, Horst et al. 1994). In 1997, the United Nations Environment Program (UNEP), in conjunction with Delft University of Technology and other experts in the field of Ecodesign, published the manual 'Ecodesign: A Promising Approach to Sustainable Production and Consumption' (Brezet and Hemel 1997).

The UNEP Ecodesign approach (built upon the DUT PIM (see section 3.5) exists of seven successive steps (see Figure 3.8) in order to Ecoredesign a company's product starting from organizing an Ecodesign project towards the launch of the product and establishing follow-up activities. According to Bauman et al. (2002) the UNEP Promise Ecodesign manual is most frequent used as a reference material on Ecodesign.

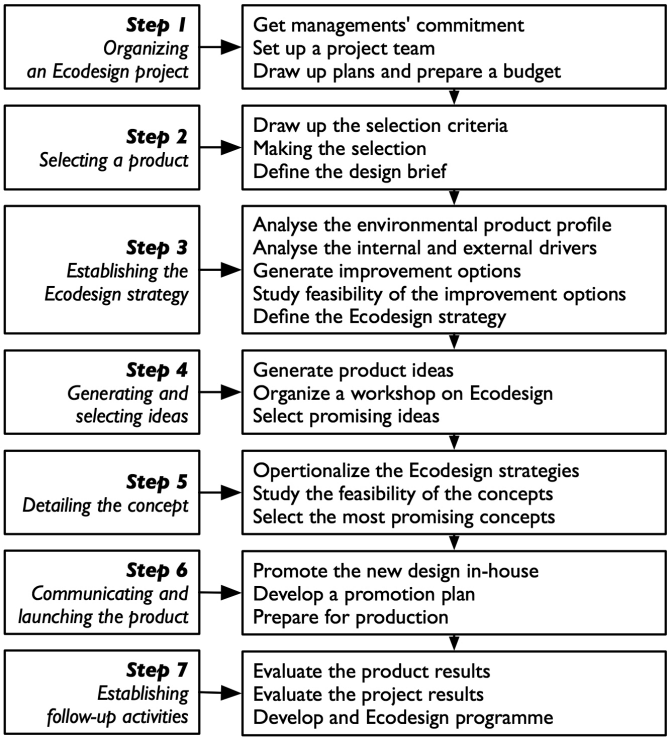

Figure 3.8: Steps of the UNEP Ecodesign manual (Brezet and Hemel 1997).

The concept of Ecodesign has since then spread as seen in the number of manuals and sector specific supporting materials that are now available in many languages. Many of them have been grounded upon the UNEP Ecodesign manual like for example in Spain (Quintana, Rebate et al. 2000), Central America (Crul and Diehl 1999), East Africa (Crul and Diehl 2002) Canada (NRC) and Norway (NTNU 2000).

Design for Sustainability (D4S)

It is just since 1995 that the term *Design for Sustainability* has received greater acceptance (Baumann, Boons et al. 2002). Many scholars (Weenen 1995; Dewberry and Goggin 1996; Charter and Chick 1997; Tischner, Schminck et al. 2000), in describing Design for Sustainability (also referred to as Sustainable Product Design) draw heavily on a more broader and holistic scope than Ecodesign by incorporating social, ethical and equity issues (such as wealth disparities and developing world factors) into design. The difference in focus of Design for Sustainability and Ecodesign can be illustrated by Figure 3.9.

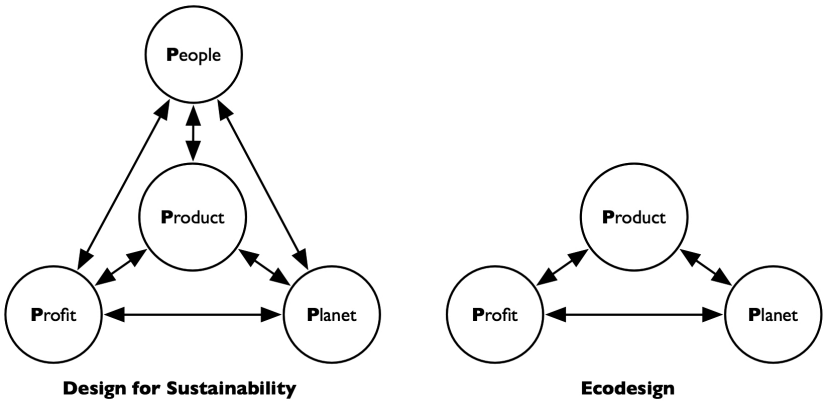

Figure 3.9: Design for Sustainability versus Ecodesign (Boks and Diehl 2004).

A broad definition of D4S would be: *"that industries take environmental and social concerns as a key element in their long-term product innovation strategy. This implies that companies incorporate environmental and social factors into product development throughout the lifecycle of the product, throughout the supply chain, and with respect their socio-economic surroundings (from the local community for a small company, to the global market for a trans national company)" (Diehl and Brezet 2004; Crul and Diehl 2006).*

It is expected that this inclusion of the social (people) aspects has made the approach more appropriate for developing countries since they often have to face big social challenges as well like for example income generation, education and health problems. Most Ecodesign and D4S manuals, at the start of this research project reflected a Western perspective, there was little emphasis on the developing countries and their specific environmental, economical and social problems (Baumann, Boons et al. 2002). Meanwhile, a rapid increase of interest for adapting and applying D4S in developing economies can be observed.

Ecodesign approaches

Like in the case of common product innovation, also within Ecodesign different levels of innovation can be distinguished, varying from more incremental towards more radical Ecodesign approaches. Bakker (1995) describes two Ecodesign approaches, with the first (Ecoredesign) dealing with a straightforward process of incorporating environmental principles into the design process, using the lifecycle principle while being largely technologically focused. The second approach (Beyond Ecoredesign) aims to develop attractive new products, services and scenarios that enhance sustainable lifestyles. Van Hemel (1998) makes a similar kind of distinction, describing the two as the 'Evolutionary' and the 'Revolutionary' approach. The evolutionary approach integrates Ecodesign into existing design practice – the key words are product modification and pragmatism. The revolutionary approach requires breakthrough innovation, and new thinking, ideas and products to fall in line with sustainability targets. Tischner et al. (2000) define three Ecodesign approaches: EcoRedesign, Eco-Innovation and New concept/system/service. According to them, most Ecodesign projects today are aimed at an existing product or process: EcoRedesign. Less frequently, the aim is to develop a completely new product or method in which ecological considerations play a major role from the very beginning: Eco-Innovation. Relatively rare are still projects aimed at finding sustainable systems or services innovations.

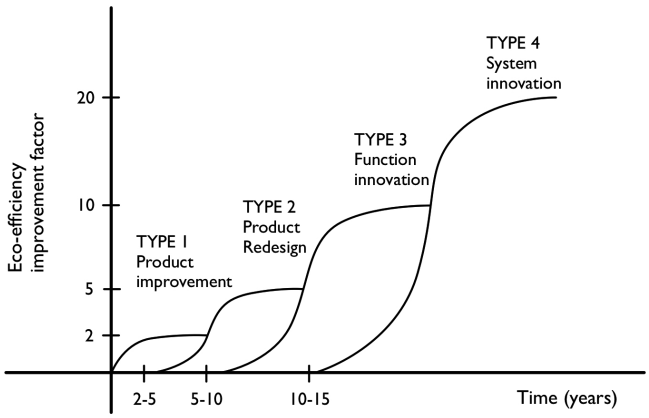

Figure 3.10: Degrees of environmental benefits and innovation levels required (Brezet 1997).

Finally, Brezet (1997) proposes a four-step model of Ecodesign consisting of differing innovation levels, eco-efficiency factors and timeframes. The four steps are illustrated in see Figure 3.10 and are described as:

- *Product improvement:* Partial changes and environmental improvements to products that already exist on the market.
- *Product redesign:* The product concept stays the same, but parts of the product are developed further or replaced by others.
- *Function innovation:* Involves changing the way the function is fulfilled.
- *System innovation:* New products and services arise requiring changes in the related infrastructure and organizations.

To move from level 1 to level 4, increasing amounts of time and complexity are required, which leads to higher eco-efficiency improvements. This model suggests that these more radical Ecodesign innovations will (or can) only be achieved over a significant time period, say 10-20 years. Based upon the work of these scholars it can be concluded that there are different levels of innovativeness within the Ecodesign approach (see Figure 3.11). It can be expected that they have similar kinds of characteristics and conditional requirements like incremental and radical product innovation processes in ordinary product design (see section 3.2).

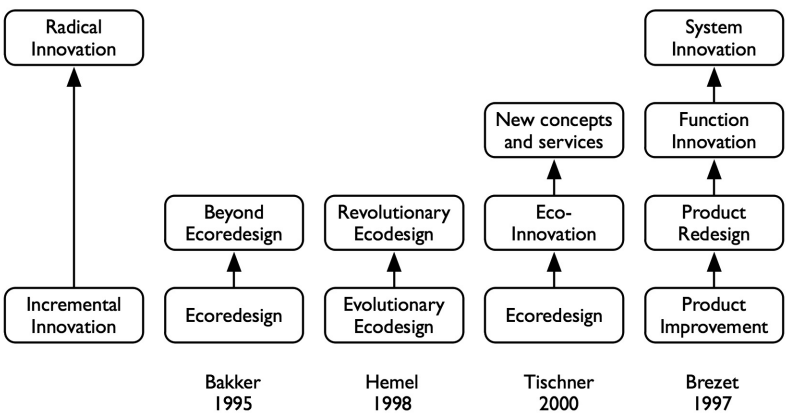

Figure 3.11: Incremental and more radical Ecodesign innovation approaches.

Ecodesign methodology and tools

The need to incorporate environmental considerations into the product development process has given birth to a variety of Ecodesign methods and tools to assist and guide the practitioner (Ehrenfeld and Lennox 1997; Baumann, Boons et al. 2002). In order to achieve environmental product improvements in practice, Ecodesign must adapt to and become a natural part of the normal product innovation process, preferably as early in the process as possible. Early product phases are widely believed to have the most influence in defining environmental aspects of products. At the of end of the design process the design freedom is very limited since most of the design parameters are settled and small changes can be made (Lofthouse 2004). Taking into consideration the environmental impact of a new product is one more task to be added and integrated into the long list of things already under consideration. Due to the complexity of the situation, there is a real need for efficient and easy-to-understand environmental methods applicable to product development and design (Lagerstedtt 2003).

Currently, there are many Ecodesign tools from simple, qualitative tools to complex quantitative software. The selection of the best tool for a given project depends on the needs and the knowledge of the user, and the degree of environmental improvement sought (Astill 2006). Generally Ecodesign tools can be classified into two groups, analysis tools and improvement tools, according to the purpose of the tools respectively. Analysis tools enable designers to identify key characteristics which determinate the environmental impacts of the products. Furthermore they make it possible to compare and evaluate different design alternatives, they may be used to benchmark a previous product or that of a competitor and they may be used at the end of a design project to validate the product improvements options (Magnusson 2001; Astill 2006). Whereas improvement tools, on the other hand facilitate generation of product improvement options (Astill 2006). Tischner et al. (Tischner, Schminck et al. 2000) have categorised Ecodesign tools in four categories: Tools for 1) Environmental analyses, 2) Creativity techniques, 3) Setting priorities & decision making and 4) Cost accounting. Based upon this last categorisation for Ecodesign tools, 18 international Ecodesign manuals have been evaluated (Diehl and Brezet 2003). In total more than 60 Ecodesign tools were identified distributed over the 4 Ecodesign tool categories (see Table 3.4).

Table 3.4: Ecodesign tools distributed over the four categories.

Ecodesign tools	**Amount**
Tools for environmental analyses	39
Creativity techniques	6
Setting priorities & decision making	10
Cost accounting	6

As can be concluded, Ecodesign tools predominantly target problem definition, rather than solution creation. The far out greater part of the Ecodesign tools fit into the category of 'tools for environmental analyses', and much less in the categories to identify improvements (Creativity techniques) and setting priorities.

The explanation for this is the fact that the Western Ecodesign manuals assume that the user already has a industrial design background and experiences and as such already posses of domain specific design knowledge as well as domain independent process knowledge (see section 3.6). For this reason relative few or no diverging (creative) and converging (selection) tools have been incorporated. The main focus of the manuals is on domain specific basic knowledge.

As we will conclude later on in this study in the empirical research, most of the knowledge recipients in developing countries do not have an industrial design background or do have earlier experiences with product innovation in practice and as such will need domain specific design knowledge as well. This will be incorporated in the design manual (Chapter 11).

3.6 Conclusion

Chapter 3 aims to further open the black box of how the transfer of the transfer of production innovation knowledge to developing countries takes place (RQ 1), especially related to the knowledge content (cluster A) and the knowledge source (cluster C). Innovation is about 'newness' and 'successful application'. Different types and levels of innovation can be distinguished. The focus of this research is on product (and partly market) innovation in a range between incremental and radical innovation. To be successful in either incremental or radical innovations requires different kinds of thinking, ways of working, and taking risks. Consequently, different types of knowledge and tools have to be transferred to the knowledge recipients in order to build up the appropriate competencies and skills for the specific innovation levels. Firms can address product and market innovation in different strategic ways.

Product innovation is neatly connected to the profession of 'Industrial Design'. Designing can be seen as a range of activities over time starting from identifying and defining the design problem till the launch of the products into the market. To support the Industrial Designer is this process many scholars have been developing design methodologies. One of them, the 'Delft Product Innovation Model' has been discussed in more detail. Three different kinds of industrial design knowledge components can be distinguished: *domain-specific* basic and design knowledge on the one hand and *domain-independent* general process knowledge on the other. Solving product innovation problems is an integration of these three. One of the domain specific basic knowledge topics is Design for Sustainability. Initially in the 90's the need to incorporate environmental considerations into the product development process has given birth to a variety of Ecodesign methods and tools especially in Europe. One of the outcomes is the in 1997 published UNEP Ecodesign manual, which is structured according to the Delft Product Innovation Model. The majority of the Ecodesign manuals still reflect a Western perspective; there is little emphasis on the developing countries and their specific environmental, economical and social challenges. Since 2000 Design for Sustainability has received greater acceptance by drawing on a more broader and holistic scope than Ecodesign by incorporating social, ethical and equity issues into design. This inclusion of the social (people) aspects has made the approach also more appropriate for developing countries since they often have to face big social challenges like income generation, education and health.


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4 Knowledge recipients in developing countries

The previous two chapters of literature review explored, described and explained the process and content of product innovation knowledge transfer. The last literature review chapter is focused on the knowledge recipients in developing countries. Based upon three groups of factors (national (4.2), organisational (4.3) and individual (4.4)) the knowledge recipient and the context in which he or she operates will be explored and described.

4.1 Introduction

As discussed in the problem context (section 1.3) a given piece of knowledge does not work in the same way in developing countries as in developed countries (Johnson and Lundvall 2001). If the knowledge source, be it a university, consultant or development organisation, has insights in and understanding of the context in which the knowledge has to function and about the context dependency, he will have better opportunities to support the necessary knowledge transfer (Jensen, Johnson et al. 2004). For that purpose this chapter attempts, based upon literature review, to identify and describe the knowledge recipient (cluster D) and the broader context in which he or she operates (cluster F).

There is wide range of factors related to the knowledge recipient, which can influence the process of knowledge transfer. In order to identify and describe the most essential ones, initially an extensive literature review was executed after knowledge recipient related factors that influence the knowledge transfer process. In total 100 statements were collected from literature, which state one or more factors and mechanisms. In a next stage these factors have been organised on national (macro), organisational (meso) and individual (micro) level. Within each of the three groups a shortlist was made of those factors, which are expected to have a relative bigger impact on the product innovation knowledge transfer. They will be discussed in the following paragraphs, starting on the national level, followed by the organisational level and in the end the individual level.

4.2 National level

First the factors on national level will be discussed, they will provide a more detailed picture of the broader context (cluster F) in which the knowledge recipient operates. The following factors will be discussed: economical, social and industrial development, national absorptive capacity and cultural dimensions. Most of these factors can be expressed in a qualitative as well as a quantitative manner (indicators). To put these numbers in perspective as well as to make an initial link to the case study research later on in our study, the relevant national indicators for the case study countries will be displayed at the end of each paragraph. The selection of the case studies will be justified in chapter five. For this part of the research it is sufficient to mention the countries in which the case studies take place: Tanzania, India, Guatemala, El Salvador, Costa Rica and Croatia. In addition to emphasize on the distance between the knowledge recipient and the knowledge source (cluster E) also the national indicators of the Netherlands (knowledge source in the case studies) will be provided. Within each table or graph the countries are exhibited in

sequence of national income, with Tanzania as first (lowest national income) and the Netherlands as last (highest national income).

Since indicators are subject to change over time, it was decided to provide and compare the data of the countries in the year 2005 (the year in which the last case study was finished).

4.2.1 Developed and developing countries

Often countries are referred to as 'developed' and 'developing' countries. However there are no uniform definitions for 'developed' and 'developing' countries. Kofi Annan, former Secretary General of the United Nations, defined a developed country as follows: "A developed country is one that allows all its citizens to enjoy a free and healthy life in a safe environment".

In practice, generally the term 'developed' countries is used for countries with developed economies in which the tertiary (service) and quaternary sectors of industry (high tech and R&D) dominate. The United Nations Statistics Division (UN 2009) considers Japan, Canada, USA, Australia, New Zealand and Europe as being developed economies. The International Monetary Fund (IMF 2008) lists every year developing countries, whereby most of them are located in Africa and Asia (see Figure 4.1). In the context of this study the list of IMF will be used to distinguish between developed countries and developing countries.

Besides developed and developing countries, also other country classifications are being aplied:

- LDC: Least Developed Countries: The 50 poorest countries in the world (mostly in Sub-Sahara Africa) (UNCTAD).
- NIC: Newly Industrializing Countries: Countries switching from an agricultural to an industrial-based economy, especially the manufacturing sector. Current examples are Brazil, China, India, Philippines, Turkey, Thailand, Malaysia, Mexico and South Africa.
- TC: Transition Countries: Those countries that undergo the process of transition from a centrally planned economy to a free market based economy, mainly the former East European countries.
- IC: Industrialized or Developed Countries.

Data for the case study countries:

Table 4.1: Classification of the case study countries.

Country	IMF	World Bank	Other
Tanzania	Developing Countries	Low-income	Least Developed Countries
India	Developing Countries	Lower-middle income	Newly Industrializing Countries
Guatemala	Developing Countries	Lower-middle income	
El Salvador	Developing Countries	Lower-middle income	
Costa Rica	Developing Countries	Upper-middle income	
Croatia	Developing Countries	Upper-middle income	Transition Countries
Netherlands	Developed Countries	High-income	Industrialised Countries

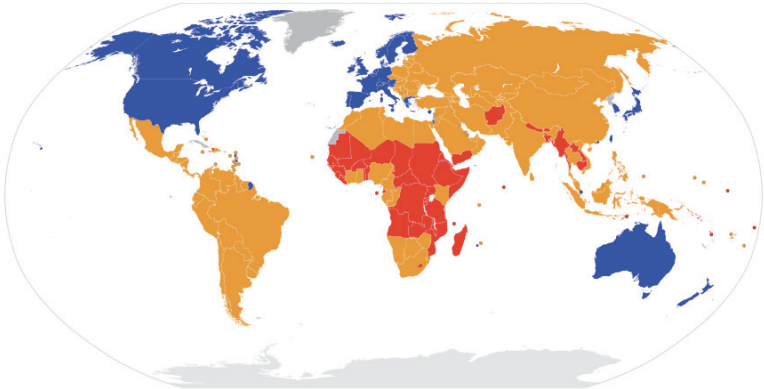

Figure 4.1: World map of 'developed' and 'developing' countries (blue = developed, orange = developing and red = least developed).

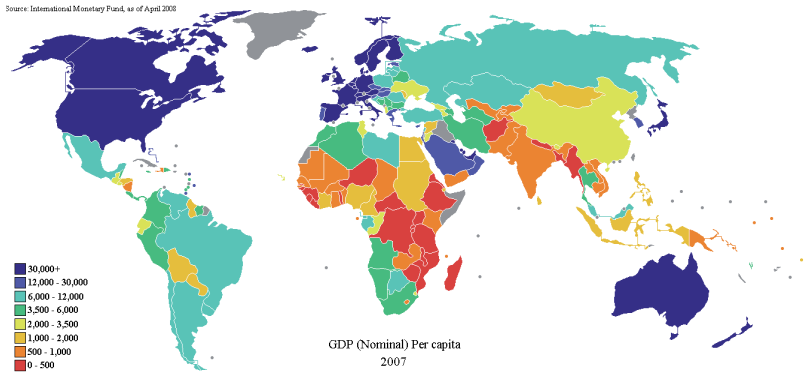

Figure 4.2: The GDP per capita in 2007 (Source: IMF 2008).

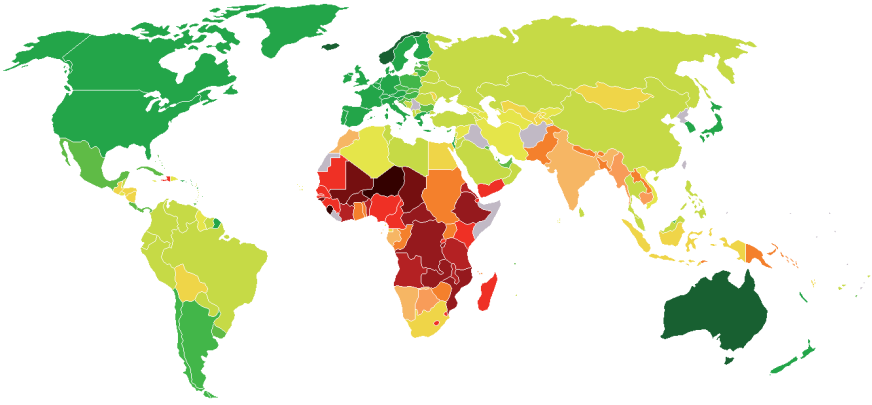

Figure 4.3: The Human Development Index (HDI) world map (high HDI = green, low HDI = red).

4.2.2 Economical and social development

A wide range of indicators can describe the economical and social development of a country. The three most relevant indicators for this study are: the Gross Domestic Product (GDP), Growth Competitive Index (GCI) and Human Development Index (HDI).

Gross Domestic Product (GDP)

The economical development of a country is commonly expressed in Gross Domestic Product (GDP) per capita and the yearly growth of it. GDP stands for the total market value of all goods and services that are produced within a country during a given period and includes the profits from all foreign-owned corporations and foreign individuals working in that country. In addition the GDP PPP per capita indicates the purchasing power of the inhabitants. The Purchasing Power Parity (PPP) is a theoretical exchange rate derived from the perceived parity of purchasing power of a currency in relation to another currency. In contrast to the 'real' exchange rate used for currencies in the official market, the PPP exchange rate is calculated from the relative value of a currency based on the amount of a 'basket' of goods the currency will buy. Typically, the prices of many goods will be considered, and weighted according to their importance in the economy. The PPP exchange rate is perceived to be a better comparison of standard of living.

Based upon their GDP, countries can be classified in different income categories. The International Monetary Fund (IMF) distinguishes two categories, advanced economies and emerging & developing economies. The World Bank divides countries in low, lower-middle, upper-middle and high income. The United Nations Development Program (UNDP) classifies countries into low, middle and high income. Figure 4.4 illustrates the average GDP and GDP PPP for the three UNDP national income groups.

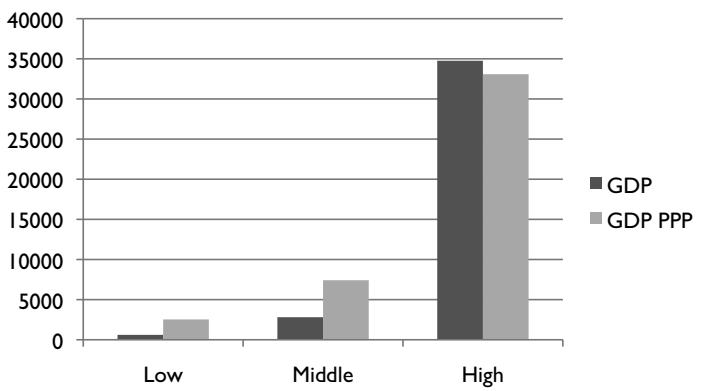

Figure 4.4: GDP and GDP PPP in US $ per capita in 2005 for the three national income groups (source UNDP).

As can be concluded from the graph, the income difference per capita between the high income and the middle and low-income countries is enormous. The relatively lower local living costs in middle- and low-income countries result in a relatively higher GDP PPP per capita.

The GDP per capita of a country is often indirect an indicator for other national developments in a country like i.e. education, R&D and relevant economical sectors (see next sections). On the other hand one should be careful by characterizing a total country on one single indicator as the GDP per capita. For example, in large countries like India and China, huge differences in development and income levels can be encountered in different regions of it.

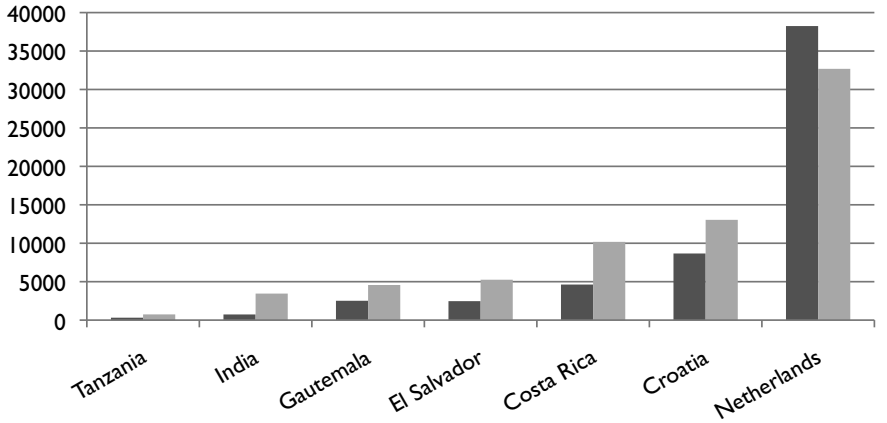

Figure 4.5: GDP (light grey) and GDP PPP (dark grey) in US $ per capita in 2005 for the case study countries (source UNDP).

Growth Competitive Index (GCI)

The process of economic growth is complex and many factors come into play as a country develops, not only the GDP. The World Economic Forum tried to capture this complexity when it started estimating the Growth Competitiveness Index (GCI). The GCI aims to gauge the ability of the world's economies to achieve sustained economic growth over the medium- to long term (Blanke, Paua et al. 2005). The GCI is composed of three 'pillars', all of which are widely accepted as being critical to economic growth: the quality of the macroeconomic environment, the state of the country's public institutions, and, given the increasing importance of technology in the development process, a country's technical readiness. The GCI highlights the strengths and weaknesses of national economics. In this way it offers a tool to get a sense of the business environment of country. Figure 4.3 depicts a world map with GCI country rankings. The highest GCI (blue) can be found in the rich developed countries, and the lowest (black) especially in the least develop countries.

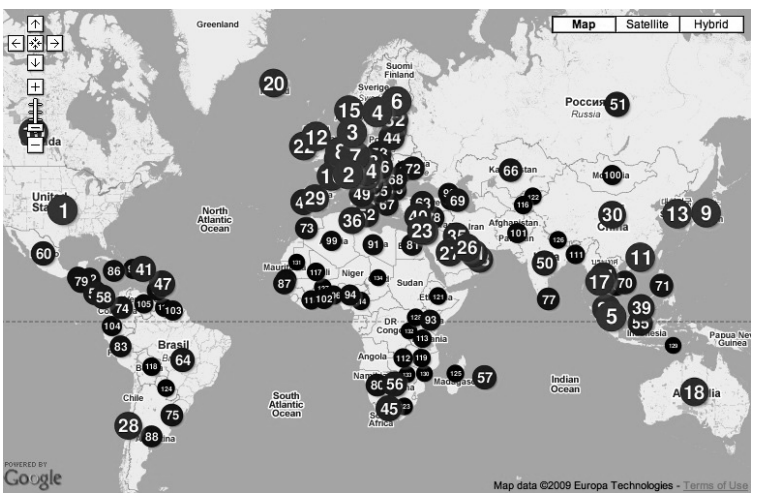

Figure 4.6: World map with the GCI country rankings (1= highest).

Data for the case study countries:

Table 4.2: GCI rankings of the case study countries (1=highest).

Country	**2001** (1-75)	**2005** (1-125)	**2008** (1-134)
Tanzania	N.A.	104	113
India	57*	43*	50*
Guatemala	66	75	84
El Salvador	58	61	79
Costa Rica	35	53	61
Croatia	N.A.	51	59
Netherlands	8	9	8

** Remark: The GCI ranking is correlated with the GDP except India. Even though India is in financial terms (GDP) still a low-income country, it does posses of high-level technical (ICT) knowledge institutions.*

Human Development Index (HDI)

The development stage of a country often relates to the economic development, but it is also closely associated to the social development in terms of education, healthcare, and life expectancy. For that reason several stakeholders argue that just GDP per capita or CGI is an incomplete measure of a country's development progress (Kenny 2004). The UNDP's Human Development Index (HDI) is a later attempt to quantify a multidimensional view of a countries social development progress. HDI is a composite index that measures the average achievements in a country in three basic dimensions of human development:

- A long and healthy life, as measured by life expectancy at birth;
- Knowledge, as measured by the adult literacy rate and the combined gross enrollment ratio for primary, secondary and tertiary schools; and
- A decent standard of living, as measured by GDP PPP per capita in US dollars.

The HDI is constructed using indicators that are available globally, and a methodology that is simple and transparent. While the concept of human development is much broader than any single composite index can measure, the HDI offers a powerful alternative to income as a summary measure of human well-being. It provides a useful indication of the economical as well as social development. According to their HDI countries can be categorized as low, medium, high and very high human development (see Figure 4.6).

Data for the case study countries:

Table 4.3: HDI rankings in 2008 of the case study countries (Source: UNDP).

Country	**HDI ranking**	**HDI category**
Tanzania	152	Medium Human Development
India	132	Medium Human Development
Guatemala	121	Medium Human Development
El Salvador	101	Medium Human Development
Costa Rica	50	High Human Development
Croatia	45	High Human Development
Netherlands	6	Very High Human Development

4.2.3 Economic relevant sectors

Economic activities in a country can be divided into agricultural-, industrial- and service-activities. The relative size of each of these sectors is often directly linked to the economic development

(GDP) of a country. In high-income economies the value added by the service sector is relatively high (72%) and the one of the agriculture sector very low (1%). The lower-middle and upper-middle income countries do have a comparative high added value by the industry (34-41%). The economic activities in low-income countries have a relative strong emphasis on agriculture activities (26%). Figure 4.7 illustrates the contribution of the three sectors to the GDP in these different country income groups. The importance of the service sector is increasing constantly in all income groups.

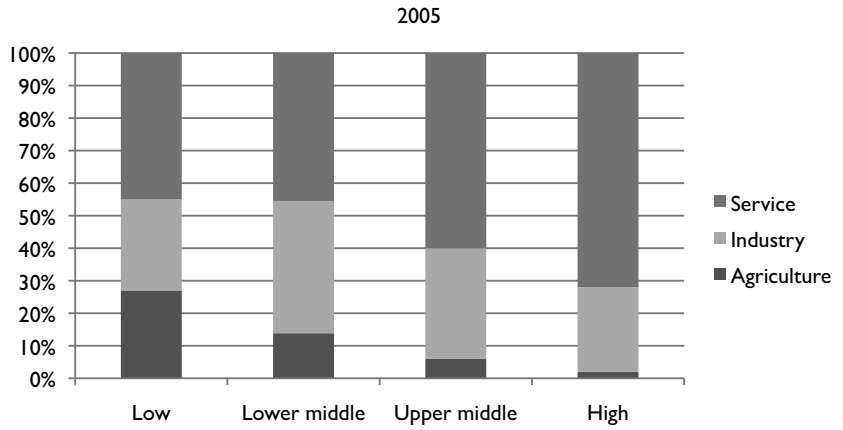

Figure 4.7: Contribution (in percentage) of agriculture (blue), industry (green) and service sector (orange) to the GDP (UNDP, 2006).

Data for the case study countries:

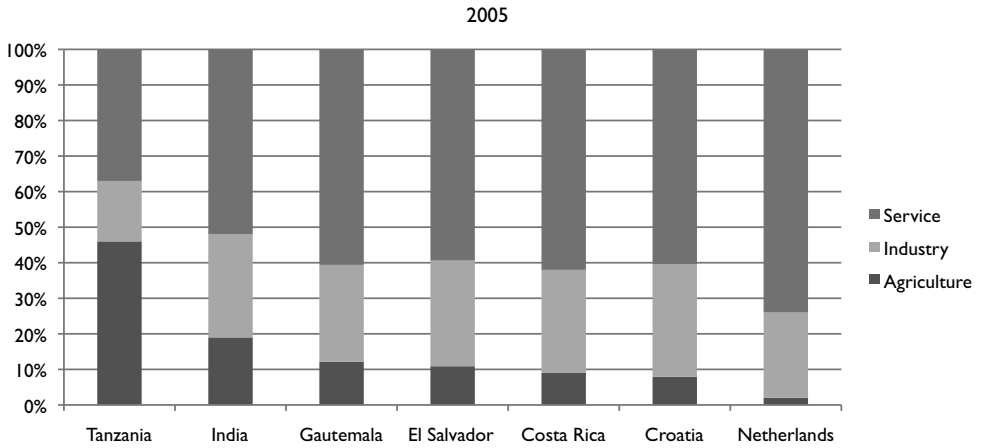

Figure 4.8: Contribution (in percentage) of agriculture, industry and service sector to the GDP of the case study countries (UNDP, 2006).

Industrial sectors

A big share of the product innovation activities takes places within the industrial sector (the industrial sector itself can be divided into sub-sectors like for example furniture, electronics and agro-processing industry). According to Kogut (2003) there is a direct link between the

economic development (GDP) of a country and its industrial activities. Developing countries are characterized by industries that are low-skill, labour intensive and not knowledge intensive. Industries in developed economies tend to have medium- and high-skilled labour, to be technology driven, and capital- and knowledge intensive. This is illustrated by Figure 4.9.

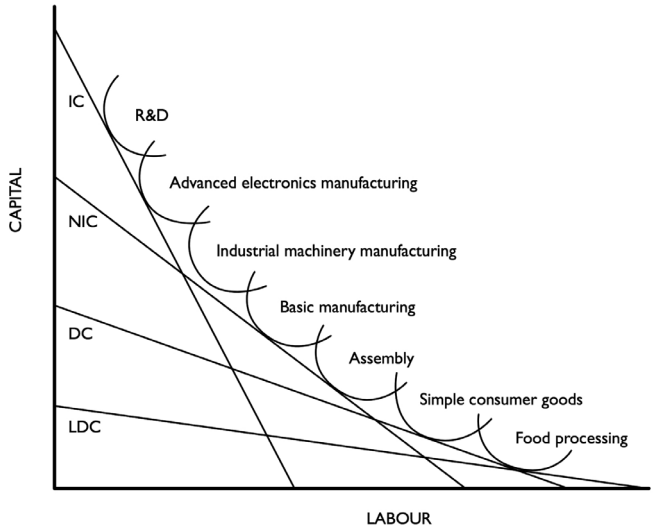

Figure 4.9 Expected industrial activities based on economical development of countries (Kogut 2003).

As Figure 4.6 illustrates, in developing countries (DC and LDC), food processing and simple basic consumer goods (like furniture) dominate the local industrial activities. In Newly Industrialising Countries (NIC) industrial activities focus on assembly (like i.e. cars), basic manufacturing and on the production of more complex technical products. Developed economies tend to concentrate industrial activities on capital- and knowledge based R&D and on advanced electronics and ICT manufacturing.

Traditionally, countries strive to move up the 'curve' of economical and industrial development from labour-intensive to more capital and knowledge-intensive economic activities and from producing simple products to more complex products (Aubert 2004; Bejakovic and Lowther 2004). This is often a gradual step-by-step process.

4.2.4 National absorptive capacity

In the case of knowledge transfer it is important that organisations in a country are able to absorb the new knowledge. This depends partly on de national absorptive capacity, which can be described by the education, R&D and ICT infrastructure in a country. Dahlman and Nelson (1995) define national absorptive capacity as 'the ability to learn and implement the technologies and associated practices of already developed countries'. Low levels of absorptive capacity in the economy limit the country's ability to effectively utilize the technological assets available to her (Adenikinju 2005). Absorptive capacity, in education as well as knowledge infrastructure, are a prerequisite for successful catch-up process (Abramowitz 1989). Inadequate infrastructures, institutions and levels of education are often thought to result in a low 'absorptive capacity' in developing countries (Al-Ghailani and Moor 1995). In such situations information and knowledge will fail to flow from developed to developing economies and catching-up will not occur (Jensen,

Johnson et al. 2004). From this perspective the factors education, R&D and ICT infrastructure will be explored in more detail.

Education

Well educated and skilled population is essential to the efficient creation, acquisition, dissemination and utilization of relevant knowledge (Chen and Dahlman 2004). Schools and universities are among the crucial institutions affecting innovative behaviour. Historically, developing a wide and diversified educational system is a key factor to generate the capabilities required for the successive stages of the industrialisation process (Montobbio and Rampa 2005). There is a significant correlation between an increased level of education in a country and the country's economic growth (Bejakovic and Lowther 2004). An additional year of education for a country's population is associated with an average increase in output per capita by four to seven percent (Bassani and Scarpetta 2001). However, educational levels are low in developing countries, and, this is a significant barrier to the development and diffusion of innovation in these countries. For example the adult literacy rate in low-income countries is only 60% and just 40% of the population enrols into the secondary education programs (see Figure 4.10).

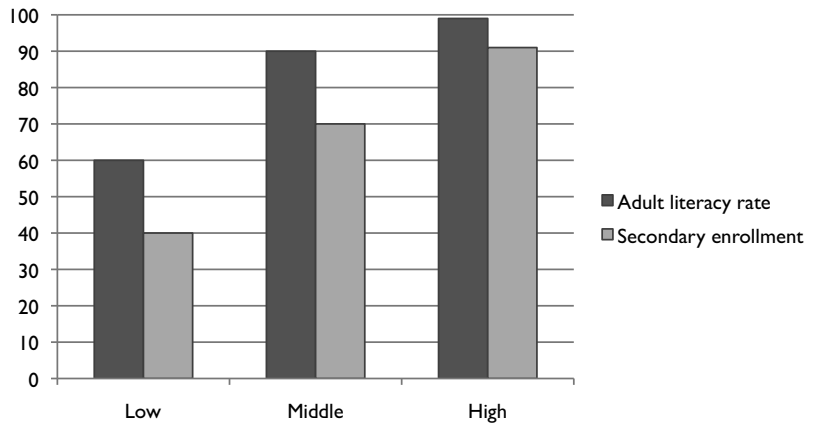

Figure 4.10: Adult literacy rate and secondary school enrolment rate in low-, middle- and high-income countries (UNDP 2005).

There is a clear relation between educational needs and the different phases of industrial development. In the pre-industrial phase, educational needs demand only basic literacy. In the industrial phase, more professional and medium-level skills are required. In the post-industrial phase, there is a need for significant share of a population with tertiary education, with the rest of the population having at least functional literacy (Aubert 2004). The production of new knowledge and its adaptation to a particular economic setting is generally associated with higher level teaching and research (Chen and Dahlman 2004).

Data for the case study countries:

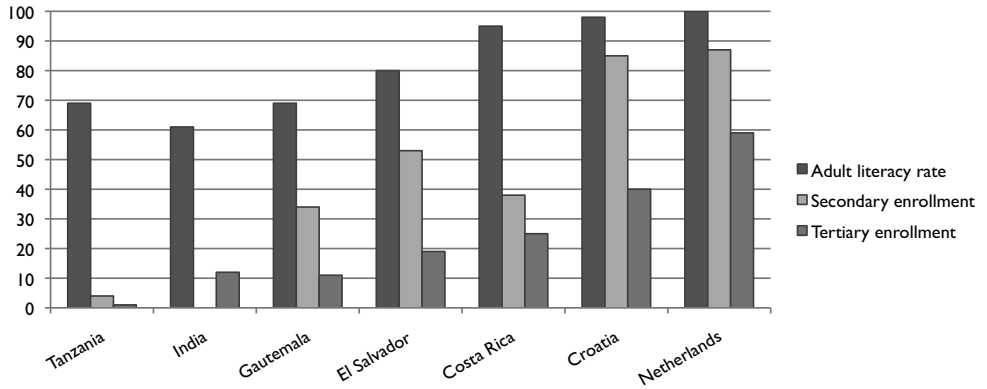

Figure 4.11: Literacy, enrolment rate in secondary school and enrollment rate in tertiary eductation as percentage of the population in the case study countries.

Research & Development

Research and development (R&D) expenditures in developing countries are low both in absolute terms and relative to GDP (Montobbio and Rampa 2005) (see Figure 4.12). While high-income countries spend 2.44% of their GDP on R&D, low-income countries only spend 0.73% of their already low GDP.

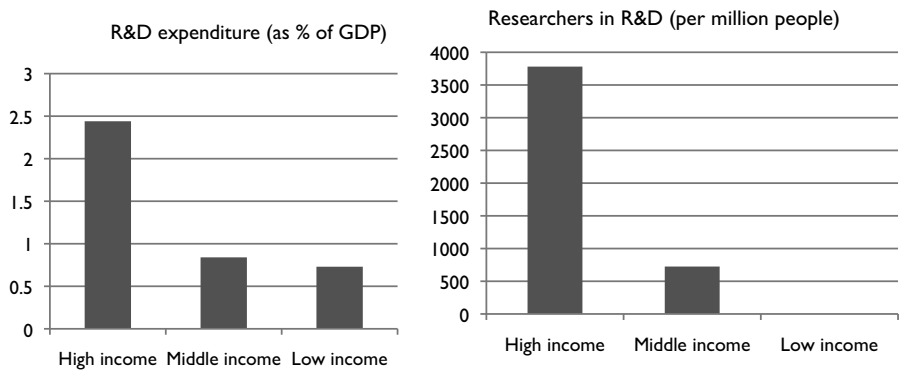

Figure 4.12: R&D expenditure as percentage of GDP (left) and amount of researchers R&D (per million people) in high-, middle- and low-income countries (source UNDP 2005).

On the knowledge side, there is generally a limited research community in developing countries. High income countries employ 3781 researchers per million inhabitants while middle income countries only 725 (see Figure 4.12). In addition developing countries are characterised by low levels of R&D in the business sector, with the bulk of national R&D effort done by university and government laboratories (Montobbio and Rampa 2005) (Aubert 2004).

These public sector institutions tend to be numerous and with questionable relevance for the economy. In this often-overcrowded support system, it is not easy to establish new, efficient organizations for the promotion of innovation. Where this is possible, the organizations are rarely appropriate, lacking the flexibility and drive crucial for innovation and entrepreneurship

(Aubert 2004). Besides, the university systems in developing countries are often poorly connected to local realities, particularly to labor market needs and business opportunities (Aubert 2004).

More specific for product innovation, there is a general lack of information and local expertise available to support the product innovation process in firms. The knowledge available is mainly concentrated in the technical institutes in urban areas with working experiences primarily in the large industries and are not easy accessible for (rural) SMEs (Masera, Crul et al. 2004).

ICT Infrastructure

ICT infrastructure within an economy refers to the accessibility, reliability and efficiency of computers, phones, television and radio sets, and the various networks that link them (Chen and Dahlman 2004). Mobile phone technology has transformed the conditions of telecommunications in developing countries. Nevertheless the mobile phone density remains weak in a number of developing countries. In 2007, still only 22% of the people in low income countries did have a mobile cellular subscription (against 100% in high income countries) (see Figure 4.13).

Progress made with mobile phone technology can lead to rapid improvements in connectivity, however it does not solve the necessity for greater internet penetration – something which remains quite low in most developing countries, especially in Africa (Aubert 2004). The Internet can provide knowledge recipients in developing countries with a fast and direct access to the knowledge sources and could provide leapfrog knowledge development. However the digital divide between the developed and developing countries is still huge. Access is still relatively expensive and the connections slow and not always reliable (Rodrigues, Thompson et al. 2007). In 2007, only 5 percent of the population of low income countries was an Internet user (see Figure 4.10) and the possession of PC very low (for example 1.6 PCs per 100 people in Uganda (UN 2009)).

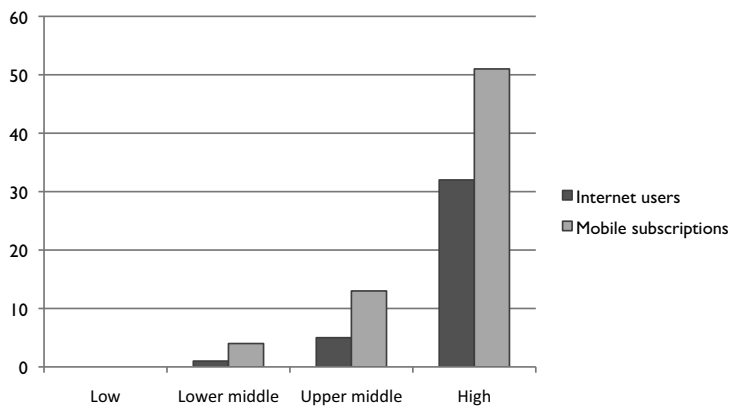

Figure 4.13: Mobile cellular subscriptions per 100 people (red) and Internet users per 100 people (blue) in 2001 (source WorldBank 2007).

Data for the case study countries:

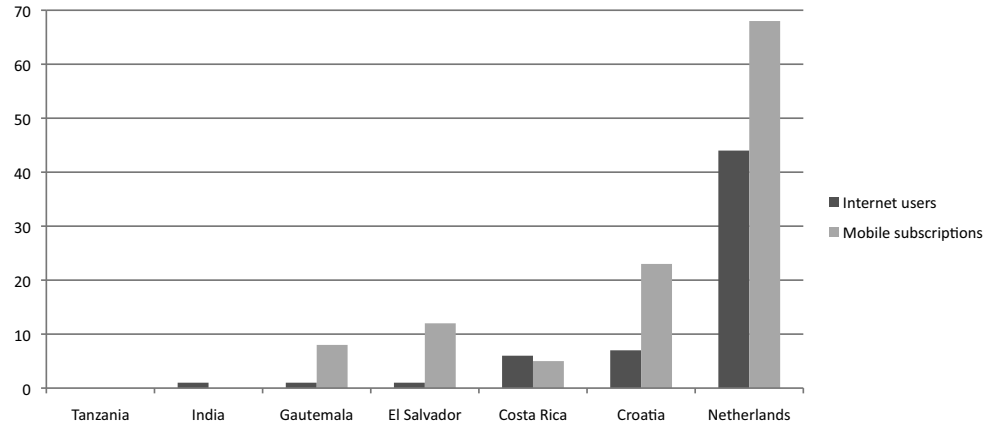

Figure 4.14: Mobile cellular subscriptions per 100 people (red) and Internet users per 100 people (blue) in 2001 in the case study countries (source WorldBank 2007).

4.2.5 Industrial design competences

While in industrialised countries, Industrial Design has been seen as increasingly important to international competitiveness, in developing countries (especially in the more poor ones) the same has not been true (Jansen 1995; Viljoen 1997). The contrast to developing countries is enormous. It is only recently that the industrial design of products has been seen as being an important factor and developing countries are beginning to focus on building this expertise. There are a number of reasons why design was not seen as being important in the past. One of them is the fact that up until the 1980s most developing countries had a policy of import substitution industrialisation. This had the effect of closing off markets to 'better designed' competitive imported products. In addition, high levels of state involvement in manufacturing and (partly) state run enterprises had a tendency to be more production- than product/market-driven. Closed market economies created low incentives for companies to innovate (Murray 2004).

Nevertheless, developing countries are increasingly concerned with design promotion and practice, especially in the light of globalisation of markets (Jansen 1995). For example, in South East Asia, formal product design activities and capacity building have been established parallel to the development policies. A successful example is South Korea. Due to their dependence on foreign buyers and MNCs, South Korea started to differentiate products by incorporating product design and product innovation into its their economic policies. As a result, South Korea has developed from a country competing on low technologies, imitation and cost leadership in the 1960s towards a nation competing on user-centered design and pioneering approaches (see Figure 4.15) (Chung 2004; Chung 2004).

Year	GDP	Level of Technology	Pattern of Manufacturing	Industry Strategy	Design Strategy
1960s	$ 80	Low Technology	Original Equipment Manufacture	Overall Cost Leadership	Design to Cost Imitator
1990s	$ 5.000	Medium Technology	Mass Production	Differentiation	Image Design Improver / Modifier
2000s	$ 10.000	High Technology	Mass Customization	Focus	USER-Centered Design Pioneer

Figure 4.15: Development of South Korea from cost leadership to design leadership (Chung 2004).

At a macro-economic level, there is a strong positive correlation between the use of design and national competitiveness (EU 2009). The New Zealand Institute of Economic Research (NZIER) developed an indicator to express the design competencies of a nation. By selecting indexes from the World Economic Forum's GCI report a country design ranking was developed (Labone 2003; Villela 2004). The selected indexes are: Extent of branding, uniqueness of product design, extent of marketing, production process sophistication and capacity of innovation. It was concluded that there is a direct correlation between design competitiveness and a country's GCI (see Figure 4.16). It clearly indicates that a country with a low GCI ranking most probably also will have a low design ranking (and low design capabilities and support). Roughly three clusters can be identified 1) Small and poor developing countries, 2) Big developing countries, middle developed countries and East Europe, 3) NICs and rich countries.

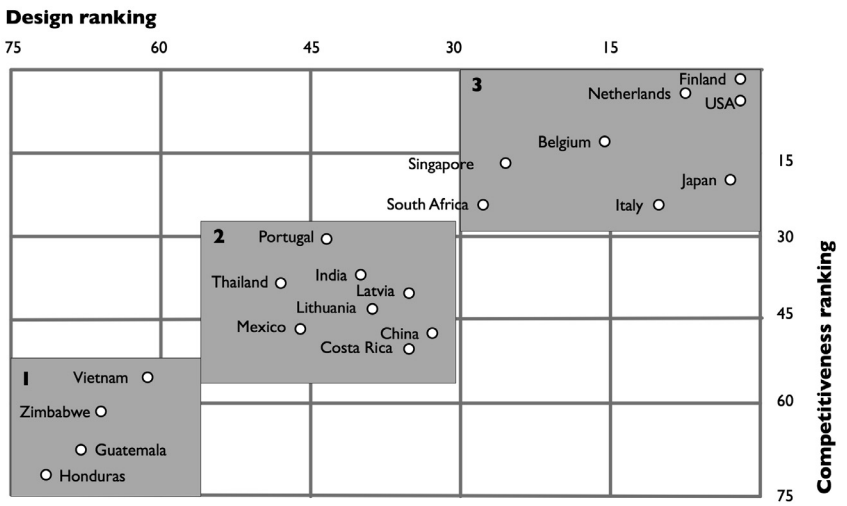

Figure 4.16: Correlation graphic of Global Competitiveness Index (GCI) and Design Competitiveness. Cluster 1: Small and poor DCs cluster 2: Big DCs, middle developed DCs and East Europe Cluster 3: NICs and rich countries.

4.2.6 Cultural dimensions

The last factor on national level is culture. In any social system, including the one of knowledge transfer, culture serves as a perceptual framework that guides the interpretation of interaction and the construction of meanings. Several scholars (Tylee ; Hofstede 1986; Chute 1989; Cortazzi 1990; Blackmore 1996; Geidt 1996; Evers 1997; Mclsaac and Gunawardena 1997; Shrestha 1997; Marcus and Gould 2001; Zahedi, Pelt et al. 2001; Smith, Dunckley et al. 2004), point out that it is

reasonable to assume that different cultures will have different preferences for the way that knowledge is acquired and processed. For example different culture groups might prefer learning by seeing or hearing, reflecting or acting, reasoning logically or intuitively, analysing or visualising and so forth. In educational institutions, this can include perceptions regarding right, rules, roles and unspoken assumptions about how to learn and what is worth learning (Hofstede 1986; Cortazzi and Jin 1997). Chute (1989) in his research concluded that "a successful cross-cultural training experience requires appropriate awareness of cultural differences and instructional design strategies". From this perspective cultural dimensions and their impact on the knowledge transfer will be discussed.

Culture

One of the most cited definitions of culture is the one of Hofstede (1980; 1991). Hofstede defines culture as 'mental software programmes' for thinking, feeling and behaving which are learned largely in early childhood and which are shared by people who live in the same social environment. Another prominent scholar in this field, Hall (1973; 1977) defines culture as "the primarily system for creating, sending, storing and processing information. Culture stands for the way of life of people, for the sum of their learned behaviour patterns, attitudes and material things".

Next to 'national cultures', we often also distinguish 'corporate or organisational cultures'. Robbins (1998) pointed out that, when organizational behaviour is investigated in different countries, the impact of national culture on employees is always intertwined with that of corporate or organisational culture. In addition Robbins' research demonstrated that national culture has a greater impact on the employees than does their corporate culture. Hofstede (1991) concluded in his research that at the national level, cultural differences reside mostly in values, less in practices. On the other hand, at the corporate level, cultural differences reside mostly in practices, less in values. Within this paragraph the focus is on national culture. The impact of the organisational culture will be discussed in section 4.3.

Cultural dimensions

Several scholars have been developing models to classify cultures. Hall (1966; 1973; 1977) was one the first scholars in the end fifties who came up with a structured approach. Hall distinguishes four aspects of culture: high vs. low context, polychromic vs. monochromic time orientation, space and speed of message. Although the first two aspects are very useful and easily to observe, the lack of empirical data makes this cultural model less suitable for 'describing' and 'comparing' cultural dimensions of a country (Dahl 2004). This lack of precision, and the lack of universally applicable framework for classifying cultural patterns, has been addressed by a number of researchers since then. The two more renowned ones are Trompenaars and Hofstede, both with a Dutch background. Their cultural models are based on a large range on interviews and surveys. Trompenaars (1993; 1997) classified cultures along a mix of behavioural and value patterns, which resulted in seven cultural dimensions (universalism vs. particularism, analyzing vs. integrating, individualism vs. communitarianism, inner-directed vs. outer-directed, time as sequence vs. time as synchronization, achieved status vs. ascribed status, and equality vs. hierarchy).

The most cited work in this area is the cultural model of Hofstede (1980; 1991). Hofstede derived his five cultural dimensions from examining work related values in employees of IBM (>100.000 samples). He rated 58 countries on each dimension on a scale from 1 to 100. The next table provides a short description of the five cultural dimensions of Hofstede:

Table 4.4: The five cultural dimensions of Hofstede.

Dimension	Description
Individualism – Collectivism (IDV)	Individualistic cultures expect their members to be independent and look after themselves. Collectivistic cultures have a tightly knit framework of mutual dependencies and obligations.
Power distance (PDI)	High power distance cultures accept unequal distribution of power within society. Low power distance cultures strive for equalization and participation.
Uncertainty-avoidance (UAI)	Strong uncertainty avoidance cultures attempt to control uncertainty by strict rules and codes of behaviour. Weak uncertainty avoidance cultures are not as strictly controlled and deviation is more acceptable.
Masculinity-femininity (MAS)	Masculine cultures emphasizes achievement, success and assertiveness. Feminine cultures emphasize caring, close relationship, and harmony.
Long-term/short-term orientation (LTO)	Long-term oriented cultures promote the family, respect for older people, and virtuous behaviour such hard work and frugality. Short-term oriented cultures develop equal relationships, emphasize the individual, and promote creativity and self-actualization.

Power distance scores are typically high for Latin, Asian and African countries and smaller for Germanic countries. Individualism prevails in developed and Western countries, while collectivism prevails in less developed and Eastern countries. Masculinity is high in Japan, in some European countries like Germany, Austria and Switzerland, and moderately high in Anglo countries; it is low in Nordic countries and in the Netherlands. Uncertainty avoidance scores are higher in Latin countries, in Japan, and in German speaking countries, lower in Anglo, Nordic, and Chinese culture countries. A Long Term Orientation is mostly found in East Asian countries, in particular in China, Hong Kong, Taiwan, Japan, and South Korea (Hofstede 2002).

Data for the case study countries:

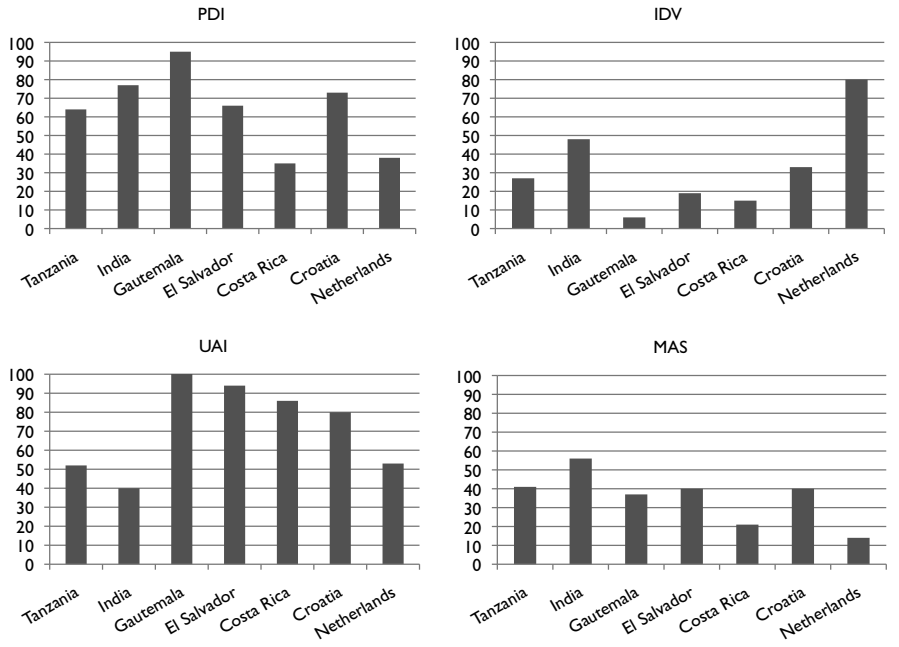

Figure 4.17: Scores on the four cultural dimensions of Hofstede in the case study countries.

Cultural dimensions and education

As mentioned cultural considerations are important in any teaching design, and as a result are increasingly recognized as a crucial variable in the area of amongst others curriculum design (Buckley). Hofstede (1986) was one the first scholars to connect cultural dimensions to learning. In 1986 he extended the context of his framework by examining the cultural dimensions in the context of teaching in cross-cultural settings. Hofstede suggested four factors to consider in developing cross-cultural curriculum:

1) Differences in the social positions of teachers and students in the two societies;
2) Differences in the relevance of the curriculum in the two societies;
3) Differences in profiles of cognitive abilities between the populations, and
4) Differences in expected patterns of teacher/student and student/student interaction.

Table 4.5 shows the cultural differences for teaching and education according to Hofstede. It is important to remember that the table provides a description of two extreme environments and characteristics for majority of countries would lie somewhere in between.

Table 4.4 The cultural dimensions of Hofstede translated to the context of education (Hofstede 1986).

Small Power Distance societies	**Large Power Distance societies**
1 Stress on impersonal "truth" which can in principle be obtained from any competent person	2 Stress on personal "wisdom" which is transferred in the relationship with a particular teacher (guru)
3 A teacher should respect the independence of his/her students	4 A teacher merits the respect of his/her students
5 Student-centred education (premium on initiative)	6 Teacher-centred education (premium on order)
7 Teacher expects students to initiate communication	8 Students expect teacher to initiate communication
9 Teacher expects students to find their own paths	10 Students expect teacher to outline paths to follow
11 Students may speak up in spontaneously in class	12 Students speak up in class only when invited by the teacher
13 Students allowed to contradict or criticize teacher	14 Teacher is never contradicted nor publicly criticized
15 Effectiveness of learning related to amount of two-way communication in class	16 Effectiveness of learning related to excellence of the teacher
17 Outside class, teachers are treated as equals	18 Respect for teachers is also shown outside class
19 In teacher/student conflicts, parents are expected to side with the student	20 In teacher/student conflicts, parents are expected to side with the teacher
21 Younger teachers are more liked than older teachers	22 Older teachers are more respected than younger teachers
Collectivist Societies	**Individualist Societies**
23 Positive association in society with whatever is rooted in tradition	24 Positive association in society with whatever is "new"
25 The young should learn; adults cannot accept student role	26 One is never too old to learn: "permanent education"
27 Students expect to learn how to do	28 Students expect to learn how to learn
29 Individual students will only speak up in class when called upon personally by the teacher	30 Individual students will speak up in class in response to a general invitation by the teacher
31 Individuals will only speak up in small groups	32 Individuals will speak up in large groups
33 Large classes split socially into smaller cohesive subgroups based on particularist criteria (e.g. ethnic affiliation)	34 Sub groupings in class vary from one situation to the next based on universalist criteria (e.g. the task "at hand")
35 Formal harmony in learning situations should be maintained at all times (T-groups are taboo)	36 Confrontation in learning situations can be salutary; conflicts can be brought into the open
37 Neither the teacher nor any student should ever be made to lose face	38 Face-consciousness is weak
39 Education is a way of gaining prestige in one's social environment and of joining a higher status group	40 Education is a way of improving one's economic worth and self-respect based on ability and competence
41 Diploma certificates are important and displayed on walls	42 Diploma certificates have little symbolic value
	44 Acquiring competence is more important than acquiring certificates
	46 Teachers are expected to be strictly impartial

43 Acquiring certificates, even through illegal means (cheating, corruption) is more important than acquiring competence 45 Teachers are expected to give preferential treatment to some students (e.g. based on ethnic affiliation or on recommendation by an influential person)	
Feminine Societies	**Masculine Societies**
47 Teachers avoid openly praising students 49 Teachers use average student as the norm 51 System rewards students' social adaptation 53 A student's failure at school is a relatively minor accident 55 Students admire friendliness in teachers 57 Students practice mutual solidarity 59 Students try to behave modestly 61 Corporal punishment severely rejected 63 Students chose academic subjects in view of intrinsic interest 65 Male students may chose traditionally feminine academic subjects	48 Teachers openly praise good students 50 Teachers use best students as the norm 52 System rewards students' academic performance 54 A student's failure at school is a severe blow to his/her self-image and may in extreme cases lead to suicide 56 Students admire brilliance in teachers 58 Students compete with each other in class 60 Students try to make themselves visible 62 Corporal punishment occasionally considered salutary 64 Students chose academic subjects in view of career opportunities 66 Male students avoid traditionally feminine academic subjects
Weak Uncertainty Avoidance Societies	**Strong Uncertainty Avoidance Societies**
67 Students feel comfortable in unstructured learning situations: vague objectives, broad assignments, no timetables 69 Teachers are allowed to say "I don't know" 71 A good teacher uses plain language 73 Students are rewarded for innovative approaches to problem solving 75 Teachers are expected to suppress emotions (and so are students) 77 Teachers interpret intellectual disagreement as a stimulating exercise 79 Teachers seek parents' ideas	68 Students feel comfortable in structured learning situations: precise objectives, detailed assignments, strict timetables 70 Teachers are expected to have all the answers 72 A good teacher uses academic language 74 Students are rewarded for accuracy in problem-solving 76 Teacher are allowed to behave emotionally (and so are students) 78 Teachers interpret intellectual disagreement as personal disloyalty 80 Teachers consider themselves experts who cannot learn anything from lay parents - and parents agree

Cultural dimensions and knowledge processing

Several scholars (Nonaka and Takeuchi 1995; Bhagat, Kedia et al. 2002) argue that Hofstedes dimension 'individualism-collectivism' is the major distinguishing characteristic in the way that various societies of the world analyze and process information. Individualism and collectivism strongly influence ways of thinking. In making sense of events, collectivists emphasize historical and contextual information and knowledge to a greater extent than individualists. People in collectivist cultures are less likely than individualists to emphasize the significance of information that is written and codified and are more likely than individualists to disregard such information. In contrast, people in individualists societies pay closer attention to personal goals over collective goals and emphasize rational analyses over historical and contextual information. Individuals look for information in its acontextual, and they emphasize the significance of information in written and codified form and are more likely to accept such information.

As discussed in section 2.10 three different dimensions of knowledge can be distinguished (i.e. simple versus complex, tacit versus explicit, and independent versus systemic). Table 4.5 summarizes the relative emphasis on these knowledge dimensions in individualist and collectivist societies. It shows that while people in individualist and collectivist cultures do not differ in terms of their preferences for handling either simple or complex types of knowledge, people in individualist cultures emphasize explicit knowledge, whereas those in collectivist cultures emphasize tacit information and knowledge. People in individualist cultures prefer knowledge

independent of its context, whereas those in collectivist cultures prefer systemic or contextually relevant knowledge.

Table 4.5: Relative emphasis of different facets of knowledge by people in individualist and collectivist cultures (Bhagat, Kedia et al. 2002).

Dimension of knowledge	Individualist cultures	Collectivistic cultures
Simple versus complex	No distinct preferences for handling either simple or complex knowledge	
Tacit versus explicit	Explicit	Tacit
Independent versus systemic	Independent	Systemic
Case study countries	Netherlands, India	Tanzania, Gautemala, Costa Rica, El Slavador, Croatia

This can be illustrated for example for the case of on-line learning. Dutch (individualistic), for example, prefer factual detail in documents and are likely to thoroughly read and absorb written documents. Consequently, Dutch may be likely to tolerate a substantial amount of textual material in web documents. Other cultures, such as Latin American (collectivistic), place a high value on personal and oral communication. Lengthy text-oriented web pages may not appeal to individuals from these cultures, but they might respond well to the same information punctuated strategically by sound clips and video clips presenting speakers quoting from authorities they know and respect (Zahedi, Pelt et al. 2001).

4.3 Organisational level

After discussing the factors on national level in the previous part of this chapter, this paragraph will talk about the factors on organisational (firm) level especially in developing countries. Because of two reasons the focus will be on Small and Medium Sized enterprises (SMEs).

Firstly, SMEs in developing economies face major challenges in strengthening their human and institutional capacities. They often lack the in-house knowledge and capacities and as such depending on external (knowledge) support. Secondly SMEs are often the backbone of the local economy and are ideal organisations for sustainable economical development as well as increase of employment because of the following arguments (UNIDO 2003; Masera, Crul et al. 2004):

- SMEs tend to lead to a *more equitable distribution* of income than larger enterprises. In addition, they are less concentrated in urban areas than the larger companies and thus create employment also in rural areas;
- SMEs contribute to a *more efficient allocation of resources* in developing countries. They often adopt labour intensive production methods and thus reflect the resource endowment in emerging countries were labour is plentiful and capital is scarce;
- SMEs *support the building of productive capacities*. They help to absorb productive resources at all levels of the economy and contribute to the establishment of dynamic and resilient economic systems in which small and large firms are interlinked.

Because of these two reasons SMEs are often the target group for international product innovation knowledge transfer projects. From this perspective, specifically the role and development of the SME sector in developing countries is explored more in depth.

4.3.1 Classification of companies

Different-sized enterprises have different ways of operating and innovation capabilities. The enterprise sector can be divided by size into small and medium sized enterprises (SMEs) and large industries. The term SMEs covers a heterogeneous group of business ranging from a single artisan working in a small shop making handicrafts for a village market, to a sophisticated engineering firm selling in overseas markets. Several criteria can be used to define company size

such as the number of employees, the sales value and production equipment value. Each of these can be useful (Wignaraja 2003). However, most often companies are being classified on their number of employees.

The World Bank defines medium-sized enterprises as those smaller than 250 employees and small enterprises as those with less than 50 employees. At the lower end of the SME sector, micro enterprises consist of companies made of self-employed and those with less than 10 employees. Irrespective of the level of development, a significant proportion of the micro, and sometimes, small enterprises are found in the informal sector or shadow of a country (OECD 2004). Informal enterprises are those that operate outside of the regulatory and legal environment. They are not formally registered and do not pay taxes. These classifications are illustrated in Figure 4.18.

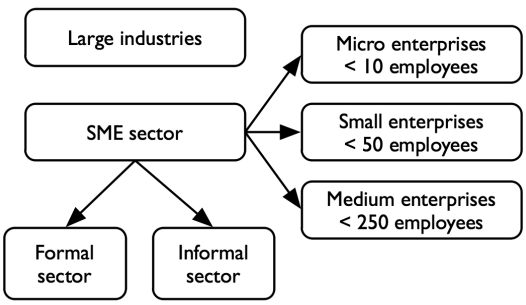

Figure 4.18: Classification of enterprises.

The enterprise sector, especially in least developed countries (i.e. Sub-Saharan Africa), shows often a distinct dual structure. At one extreme there exist a few large modern capital-intensive, resource-based, import dependent and often foreign owned enterprises, while at the other extreme there are small and informal sector (micro) enterprises that use very simple and traditional technologies and serve a limited local market (UNCTAD 1999). For a healthy economical development firms over the total spectrum (micro, small, medium and large) are needed. However, firm size in especially Sub Saharan Africa is only a fraction for comparable economies. Size is imperative for knowledge creation and storage (Oyeyinka 2004).

4.3.2 The role of SMEs in developing countries.

Most enterprises in developing countries are SMEs (OECD 2004). SMEs are the backbone of the private sector and have a significant role to play in economic development in general. These firms typically account for more than 90% of all firms outside the agricultural sector, constitute a major source of employment and generate significant domestic and export earnings. The SME and informal sector together account for over 60% of GDP and up to 70% of total employment in low-income countries (Ayyagari, Beck et al. 2003; OECD 2004). In low-income countries the contribution of SME's to employment and GDP is less than that of the informal sector. The informal sector in these countries is believed to account for over half of GDP and is mainly made up of micro enterprises (see Figure 4.19) (Morris, Jones et al. 1997; Schneider and Enste 2000; OECD 2004).

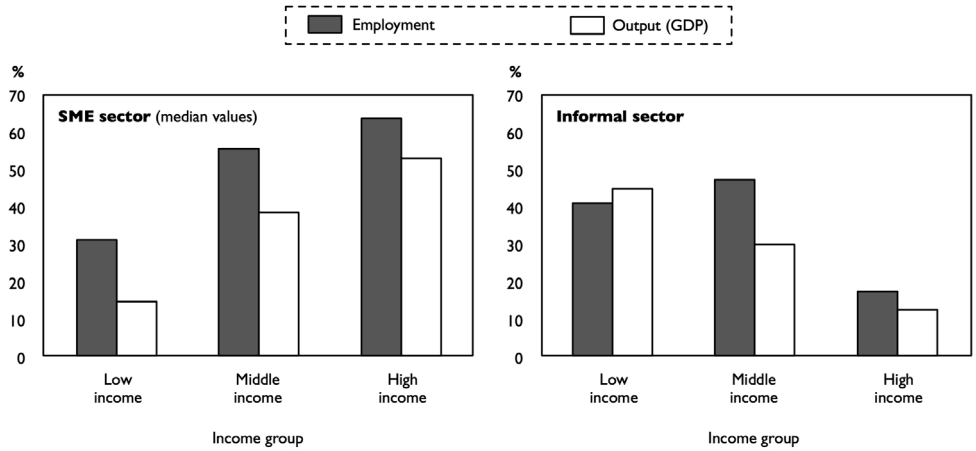

Figure 4.19: The contribution to employment and GDP of the SME and informal sector (Ayyagari, Beck et al. 2003; OECD 2004).

4.3.3 Characteristics of the SME and informal sector

In general, SMEs share a number of characteristics that make them attractive for targeting product innovation projects. They are able to react quickly and efficiently to market changes. In addition, SMEs can achieve high growth by focusing on particular product groups, avoiding spreading their marketing activities too widely, avoiding operating in markets dominated by large firms by choosing carefully the markets in which they operate (Mahemba and Bruijn 2003).

Despite the fact that there is considerable experience accumulated in the field of innovation in industrialised countries, much of this is not directly applicable to developing countries because of the nature the latter are facing. According to Diyamett (2004) the available innovations models are based exclusively on the empirical observations from the developed world. Very little is known about innovativeness of firms in developing countries. Even less is known regarding SMEs and micro-enterprises in this context. Only a few studies exist to help us to understand the overall system in which they operate which is essential to realize how they function and interact with the surrounding environment (Diyamett 2004; Masera, Crul et al. 2004).

SMEs in developing countries suffer from problems such as the lack of: capital, access to markets, finances, qualified personnel, training, and technological and marketing capabilities (Er and Ergin 2003; Masera, Crul et al. 2004). As a result a significant section of SMEs in developing countries remains in traditional activities generally with low levels of productivity, poor quality products, serving small, localised markets (Lall 2000). Due to globalization, liberalization of markets, rapid advances in information, communication and production technologies dynamics have created stiff competition. Local SMEs face the competition of international competitors entering into their local markets (Jones-Evans 1998; Wignaraja 2003).

Dynamic SMEs

According to Wignaraja (2003) and Lall (2000) a dualistic pattern of SME growth and exporting is visible in developing countries whereby a small, relative dynamic SME sector co-exist with a large under performing SME sector. The former have taken advantage of the new opportunities offered by globalisation and invested in their manufacturing capabilities to bring them up to the world of standards of price, quality and delivery. Those most likely to survive are the ones with export potential, and which, in addition grow from small into efficient medium-sized firms

(UNCTAD 1999). Dynamic SMEs mostly are found in newly industrialising countries with strong entrepreneurial bases, vibrant export sectors and a large base of educated and technical manpower. The majority of the Least Developed Countries (particularly in Sub Saharan Africa) have to face a lack of dynamic SMEs (Wignaraja 2003).

Characteristics of the informal sector

The informal sector covers a wide range of market activities that combine two groups of different natures. On the one hand, the informal sector is formed by the coping behaviour of individuals and families in economic environment where earning opportunities are scarce. On the other hand, the informal sector is a product of rational behaviour of entrepreneurs that desire to escape regulation. The informal sector plays an important and controversial role. It provides jobs and reduces unemployment and underemployment, but in many cases the jobs are low paid and job security is poor. It bolsters entrepreneurial activity, but to the detriment of regulation compliance - particularly tax and labour regulations. The informal sector can be characterized by (Laughlin, Salome et al. 1990):

- The use of family and unpaid labour (apprentices) and reliance on manual labour rather than on sophisticated machinery and equipment;
- Flexibility, allowing people to enter and exit economic activities in response to market demand;
- Simple and sometimes precarious facilities;
- A willingness to operate businesses at times and locations convenient to customers; and;
- A tendency to locate smaller markets, out of reach of the larger firms.

SME innovation strategies in developing countries

The more radical product innovation approaches (see section 3.2) require a number of factors such as a high level of technological capabilities, strong R&D and a pool of multidisciplinary skills. Because of this high demand for such resources they are often not feasible for SMEs in developing countries (Mahemba and Bruijn 2003). As a result SMEs in developing countries are mainly involved in incremental innovations, which to a large extent are cheaper and largely achieved through learning by doing, learning by using and interaction with the customer and a minimum of risk and no direct expenditure on R&D (Crul 2003; Diyamett 2004; Liet 2004; Masera, Crul et al. 2004). However, even for successful incremental innovation, a certain level of capabilities and a range of resources have to be available within the SME (Mahemba and Bruijn 2003).

A typical incremental innovation approach is copying. In most developing economies, copying (or imitating) is the prevalent method to develop new products (Romijn 1996; Adeboye 1997; Crul 2003; Mahemba and Bruijn 2003; Liet 2004; Masera, Crul et al. 2004). Products from (foreign) competitors are analysed, adapted and copied. Copying is done from physical products, product brochures, digital product information on the Internet and visits to product fairs. This process of copying or imitating competitors is in line with the idea of benchmarking - learning from others in order to improve strategies, processes and products (Boks and Stevels 2003).

4.3.4 Absorptive capacity and capabilities

As discussed in section 4.3.4, it is the firm's level of absorptive capacity that shapes the extent to which firms can benefit from knowledge available in global and local networks (Bell and Giuliani 2007). In order to identify, assimilate and adapt knowledge that is needed for innovation and to engage in interactive learning, accumulating qualified human capital is crucial (Lall 1992; Chaminade and Vang 2006). As local firms in developing countries generally have only limited access to human capital, management skills and competences, their available absorptive capacity

is rather insufficient. As such firms in developing countries can be characterized in general by low levels of absorptive capacity (Sowden, McKibbin et al. 2004; Szogs, Chaminade et al. 2008).

According to Biggs (2002) it is fundamental to understand firms' limited ability to learn from sources other than their own accumulated experience. All over the world enterprise learning takes place via a wide set of market and non-market mechanisms: interactions with buyers and suppliers, in-house and external training, hiring of employees from advanced countries, hiring of technical consultants, linkages with government or private research organizations. In developing countries many of these learning mechanisms are weak, or missing in some cases, and enterprise learning is restricted. For example Biggs et al. (1996) provide empirical evidence that weaknesses in these mechanisms, in sub-Saharan Africa, have detrimental affects on enterprise productivity.

SMEs in developing countries have special problems in upgrading their capabilities since they generally oriented toward domestic markets and do not have many links with foreign knowledge flows. Further, SMEs do not have the technical and engineering personnel available to facilitate learning from some of the mechanisms used by larger firms. Small firms often "don't know what they don't know". An increased educated labor force finds it easier to adopt foreign technology and knowledge and are more rapidly to develop its own. The creation and role of 'mid level' craft and technician skills are crucial to the absorption and use of production innovation knowledge and to informal R&D innovative activities.

Understanding the current (technological) capabilities, skills and the absorptive capacity of a company can help to define the needed product innovation knowledge and skills as well as to define how they can build up their absorptive capacity gradually (Sowden, McKibbin et al. 2004; Szogs, Chaminade et al. 2008). To facilitate this process several models have been developed to analyse, classify and support companies.

The World Bank (2002) analysed the technological ability of firms to innovate and their internal willingness to change. Based upon this study firms are distributed into four groups based on the degree to which they are aware of the need to change and the degree to which management is aware of what should be changed and how to go about changing it. At the lowest level are firms that have no capacity for innovative activities or change (see Figure 4.16).

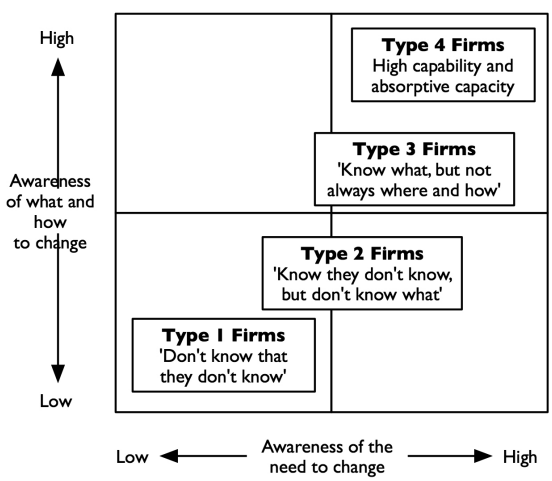

Figure 4.20: Grouping of firms according to their technological capability and motivation to change (Worldbank 2002).

According to Lall (Lall 2000) many SMEs in developing countries fit into type 1 & 2. They are poorly placed to deal with technical change and upgrading. Not only do they lack the information and resources to access new technologies and skills, they often do not know how weak they are. They may be unaware of competing technologies in other countries. They may not realize the nature of new skills and techniques needed to keep up. They may lack the entrepreneurial knowledge and education to seek technology or assistance needed.

Depending on the type of company, different support can be provided to ease their movement from the bottom left to the upper right quadrant (from Type 1 to Type 4). According to another report of the WorldBank (Aubert 2004), the integration of innovation should be done in a gradual manner, building upon the resources and capabilities available in a company. The firm's internal development and design capabilities grow as it moves between successive stages (Schnaars 1994). Depending on the absorptive capacity and the technological skills of a company the following business and innovation approaches are proposed:

1. Low technology SMEs and micro enterprises:
   Business: To stabilize business and build competitive capabilities.
   Innovation: Building awareness of scope and benefits of innovation.

2. Minimal technology SMEs:
   Business: To develop competitiveness.
   Innovation: To introduce basic skills, to encourage adoption and application of new ideas.

3. Technology competent enterprises:
   Business: To support market development and internationalization of business.
   Innovation: To build in-house innovation capabilities.

4. R&D rich enterprises:
   Business: To develop international markets and entry to global supply chain.
   Innovation: To encourage R&D engagement with international innovation networks, technology transfer and diffusion.

A large part of the firm sector in developing countries exists of micro and small enterprises which are operating in the informal economy and which have a very low technology competency (category 1), if any. A less important segment is composed of SMEs with minimal technological capabilities (category 2). An even smaller segment is constituted of technology competent enterprises (category 3). Finally, there is a small number of R&D rich enterprises (category 4)(Aubert 2004).

Product versus capacity company

Lastly SMEs can be divided into product companies and capacity companies (Buijs and Valkenburg 2000). A product company is one that develops, brands and (partly) produces its own products. A capacity company mainly offers it production capacity to other companies and customers and does not develop its own products. The main differences in characteristics can be described as:

Table 4.6: The characteristics of product versus capacity companies (Buijs and Valkenburg 2000).

	Product Company	**Capacity Company**
Design	Own Design	Design by Customer
Design Department	Yes	No
Focus	Product Design	Product Technology
Brand	Own Brand	Customers Brand
Production	Systematic & Planned	Flexible & Improvisation
Staff	Generalists & Specialists	Specialists
Time focus project	Mid- / Long-Term	Short-Term
Customer	Anonymous	Known

Logically, product companies do have more experience in developing new products and are more prepared for new (more radical) innovation activities, capacity companies much less. A capacity company that wants to (partly) transform into a product company will have limited in-house capabilities and experience with identifying end-user markets, developing products and branding. As such capacity companies will need more support to increase their in-house capacity in order to come to successful product innovations.

4.4 Individual level

After discussing the factors on national and organisation level, this paragraph will explore the factors at the individual level of the knowledge recipient. At an individual level the focus will be on individual factors related to the industrial design profession: the (design) professional background, the earlier gained (design) experience and motivation.

4.4.1 Professional background

Product innovation activities within firms are often carried out by 'designers'. Within the discipline of design the professionals and students from the different sub-domains like 'design', 'industrial design', 'design engineering', 'engineering design' are all addressed to as 'designers'. One can try to describe 'design' in general, but this denies the existence of any fundamental differences between the various design fields. A more clear distinction of the design professions will help to provide better directions for appropriate product innovation knowledge transfer taking into consideration the differences in background, ways of approaching and solving product innovation problems and application fields.

The discipline of design can be split up in three main sub-domains: Industrial Design (ID), Industrial Design Engineering (IDE) and Design Engineering (DE):

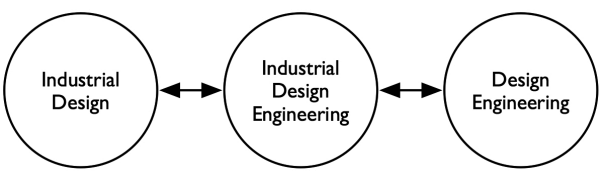

Figure 4.21: The three sub-domains of design.

The origin of these three domains varies. Industrial Design, on the one hand has its roots in the arts and crafts (Cross 1990; Lofthouse 2004) and is often taught at art academies. Design Engineering on the other hand is based on technology and technological models (Roozenburg and Eekels 1998; Buijs 2003; Lofthouse 2004) and is mostly lectured at technical universities and engineering schools. Industrial Design Engineering can be seen as a combination of the previous two, with its roots in both Engineering Design and Industrial Design (Buijs 2003).

The sub-domains of design do not only differ in their background but also in their way of approaching and solving design problems. For example, according to Bates and Pedgley (1998), Industrial Designers are commonly seen as 'people-centred' and Design Engineers as 'technology-oriented'. Moreover, Lofthouse (2004) pointed out that the Industrial Designer is predominantly an imaginative, intuitive, creative, innovative or divergent thinker, which is unstructured, at times aimless and inwardly directed. Contrarily, the Design Engineer is a reasoning, rational or convergent thinker, which is logical, purposeful and concerned with outward directed problem solving. They use scientific principles, technical information and imagination in the definition of the mechanical structure, machine or system to perform pre-specified functions with maximum economy and efficiency (Lofthouse 2004).

In addition, the 'typical' Industrial Designer has proficiencies across a wide range of skill sets such as artistry, mechanical design, marketing and psychology, whereas the 'typical' Design Engineer is an expert in a restricted amount of topics, mainly related with mechanical design, materials/manufacturing and electronic design (Bates and Pedgley 1998; Lofthouse 2004). The difference knowledge and skill portfolio of Industrial Designer and Designers can be illustrated as in Figure 4.8.

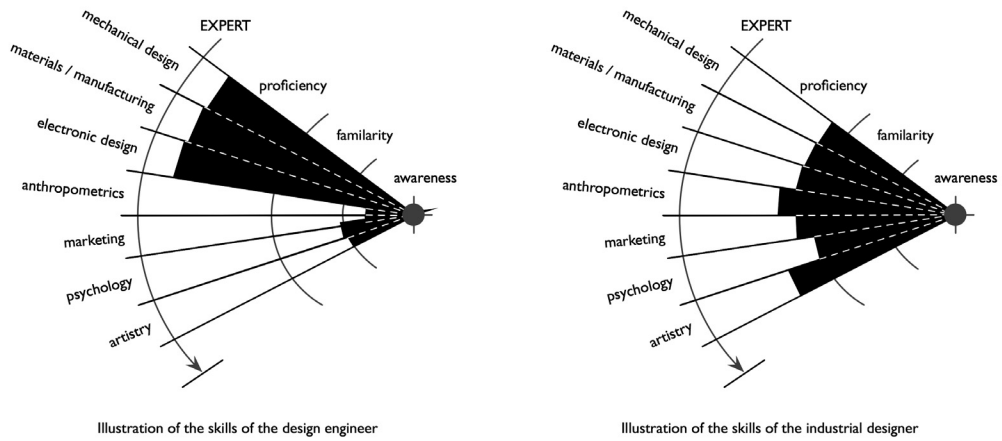

Figure 4.22: Differences in skills and knowledge of Industrial Designers (left) and Design Engineers (right) (Bates and Pedgley 1998).

The findings of these and other scholars (Cross 1990; Bates and Pedgley 1998; Sherwin and Evans 2000; Bucciarelli 2002; Lopez-Mesa, Thompson et al. 2002; Buijs 2003; Candy and Edmonds 2003; Dorst 2003; Lofthouse 2004) in relation with differences between Industrial Designers and Design Engineers have been summarized in Table 4.6.

Table 4.6: Characteristics of Industrial Designers versus Design Engineers.

Industrial Designer	**Design Engineer**
Background in arts and crafts	Background in engineering
Art academy	Technical university, engineering school
People-centred	Technology-centred
Subjective interpreter	Objective interpreter
Problem finder	Solution finder
Divergent thinker	Convergent thinker
Unstructured	Structured
Imaginative, intuitive, creative, innovative	Logical, purposeful
Inwardly directed	Outward directed

Intuitive performance calculations	Performance calculations with calculator
Proficiency in a wide range of skills	Expert in a restricted amount of skills
Prefer innovative methods	Prefer adaptive methods
Consumer and behavioural oriented design issues	Technological and product focused design issues
Using incomplete and imprecise information from a variety of sources like examples or case studies	Using precise information like data, figures and quantifiable information

Tools for the different design sub-domains

Likewise, design tools which are appropriate to one sub-domain of design, cannot automatically be transferred to another (Lofthouse and Bhamra 2000). Within this context Lopez et al. (2002) have made a distinction between 'adaptors', designers that prefer adaptive methods, and 'innovators' which prefer 'innovative' methods and tools for problem solving tactics. Industrial Designers can be typified as 'innovators' and Design Engineers as 'adaptors'.

High adaptors prefer to produce a low number of sound ideas, they prefer to pay meticulous attention to detail and they prefer to use approved structures to solve problems. High innovators prefer to produce a large number of potential ideas, they prefer to have a wide overview of the problem and they prefer to solve the problems by doing things differently. Adaptors prefer to work with precise information. In contrast innovators prefer to handle incomplete, imprecise data that involves uncertainty. Applying these principles to methods classification, it can be seen that:

- Adaptive divergent methods are intended to generate solutions to problems that have been identified in a concept through successive incremental improvements. Value engineering is for instance a very adaptive divergent tool.
- Innovative divergent methods facilitate the search of novel concepts, such as the ladder of abstraction and brainstorming.

Adaptive methods are therefore appropriate for products improvements (incremental innovations) while innovative ones for product renewal (radical innovations). The following table summarizes some of the characteristics of the different methods and tools:

Table 4.7: Classification characteristics of tools used by Industrial Designers and Design Engineers (Lopez-Mesa, Thompson et al. 2002).

INNOVATIVE METHODS Industrial Designer	Divergent Methods		ADAPTIVE METHODS Design Engineer
	Facilitate the detachment of the problem from the way it is customarily perceived	Useful for further development of already known solutions	
	Stimulate the generation of a large amount of ideas	Develop further a single idea	
	Tend to produce imprecise ideas of wide diversity	Tend to produce concrete solutions within a focussed solution space.	
	Convergent Methods		
	Require approximate or soft information on concepts	Require hard and precise information about concepts	
	Evaluation of a large amount of diverse ideas	Evaluation of a single concept	
	Gather together information that helps to take a decision	Give a numerical solution	

4.4.2 Novice versus Expert designers

Differences in how designers perceive, interpret, structure and solve design problems can also partially be understood by taking into account their level of design expertise (Dorst 2003). Something that distinguishes experts (i.e. design professionals) from novices (i.e. design students) is that the experts have been exposed to a large number of examples of problems and solutions in their domain.

The following Table 4.8 based upon the work of Christiaans (Christiaans 1992) and Popovic (Popovic 2003) summarizes the main differences in characteristics of novice and expert designers:

Table 4.8: Overview of differences of novice and expert designers (Christiaans ; Christiaans 1992; Popovic 2003; Weir, Lewis et al. 2003; Cross 2004).

	Novice Designer	**Expert Designer**
Orientation	Solution oriented	Problem oriented
Information	Few gathering of information.	A lot of information gathering
Problem	Simplification of problem	Abstraction of problem
Thinking	Backward thinking	Forward thinking
Personality	Dependent	Independent
Motivation	From outside	From inside
Barriers for change	Few	Negative self-image, limited possibilities & time, inappropriate educational background, inborn habits and attitudes, afraid for failing
Experiences	Limited	Much
Attitude to learning	Focus on topic	Focus on problem
	Weak content of goal-limited strategies	Rich content of goal limited strategies.
Amount of information	Small 'chunks'	Very large 'chunks'
Domain specific knowledge	Very weak	Possession
Assumption	A lot	Few
Experiential knowledge	Limited	Possession
General strategies	Very weak	Well developed

The consequence is that experts and novices differ in relation to the amount of their domain-specific knowledge, the organization and integration of schemata in the long-term memory and in relation to the efficient application of reasoning (Badke-Schaub 2004). Additionally the novice is more depending. He or she follows strict rules to deal with a problem, relies on the information provided and deals with small bits of the problem at the same time. The general strategy of the expert is much better developed; he or she intuitively acts in a certain way and is able to obtain a larger overview of the problem and processes. On the other hand the expert has got used to a certain method or approach and is sometimes stuck in his approach. A novice is more flexible and eager to learn.

4.4.3 Attitude and motivation

A last individual factor is motivation. Lack of motivation to accept and internalize the knowledge from outside can result in passivity, insincere acceptance, active rejection, or even hidden sabotage during implementation (Szulanski 1996; Timbrell, Andrews et al. 2001). Also Weggeman (2000) clearly states in his formula for knowledge transfer (see section 2.2) that a positive attitude of the knowledge recipient is essential for success. Motivation is an important factor. Without proper motivation and commitment efficiency may decline. This motivation for knowledge transfer can come from inside the knowledge recipient (understanding of the usefulness of the new knowledge for future activities as well as can be stimulated by incentives from within the organisation.

4.5 Conclusions

In this chapter the characteristics of the knowledge recipient and the context in which he or she operates have been explored, described and analysed. To illustrate the differences between different settings the main characteristics have been illustrated for the countries of the case

study research, which will take place later on in our study (Tanzania, India, Central America and Croatia. Based upon an extensive literature review a range of factors related to the knowledge recipient that can influence the knowledge transfer process have been identified and clustered in three sub-clusters: factors at 1) national, 2) organisational and 3) individual level. On each of the three levels the factors have been discussed in a quantitative, qualitative or combined way.

At a national level the national income (GDP), the competitive situation (GCI) and the quality of life (HDI) are expected to be essential describers of the socio-economic development. A wide range of other indicators such as the level of education and the importance of certain economical sectors can be derived from the Gross Domestic Production (GDP). From the literature review it has become clear one can expect in general in developing countries a low investments in R&D, low levels of education and a limited ICT infrastructure. Together they result in a low national absorptive capacity. Cultural dimensions in a society do have their direct impact on the management of organisations as well as the way of teaching at schools and universities. Based upon the model of Geert Hofstede examples have been provided how this influence can work out in practice.

At the organisational level the focus of the literature review has been on SMEs. They are the backbone of most (developing) countries and have a significant role to play in economical and social development as well as are in need the most for external support (knowledge transfer) to innovate. Even though they are expected to play an important role in product innovation their capabilities are limited and the local support is poor. In order to assess their capabilities two models have been discussed.

Lastly a literature review has been executed after the characteristics of the knowledge recipient at an individual level. At a personal level three main factors are expected to play a role in the transfer of product innovation knowledge. One of them is the professional and educational background of the knowledge recipient. Design engineers are used to different types of methods and tools to compared to industrial designers to 'solve' a design problem. More experienced staff have different learning behaviours then young and novice members of a product innovation team. Last but not least, independent of the professional background and earlier experience, the attitude towards the introduction of new knowledge, methods and tools is very critical in order to be successful.


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5 Research method and conceptual framework

Chapter 1 identified the problem setting and the research questions. Next a literature review was carried out in Chapter 2, 3 and 4 to explore and describe how knowledge transfer takes place according to literature. The main goal was to find an answer to Research Question 1: How does product innovation knowledge transfer to developing countries take place? Based upon the outcomes of the literature review a conceptual framework and list of 'focal points' and 'expectancies' will be constructed in 5.1. Next in section 5.2 the research approach for the next steps of this study will be discussed and a proper research method will be selected: design-based research. Finally, section 5.3 will expand on the first stage of the design-based research: Preliminary research stage. This stage, which commenced with the literature review, will be completed by a case study.

5.1 Conceptual framework

Research Question 1, "how does product innovation knowledge transfer to recipients in developing countries take place…" aims at exploring and describing current practices of knowledge transfer. First an exploration of the current practice was done by means of a literature review after knowledge and knowledge transfer (Chapter 2), product innovation (Chapter 3), and the characteristics of the knowledge recipient (Chapter 4). The outcomes of the literature review are used to construct a conceptual framework, which describes the transfer of product innovation knowledge. The conceptual framework will provide a basis for the development of methods and tools to improve the transfer of knowledge on product innovation (RQ 2). In addition a list of 'focal points' and 'expectancies' will be derived from the literature. The list of 'focal points' can help to describe the current situation of how knowledge transfer takes place (RQ 1). The list of 'expectancies' is expected to support the development of methods and tools (RQ 2).

5.1.1 Exploring the transfer of product innovation knowledge

In Chapter 2, six clusters of factors were introduced to describe part of the process of knowledge transfer of product innovation knowledge to developing countries: (A) knowledge, (B) knowledge transfer process, (C) source, (D) recipient, (E) relation and distance between source and recipient, and (F) the broader context in which it takes place. In the literature review described in the previous chapters each cluster has been explored, described and discussed. Chapter 2 elaborated on knowledge (cluster A) and the knowledge transfer process (cluster B). Chapter 3 discussed the knowledge content (product innovation) and the source (cluster C). Lastly Chapter 4 described the characteristics of the knowledge recipient in developing countries and the larger context in which the knowledge transfer takes place (cluster D and F). This way the 'black-box' of product innovation knowledge transfer has been explored and opened (see Figure 5.1). Subsequently each box in turn can be unfolded again.

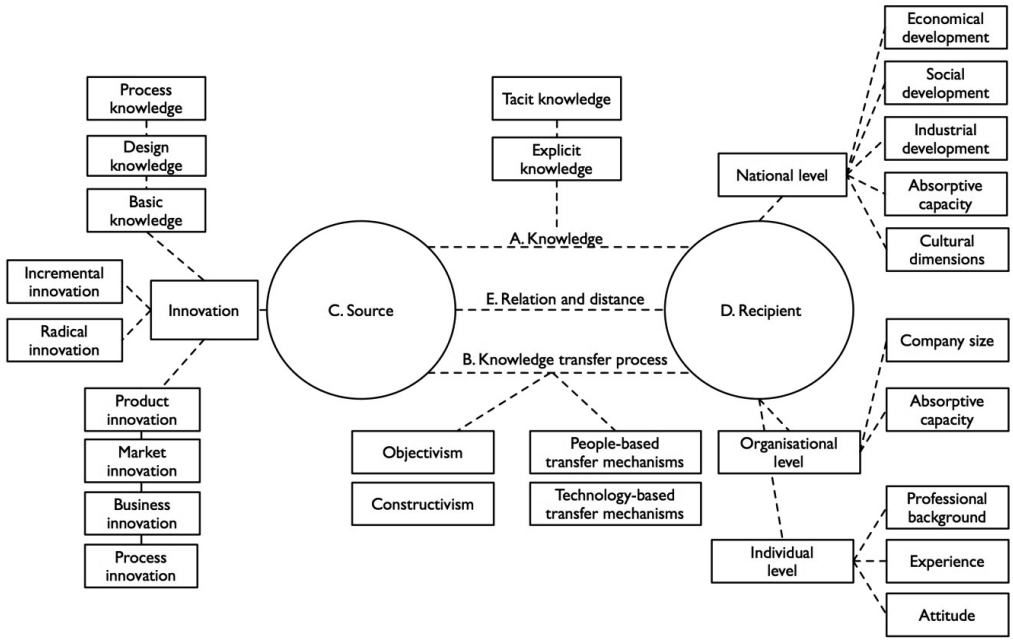


Figure 5.1: Opening the 'black-box' of product innovation knowledge transfer based upon literature review (Diehl 2010).

The picture provides an overview of a wide range of knowledge and context related factors that influence the knowledge transfer process. Together these clusters of factors provide an increased theoretical insight into how the transfer of product innovation knowledge takes place and how it is being influenced. The majority of the examined literature resources describe the impact of these factors in a one-dimensional way (in isolation), rather than from a multidimensional perspective. Even though the factors are represented in the above figure as separate blocks, in practice they are. For example, product innovation can take place at an incremental and radical innovation level. In addition, within incremental and radical product innovation, basic, design and process knowledge can be distinguished. Similarly, teaching approaches are strongly linked to knowledge transfer mechanisms and characteristics of the knowledge recipients. An overview of the clusters and the accompanying factors derived from the literature review can be found in Appendix 1.

As mentioned in section 2.10, several scholars (Sagafi-Nejad 1990; Inkpen and Dinur 1998; Szulanski 2000; Cummings 2003) stated that a comprehensive view of all these factors simultaneously is needed in order to come to an optimal knowledge transfer. In other words the impact of as many factors as possible should be taken into consideration. In addition, a number of literature resources suggest interrelations between several factors, which makes the situation even more complex. An example of the interrelation of factors is provided in text box 5.1 (see also Figure 5.1 for reference).

A practical example of product innovation knowledge transfer

Palray (the knowledge recipient) is a SME situated in a Tanzania (low income country), a country with a collectivistic culture. Based upon the characteristics of the company - small (company size) and low educated staff (absorptive capacity) - it is expected that incremental innovation approaches (innovation level) do fit best the current development stage of this organisation. The

staff of the company has no previous experience with product innovation (capacity company). As such it is decided to transfer basic, design and process knowledge (industrial design knowledge). Design and process knowledge can be best transferred as tacit knowledge and basic knowledge as explicit knowledge (type of knowledge). In addition, people in countries with collectivistic societies prefer tacit knowledge (cultural dimension). The transfer of tacit knowledge often requires people-based knowledge transfer mechanisms (type of knowledge transfer mechanisms) in combination with constructivism and problem-based learning (educational approach). The next consideration is to select the proper people-based knowledge transfer mechanisms, for providing in-house workshops or by letting students carry out demonstration projects in collaboration with the company staff. Another consideration is how to reduce the factor of tacit knowledge because of its high transfer costs (as compared to explicit knowledge).

Text box 5.1: The interdependency between factors.

5.1.2 Conceptual framework version 1

In order to reduce the complexity as well as to provide a comprehensive overview, a conceptual framework was developed. This is a first step towards a systematic approach for the transfer of product innovation knowledge. As can be concluded from the previous paragraph, in order to get a comprehensive view of the product innovation knowledge transfer it will be essential to not only get an overview of all factors that have an impact, but also how they are interrelated. Previously in section2.9 it was discussed that the factors can influence the content of the product innovation knowledge transfer (What) as well as the way knowledge is transferred (How).

Building upon these findings from the literature review (identified factors, their potential impact, and their inter-relation) a conceptual framework was developed, which describes the product innovation knowledge transfer process and how it is being influenced (see Figure 5.2). Each box represents a cluster of principle factors derived from the literature review. The presented conceptual framework can be applied in any type of context of product innovation knowledge transfer (i.e. both in developing and developed countries).

The aim of the conceptual framework is twofold: 1) to describe how the product innovation knowledge transfer process takes place (RQ 1) and 2) to make a first step towards developing a systematic approach to improve the product innovation knowledge transfer process (RQ 2).

In Figure 5.2 the first version of the conceptual framework is depicted. Each box represents parts of the opened 'black box' of product innovation knowledge transfer (see Figure 5.1) and 'contains' a range of factors (see Appendix 1). The bold lines indicate the transfer of knowledge from the knowledge source to the knowledge recipient. All lines (bold and thin) illustrate how the factors are interrelated and affect the product innovation knowledge transfer. The proposed conceptual framework does not have a specific entry or exit point.

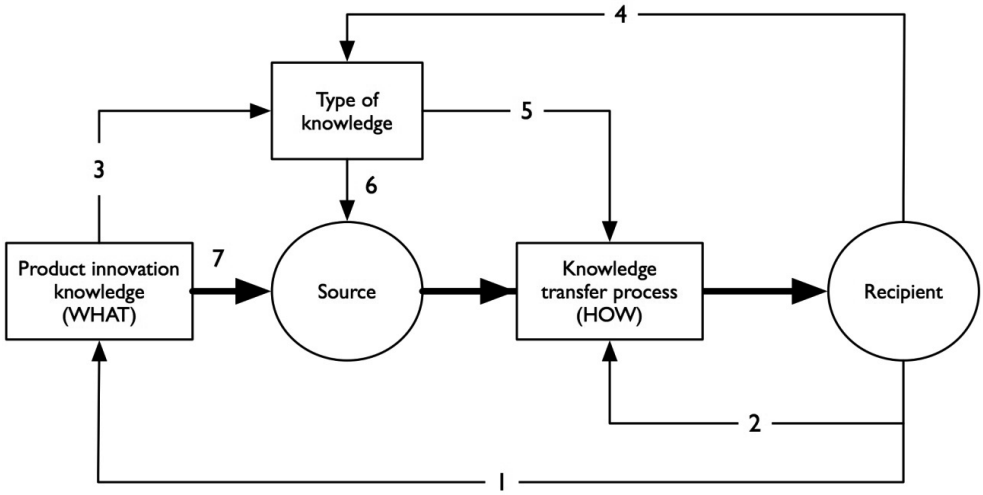


Figure 5.2: Conceptual framework version 1 (Diehl 2010).

The impact of the connecting lines can be described as:

1. Recipient → Product innovation knowledge: selection of the proper knowledge content based on the characteristics and needs of the knowledge recipient himself, the organisation in which he operates and the context of the country in which it will be applied.
2. Recipient → Knowledge transfer process: selection of the proper knowledge transfer mechanisms and educational approaches fitting to the characteristics of the knowledge recipient himself, the organisation in which he operates and the context of the country in which it will be applied.
3. Product innovation knowledge → Type of knowledge: based on the selected product innovation knowledge content the preferred type of knowledge can be determined.
4. Recipient → Type of knowledge: based on the (cultural) characteristics of the knowledge recipient the preferred type of knowledge can be determined.
5. Type of knowledge → Knowledge transfer process: based on the type of knowledge the proper knowledge transfer mechanisms can be selected.
6. Type of knowledge → Source: depending on the type of knowledge a different source might be selected.
7. Knowledge content → Source: depending on the selection of the needed knowledge different sources might be needed.

5.1.3 List of 'focal points' and list of 'expectancies'

In addition to the conceptual framework, a list of 'focal points' and a list of 'expectancies' were derived from the literature review. Both lists provide additional insights into the reasoning of the conceptual framework. These lists are not restrictive and will evolve in the next stages of this research.

List of 'focal points'

At first instance, the factors deduced from the literature review were translated into a list of 'focal points'. A 'focal point' assists the researcher in identifying the significant factors as well in distinguishing the different options for such a factor. For example, focal point three draws

attention to the knowledge transfer mechanisms used within the knowledge transfer process and facilitates distinguishing between people-based and technology-based knowledge transfer mechanisms. On the basis of this focal points list, the process of knowledge transfer can be described in detail and analysed in a structured and systematic manner. The list of focal points will contribute to answering RQ 1 and can be found in Appendix 2 This list will also be used in the case study research to construct the case descriptions and will function as a checklist to describe the essential factors of the product innovation knowledge transfer process.

List of 'expectancies'

Certain expectancies can be made based on the literature review on how the knowledge transfer is influenced by the identified factors. For example in section 2.7 it is mentioned that tacit knowledge plays an important role in the industrial design process. As a result, industrial design education is largely focussed on transferring tacit knowledge. From this statement it can be 'expected' that the tacit component and people-based knowledge transfer mechanisms will be dominant in the product innovation knowledge transfer process. Accordingly each 'focal point' of the above list was checked for whether any expectancy could be made. As a result 27 'expectancies' were derived from the literature related to the product innovation knowledge transfer process, specifically when it takes place in developing countries. The list of expectancies is assumed to contribute in a later stage of this research to the improvement of the transfer of product innovation knowledge (RQ 2). The expectancies are listed underneath. A reference is indicated to the relevant literature source used for each expectancy.

List of expectancies

The following is expected in the context of product innovation knowledge transfer to organisations in developing countries:

		Source
E1	The tacit knowledge component will be dominant.	*§2.6*
E2	Primarily socialization and externalization types of knowledge transfer will take place.	*§2.6*
E3	Comparatively more 'people-based' than 'information-based' knowledge transfer mechanisms will be used.	*§2.3*
E4	The principal teaching approach will be constructivism.	*§2.6*
E5	Problem-based learning will be applied intensively.	*§2.6*
E6	Objectivism teaching approaches are dominant at the local universities.	*§4.2.6*
E7	For successful product innovation both domain specific (basic and design) and domain independent (process) knowledge are needed.	*§3.4*
E8	Food-processing and simple products (i.e. furniture) dominate the local industrial activities.	*§4.2.3*
E9	The industry can be characterized as low-skill, labour intensive and not capital & knowledge intensive.	*§4.2.3*
E10	The R&D support from outside as well as inside the companies is (very) limited.	*§4.2.4*
E11	Local public R&D institutions are poorly connected to the needs of SMEs.	*§4.2.4*
E12	There are limited local industrial design capabilities and support.	*§4.2.5*
E13	Comparatively more enterprises operate in the informal sector.	*§4.3.2*
E14	SMEs have limited resources.	*§4.3.3*
E15	Especially small- and micro-enterprises have a low absorptive capacity.	*§4.3.3*
E16	A large number of the companies have low technological capabilities.	*§4.3.4*
E17	The majority of SMEs is not aware of the need to change, nor what and how to change.	*§4.3.4*

E18	The best way for SMEs to grow is gradually, building upon the resources and capabilities that are available in a company.	*§4.3.4*
E19	Cultural dimensions can hamper the innovation process within a company as well as within the project team.	*§4.2.6*
E20	Product innovation strategies with a lower risk are more successful for SMEs.	*§3.2*
E21	Incremental innovations fit better to the characteristics of SMEs.	*§4.3.4*
E22	A large number of the companies uses a kind of benchmark approach.	*§4.3.3*
E23	Capacity companies need a greater amount and more specific support compared to product companies in order to come to successful product innovations.	*§4.3.4*
E24	There will be a stronger focus on people (social) aspects.	*§3.7*
E25	Different design professions have different preferences for design tools and approaches.	*§4.4.1* *§4.4.2*
E26	Novice and expert designers prefer different types of knowledge transfer as well as apply different approaches to solve product innovation problems.	*§4.4.3*
E27	A negative attitude can hamper the knowledge transfer process.	*§4.4.4*

These 27 expectancies can be grouped and positioned around the boxes of the conceptual framework (see Figure 5.3). Within the next stage of this research, the case study research, it will be validated if these expectancies prove to be correct in practice.

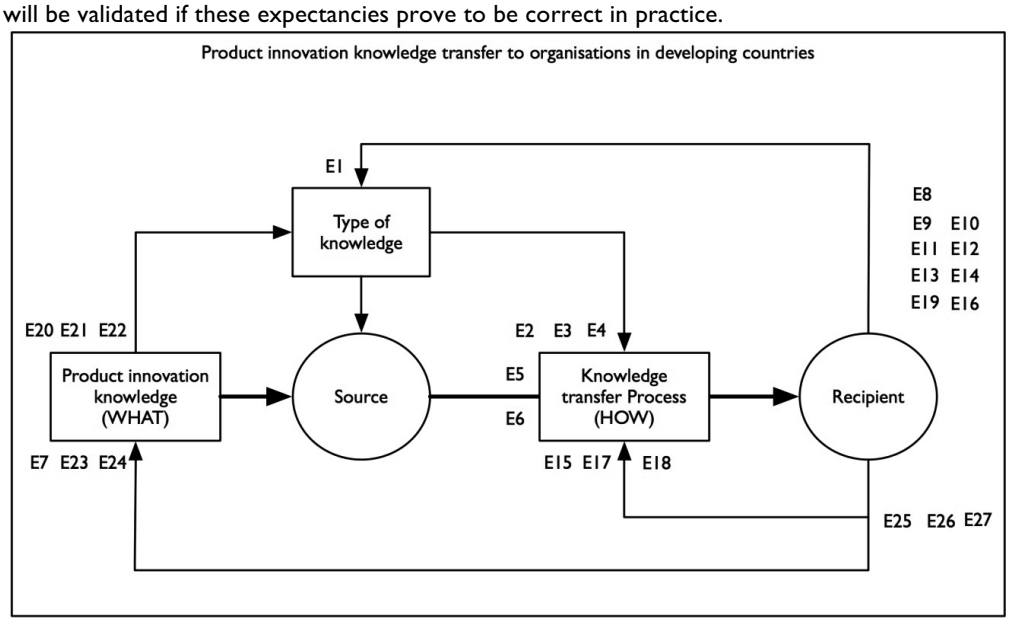


Figure 5.3: Positioning of the expectancies within the conceptual framework (Diehl 2010).

5.1.4 Conclusions and next steps

Based upon the literature review a theoretical description can be made of how the product innovation knowledge transfer takes place. The original 'black-box' model of product innovation knowledge transfer was opened and (clusters) of factors were identified that have an impact on the knowledge transfer. Numerous factors can influence the product innovation knowledge transfer and in addition many of them are interrelated. It is thus a complex system. In order to

reduce the complexity as well as to provide a comprehensive overview, a conceptual framework of the product innovation knowledge transfer was developed.

Nevertheless, the picture of how the product innovation knowledge transfer takes place in practice is still fragmented. Many (interrelated) factors do have an impact, and most literature describes them in isolation. The literature review has not resulted in sufficient information and evidence to develop a systematic approach for improving the product innovation knowledge transfer process. The only way to substantiate and expand the conceptual framework is by executing empirical research. In this way the theoretical insights from the literature can be complimented with empirical data from practice.

The selection and justification of the research methods for the empirical study (case study research) will be made in section 5.3. First, this chapter will continue with identification and selection of the main research approach for this study, which guide the next research steps.

5.2 Research approach

The main objective of this research was to improve the transfer of product innovation knowledge to developing countries. As a starting point of the study, a literature review was carried out and an initial conceptual framework for the transfer of product innovation knowledge was set up. In order to achieve the main objective, further empirical studies taking the initial conceptual framework as a starting point were needed. To guide the next studies, a proper research approach and associated research methods were identified and selected.

The identification and selection of the research approach and methods was guided by the research questions and phenomenon under study. As discussed in section 1.4 'research objectives and research questions', the two research questions posed have a different focus and hence ask for different methods. Research Question 1 aims at *exploring* and *describing ("what", "who" and "how")* current practices of product innovation knowledge transfer. In order to further study this phenomenon, case study research was proposed. Case study research has advantages when used in descriptive and explorative research or where the context and the respondent's frame of reference are important (Marshall and Rossman 1995). According to Myers (2000), case study research is particularly suited to research topics seeking an explanation of "why" or "how" and that are at the exploration ("what" and "who") stage. In addition, case studies are especially suited for developing causal explanations in complex systems, generating new theories and understanding the meaning, actors, phenomena and contexts of phenomena (Maxwell 1996).

Research Question 2 aims at the improvement of the product innovation knowledge transfer process and is focussed on *designing* and *developing* knowledge transfer methods and techniques. This requests a "design by research" type of research approach.

A "design-based research" approach integrates both types of research (case study research and design by research). Consequently, the design-based research approach was selected as guidance for the next steps of this research. Furthermore, design-based research is typically applied in the setting of knowledge transfer and education research projects.

5.2.1 Design-based research

The rationale behind this study is consistent with that of 'design-based research': by working toward a better understanding of certain processes (RQ 1), the aim is to make steps towards improvements (RQ 2); in this case the process of transferring product innovation knowledge to developing countries. Design-based research (similar approaches were named 'design research'

and 'development research') has recently received considerable attention by researchers in knowledge transfer and education (Amiel and Reeves 2008). Design-based research by its character aims to be practically relevant. It is initiated to design and develop innovative interventions in order to meet a need that is felt in a complex, practical situation for which no ready-made solutions or guidelines are available. The focus of design-based research is upon *improving* the knowledge transfer process, rather than *proving* that one approach works better than another (Herrington, Herrington et al. 2009). Design-based research can be circumscribed as:

"the systematic but flexible study of analyzing, designing, developing, evaluating and implementing (educational) interventions (such as programs, teaching-learning strategies and materials, products and systems,) based on collaboration among researchers and practitioners in real-world settings, as solutions for complex problems in educational practice, which also aims at advancing our knowledge about the characteristics of these interventions and the processes of designing and developing them (Barab and Squire 2004; Wang and Hannafin 2005; Plomp 2009)".

The key characteristics of design-based research are that it is focussed on designing interventions in the real context of education or training (interventionist characteristic) combined with efforts to understand and improve interventions (process orientation) utilizing state of the art theories whilst the field testing and the evaluation of the consecutive prototypes should contribute to theory building (theory orientation) (Plomp 2009). These characteristics of design-based research match with the objectives of this research, which is aiming at both practical and theoretical contributions based on an iterative design and development process, and focused on interventions in real-world contextually sensitive (complex) settings.

Design-based research projects typically result into two types of output: interventions (practical relevance) and design principles (theoretical relevance). Intervention is also referred to as 'successive approximations of practical products' or 'practical outcomes'. Informed by prior research and review of relevant literature, researchers in collaboration with practitioners design and develop workable and effective interventions by carefully studying successive versions or prototypes in their target contexts (Van den Akker 1999; Nieveen 2009; Plomp 2009). The main characteristic is the use of prototypes (educational services, process and products) that immediately form an intervention in practice and reflect theory. Therefore, design-based researchers aim at developing interventions that can be used in practice and that are empirically underpinned solutions to the problems identified. The design of the intervention is (at least partly) based on a conceptual framework. The merit of design is measured in part by its practicality for users in real contexts (Van den Akker, Gravemeijer et al. 2006).

The second challenge for design-based research is to capture and make explicit the design decisions associated with a design process, and to transform them into guidelines or a list of criteria or design principles for addressing educational problems (Van den Akker 1999; Barab and Squire 2004; Herrington, Herrington et al. 2009; Nieveen 2009). Design principles are also described as 'contribution to theory', 'successive approximation of theory', 'theoretical yields' or 'new theories guidelines'. Each iteration or cycle in the process of doing research includes systematic reflection on the theoretical aspects in relationship to the status of the intervention, eventually resulting in design principles (Van den Akker 1999; Van den Akker, Gravemeijer et al. 2006). In general two main types of design principles can be distinguished (Van den Akker 1999):

1. Procedural design principles (characteristics of the design approach)
2. Substantive design principles: characteristics of the design (= intervention) itself.

In this way the researcher reflects on the design and development process of the intervention as well as produces knowledge about 'whether', 'how' and 'why' an intervention works in a particular context. In the end, the research team has at its disposal not only the intervention resulting in the desired outcomes, but also one or more design principles based on systematic reflection and analysis collected during this cyclical process.

This thesis works towards interventions (i.e. training manuals, knowledge transfer methods and tools) that can improve the transfer of product innovation knowledge towards developing countries. This part of the research process will be presented and discussed in the second part of this dissertation. The design principles will be presented and discussed in the last chapter of this thesis.

Design-based research is different from other approaches that might seem similar at first. Given its focus on practical problems and its nature of conducting the research in a real world setting with active involvement of practitioners, design research may look like action research. Action research, however, is not the same as design-based research, but could be seen as part of design-based research. Both are focussed on problems in practice; and practitioners are involved in the research process. The goal of action research is to improve practice by reflection; one of the goals of design-based research is generating new theory or reflecting on theory that supports practice in coping with practical problems. Action research is not aimed at generating design principles (Plomp 2009).

The study process in design-based research encompasses general design processes. Therefore, it is cyclical in character: analysis, design, evaluation and revision activities are iterated until a satisfying balance between the ideals ('the intended') and realization is achieved (Plomp 2009). Different authors may vary in the details of how they picture design-based research, but they all agree that design-based research comprises a number of stages or phases. Plomp (2009) proposes a four stage design-based research approach:

1. *Preliminary research:* thorough needs, context and problem analysis, literature review along with the development of a conceptual framework;
2. *Prototyping stage:* iterative design phase consisting of iterations, each being a micro cycle of research with formative evaluation as the most important research activity aimed at improving and refining the intervention;
3. *Assessment stage:* semi-summative evaluation to conclude whether the solution or intervention meets the pre-determined specifications. As this phase often also results in recommendations for improvement of the intervention, it is referred to as a semi-summative phase.
4. *Systematic reflection and documentation:* these are continuous activities that take place during all cycles in the research – however, at the end the researcher portrays the entire study to support retrospective analysis, followed by specification of design principles and articulation of their links to the conceptual framework (Reeves 2006; Van den Akker, Gravemeijer et al. 2006).

Within design-based research the function of *formative evaluation* is 'to improve'. It focuses on uncovering shortcomings of an object during its development process with the purpose to generate suggestions for improving it. The function of *summative evaluation* is 'to prove'. A summative evaluation is carried out to gain evidence for the effectiveness of the intervention and find arguments that support the decision to continue or terminate the project. In practice it is not always possible to draw a sharp line between formative and summative evaluation (Nieveen

2009; Plomp 2009). Typical activities for the first three stages of design-based research are depicted in Table 5.1.

Table 5.1: Stage and typical design-based research activities (Plomp 2009).

	Stage	Short description of typical activities
1	Preliminary research	Review of the literature and of (past and/or present) projects addressing questions similar to the ones in this study. This results in (guidelines for) a framework and first blueprint for the intervention.
2	Prototyping	Development of a sequence of prototypes that will be tried out and revised on the basis of formative evaluations.
3	Assessment	Evaluate whether target users can work with the intervention (practicality) and are willing to apply it in their teaching (relevance and sustainability). Also evaluate whether the intervention is effective.

Because of its specific characteristics, design-based research projects typically utilize multiple research methodologies and designs, with different designs again being used for different phases of the project. For each stage research methods and evaluation approaches that are suitable for the purpose of that particular stage of the research are selected (Richy and Klein 2005).

5.2.2 Research stages

In answering the research questions, a design-based research approach was used. A three-stage design-based research approach is proposed which is composed of elements of the above discussed design-based research methods (Barab and Squire 2004; Wang and Hannafin 2005; Van den Akker, Gravemeijer et al. 2006; Nieveen 2009; Plomp 2009). The original four stages were reduced to a three-stage design-based research by merging prototyping and assessment stage. In this way the three stages of the research are directly linked to the research questions. The first stage, preliminary research, attempts to answer the first research question. The second stage, prototyping and assessment, contributes to the answer of research question two. The three stages are shortly described underneath and illustrated in Figure 5.4.

Stage 1: Preliminary research
An exploration and description of how the current transfer of product innovation knowledge to developing countries takes place along with the development of a conceptual framework.
This stage provides an answer to Research Question 1

Stage 2: Prototyping and assessment
Design and development of a systematic approach and associated methods and tools that can improve the transfer of knowledge on product innovation to developing countries, followed by testing and evaluation in practice.
This stage provides an answer to Research Question 2

Stage 3: Reflection
Retrospective analysis of the study and specification of design principles.

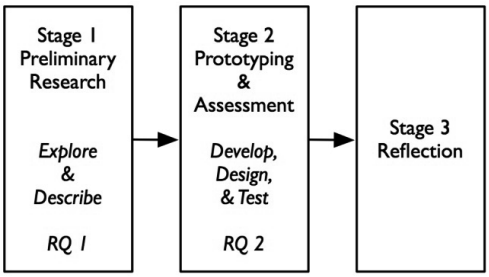


Figure 5.4: The three-stage research approach of this dissertation (Diehl 2010).

Stage 1, preliminary research, commenced with the literature review in Chapters 2, 3, 4 and with the development of the initial conceptual framework in this Chapter. The preliminary research stage continues in the following chapters (6, 7, 8, 9 & 10) with case study research. The justification of selecting case study research and its procedure is discussed in the next paragraphs. Chapter 11 introduces the research methods for Stage 2: Prototyping & assessment.

5.2.3 Research scope and delimitations

As defined in Chapter 1, this PhD research investigated how the transfer of product innovation knowledge to developing countries takes place and how it can be improved. Local knowledge creation, as well as the dissemination of knowledge, is of importance as well. However taking into consideration that, at least for the coming decade, the transfer of knowledge from developed countries to developed countries will play a major role, it was decided to focus on the *transfer* of knowledge. The focus of this study was on local universities and small and medium sized enterprises as knowledge recipients, as they are expected to need external support. This focus excluded large and international enterprises, which can finance and organize the product innovation knowledge transfer themselves. With product innovation knowledge transfer the aim is to support the development of consumer- and professional products in local industries and excluding large systems and technologies such as sewage and water treatment systems for example. The bulk of the primary data in this research was collected in projects in which the researcher and Delft University of Technology were involved. The implications of these decisions are discussed in the next paragraphs.

The role of researcher

This research can be characterised as qualitative research. Qualitative research is the interpretative study of a specified issue or problem in which the researcher is central to the sense that is made (Foster and Parker 1995). The researcher is the main instrument of inquiry, aided by semi-structured interview guides, observation strategies, and a thorough review of secondary data. Qualitative research takes the researchers interaction with the field as an explicit part of knowledge production and includes the subjectivities of the researcher and of those being studied as part of the research process (Flick 2002).

One of the choices to be made in qualitative research is the degree of involvement of the researcher: whether the researcher stays independent or gets involved with the subject (Mont 2004). Since design-based research is conducted in close collaboration with practice, design-based researchers are commonly intensively involved with the research subject (Richy and Klein 2005). Within this research study, the author was actively involved in the case studies as well as in the design and development of the interventions to improve the transfer of knowledge on product innovation to developing countries. In other words, by design the researcher is

observing him and his team. The advantage of this involvement is the fact that the researcher is close to the practice and can gain access to rich data, insights and understanding of the topic under research. The disadvantage of close involvement is that it can hinder objective observations and analysis by the same person (Crul 2003). Any time researchers assume dual roles in a project, the research design of the study must delineate specific strategies for ensuring unbiased data (Richy and Klein 2005). In order to increase the 'objectivity' of the research, triangulation and complementarity were used amongst other methods. This matter is discussed in the next paragraph.

Quality check of the research design

One important aspect of research is to guarantee its quality and validity. Since design-based research is characterised by a variety of research methods in different contexts it is of more importance to design the research is such a way that the required quality and validity is achieved. McKenney et al. (2006) and Plomp (2009) present several guidelines for conducting design-based research that can help researchers monitor the scientific quality of his/her research. The most relevant guidelines for this research are listed underneath:

1. Have an explicit *conceptual framework* (based on review of literature, interviews of experts, studying other interventions).
2. Use *triangulation* (of data source, data type, method, evaluator and theory) to enhance the reliability and internal validity of the findings.
3. Apply *variety of methods*; both inductive and deductive data analysis`.
4. *Empirical testing* of both usability and effectiveness of the intervention.

These four guidelines were built into the research design of this study. During the preliminary stage a conceptual model was constructed on the basis of literature review as well as case studies (guideline 1). Triangulation, especially in the case study research, was applied for the analysis (guideline 2): different techniques were used to examine the same research question in order to verify findings or identify biases in one of the techniques used. Mixing methods for this purpose strengthens confidence in the research findings if the same results are obtained using different methods. In each of the three stages of the research, multiple research methods (complementarity) were applied (i.e. literature review and cases study in the preliminary research) and both deductive and inductive analysis took place (guideline 3). Different methods were used so that the findings from one method were elaborated, illustrated, or clarified by the findings of the other method. The developed interventions (systematic approach and accomplishing methods and tools) were tested in 'real settings' on their usability and effectiveness (guideline 4).

In addition, Nieveen (1999) proposes four generic criteria for guaranteeing high quality interventions (results in practice). At the end of a design-based research project, the intervention should suffice all these criteria. These criteria are depicted in Table 5.2.

Table 5.2: Criteria for high quality interventions (Nieveen 1999).

Criterion	
Relevance (also referred to as *content validity*)	There is a need for the intervention and its design is based on state-of-the-art (scientific) knowledge.
Consistency (also referred to as *construct validity*)	The intervention is 'logically' designed. All components should be consistently linked to each other.
Practicality	The intervention is practically usable in the settings for which it has been designed and developed.
Effectiveness	Using the intervention results in desired outcomes.

These four criteria place different emphasis in different stages of the research as illustrated in Table 5.3. Along the timeframe of the research project, the attention shifts from the criteria at the top (relevance and consistency) towards the ones at the bottom (practicality and effectiveness).

Table 5.3: Evaluation criteria related to the stages in design-based research (Plomp 2009).

	Stage	Criteria
1	Preliminary research	Emphasis mainly on *relevance*, not much on *consistency* and *practicality*.
2	Prototyping stage	Initially: *consistency (construct validity)* and *practicality*. Later on: mainly *practicality* and gradually attention for *effectiveness*.
3	Assessment phase	*Practicality* and *effectiveness*.

During the last stage of the research, the research activities and practical results will be evaluated on these criteria.

Generalizability

Despite the many positive aspects of qualitative research, studies continue to be criticized for their lack of generalizability (Meyers 2000). The word 'generalizability' is defined as the degree to which the findings can be generalized from the study sample to the entire population. In design-based research, case studies and experimental studies, the findings cannot directly be generalized to a larger universe – there is no statistical generalization from sample to population, such as is the case in survey research. However Yin (2003) points out that in case studies and experimental studies, the investigator should try to strive to generalize a particular set of results to a broader theory. This is also the case in design-based research; the researcher should strive to generalize the findings to some broader theory.

In addition to concerns about generalizability, qualitative methodology is rebuked because studies are often difficult to replicate (Meyers 2000). Future researchers may not have access to the same subjects, and if other subjects are used, results may differ. Subjects (respondents) may openly communicate with one researcher and remain distant with others. In this research, however, the aim is to replicate the approach using the knowledge transfer methods and techniques, not so much for the sake of science but for practical purposes.

The last chapter of this dissertation elaborates on the generalizability of the outcomes of this study.

5.3 Stage 1 Preliminary research

After the introduction and discussion of the guiding research approach of this PhD dissertation, the first stage is continued: the preliminary research. The first stage of this research commenced with the literature review in Chapters 2, 3, and 4 as a first step to explore and describe how product innovation knowledge transfer to developing countries takes place (RQ 1). Based upon the literature review it was concluded earlier in this chapter that numerous factors influence the product innovation knowledge transfer and that many of them are interrelated. Most literature sources describe the factors in isolation and not simultaneously. It is a complex system. In order to reduce the complexity, as well as to provide a comprehensive overview, a conceptual framework was developed. It was concluded that the picture based upon the literature review of how the product innovation knowledge transfer takes place in practice is still much fragmented

and not yet sufficient to develop a systematic approach to improve the process (RQ 2). Thus more research is needed.

Next to literature (theory), design-based research suggests that former or ongoing interventions (practice) can be a rich source for data. As knowledge is incorporated in interventions, it is profitable for design-based researchers to search for already available interventions (earlier or ongoing cases) that can be considered useful examples or sources for inspiration for the problem at stake (Plomp 2009). In this way the theoretical insights from the literature can be complimented with empirical data from practice. From this perspective it was decided to continue the 'preliminary research stage' with studies in 'the real world': case study research.

A case study research would provide the possibility to (partly) confirm the developed conceptual framework and the identified factors in practice as well as to observe the numerous factors simultaneously within the same situation (multidimensional perspective). In addition, by observing and analysing the product innovation knowledge transfer in a real-life setting, it is expected that additional factors (not yet identified by the literature review) influencing the process might be identified and the conceptual framework can be improved.
Other methods such as interviewing or using questionnaires would merely deliver the retrospective opinions of individuals. Describing cases on the basis of protocols of running knowledge transfer processes will largely result in rich data.

5.3.1 Case study

To complete the first stage (preliminary research) of this design based research, next to the literature review (theory), a case study research (practice) was carried out. There are several arguments for selecting the case study approach. First of all, as stated above, there is a need to observe and analyse product innovation knowledge transfer in a real-life setting. According to Yin *(1989)* the case study method allows the researcher to investigate a contemporary phenomenon within its real-life context, when the boundaries between the phenomenon and the context are not clearly evident, and in which multiple sources of evidence are being used. Likewise Punch (1998) states that case studies emphasize detailed contextual analysis of a limited number of events or conditions and their relationships in its natural setting, recognizing its complexity and its context.
A second argument for carrying out a case study is the complexity of the issue. Merriam (1998) argues that a case study approach is appropriate for studying a complex phenomenon, because case studies aim at studying several aspects related to a phenomenon or event. As concluded in the previous section, the product innovation knowledge transfer is a complex system with many inter-related factors. Quantitative methods such as surveys provide neither the in-depth observation of the phenomenon nor the identification of the mechanisms by which the variables interrelate (Yin 1994).
The third argument is the fact that the topic under study is still novel (see Chapter 1). To date, not many research studies have been published about this phenomenon. Eisenhardt (1989) as well as Straus and Corbin (1990) argue that the case study approach is especially appropriate for studying new topic areas. The case study research can lead to new insights, which have not been described before in literature.
The final argument is that the setting of case study research offers the opportunity to make implicit knowledge explicit. Knowledge within people and organisations can be made explicit and shared with others.

For the purpose of this study, a six-step case study research approach was developed (see Figure 5.5). This approach was used to conduct the case study.

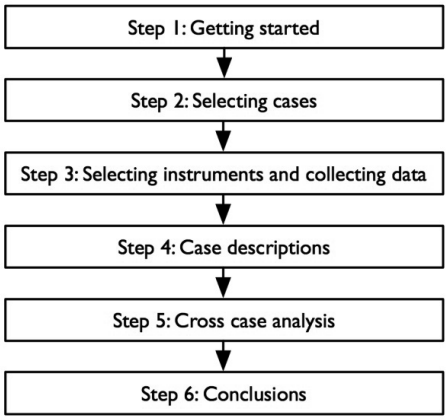


Figure 5.5: Six-step case study approach (Diehl 2010).

Getting started (step 1)

Yin (1984) states that every case study should start with a general analytical strategy to provide the researcher with a system by which he can set priorities for what is needed to analyse and why. Without a research focus, it is easy to become overwhelmed by the volume of data. Thus the investigators should formulate a research problem and possibly specify some potentially important variables, with some reference to existent literature. Within this case study research a literature review was initially carried out to learn how, according to literature (theory) product innovation knowledge transfer takes place. Based upon the outcomes of the literature review, a conceptual framework together with the list of focal points were composed which were used to guide the process of describing the cases and to set priorities.

Selecting cases (step 2)

Case study research can involve either single or multiple cases. Patton (1990) stresses that there are no rules about how many samples have to be used in qualitative research study. Everything depends on what the researchers aim to find out, on the acquired information in terms of its usefulness and its ability to generate the necessary credibility. Yin (1989) (page 52) states that "The evidence from multiple cases is often considered more compelling, and the overall study is therefore regarded as being more robust". There is no ideal number of cases, a number between 4 and 10 cases normally works well (Eisenhardt 1989). With fewer than 4 cases its outcomes are likely to be unconvincing, unless the case has several mini-cases within it. As such it was decided to select at least 4 cases for this case study research.

The choice of specific cases to study is important when carrying out case study research (Eisenhardt 1989). At the first place the case studies should reflect the topics identified in the underlying conceptual framework: they should be specifically about product innovation knowledge transfer to developing countries. The study can be based on existing case descriptions or new case descriptions to be developed by the researcher. An intensive literature and Internet search was executed in order to figure out if existing suitable case (descriptions) were available. No existing cases could be identified that cover the research topic of this thesis and provide sufficient rich data for analysis. Meanwhile, at the time of this research, several projects on the transfer of product innovation knowledge to developing countries in different regions of the world were being carried out by Delft University of Technology. This offered the

opportunity for the researcher to collect and analyse insightful data to create new and detailed case descriptions.

Furthermore, each case must be selected so that it either 1) predicts similar results or 2) produces contrasting results but for predictable reasons. The second approach was chosen for this research. As discussed in Chapter 4, it is expected that the characteristics of the knowledge recipient and the context in which he or she operates will have a large influence on both the content (What) and the way of transfer (How). The factors related to the knowledge recipient are often related to the national income of a country (Chapter 4). From that perspective, four cases in different regions with a different economic development (expressed in GDP per capita) were selected. In sequence of rising economic development: Tanzania, India, Central America and Croatia (see Table 5.4).

Table 5.4: Overview of the four selected case studies.

Case	**GDP per capita**	**Focus**	**Innovation approach**
1. Tanzania	US$ 316	Economical development	Product innovation
2. India	US$ 736	Sustainable development	Sustainable product innovation
3. Central America	US$ 2517-4627	Sustainable development	Sustainable product innovation
4. Croatia	US$ 8666	Economical development	Product innovation

The four projects took place in four different continents and provide as such a distributed picture of the world. Since habitually the goal of transfer of product innovation knowledge to developing countries is to support and facilitate economic as well as sustainable development (see section 5.4), two cases of each approach were selected (see Table 5.5).

The four selected product innovation knowledge transfer cases had a similar type of setup, which made it easier to compare their outcomes and to arrive at founded conclusions. The Faculty of Industrial Design Engineering of the Delft University of Technology (DUT) carried out all four cases. DUT was the main knowledge source and the DUT product innovation model (see section 5.2) was used as the backbone for the product innovation approach. Last but not least, all cases applied similar types of knowledge transfer mechanisms. Table 5.5 provides an overview of the main knowledge transfer mechanisms applied within the four cases.

Table 5.5: Overview of the main knowledge transfer mechanisms in the four case studies.

	TZ	**IN**	**CA**	**CR**
Training of Facilitators	2	1	2	1
In company demonstration projects	11	8	14	3
Development of education material	6	1	-	-
Development of manual	-	1	1	-
Workshops	2	6	3	1
International conference	1	1	1	-

The duration of the case studies varied from one to four years and they took place within the period from 1998-2005 (see Figure 5.6). During the projects, data was gathered and captured related to the product innovation knowledge transfer process.

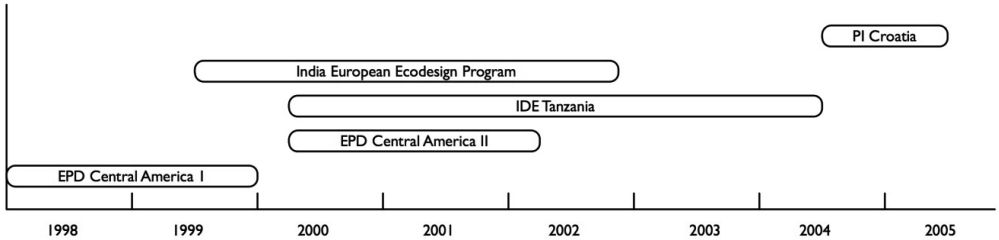


Figure 5.6: Overview of product innovation knowledge transfer case studies.

These knowledge transfer projects were financially supported (50-80%) by external national and international organizations. The researcher of this thesis was involved in all four cases as the DUT project leader (see Table 5.6)

Table 5.6: Overview of the responsible DUT staff within the four projects and the co-funding organisations.

	Project coordinator DUT	**Project leader DUT**	**Funding**
Tanzania	Dr. H.H.C.M. Christiaans	J.C. Diehl	Nuffic
India	Prof. Dr. J.C. Brezet	J.C. Diehl	EU CC Program
Central America	Dr. M.R.M. Crul	J.C. Diehl	Dutch Embassy
Croatia	Dr. H.H.C.M. Christiaans	J.C. Diehl	Senter Novem

Selecting data collection methods and collecting data (step 3)

There are no particular methods for data collection or analysis unique to the case study design (Merriam 1998). A key strength of the case study method involves using multiple sources and techniques in the data gathering process (triangulation). Case studies typically combine data collection methods such as archives, document reviews, interviews, questionnaires, and observations. Gathered data is normally largely qualitative, but it may also be quantitative.

For this case study research, the empirical data was mainly collected during and after the projects via interviews and documents such as M.Sc. graduation thesis, internal and external evaluation reports, mid-term reports, and refereed journal and conference papers. Since all four cases were well documented for external (i.e. funding) as well academic reasons (i.e. refereed papers and graduation thesis), a rich source of 15 binders with documents was compiled for use for the case study research. Several measures were taken to assure the quality of the research. These include the use of multiple resources of evidence to enable triangulation. In addition, the original project coordinators (see Table 5.6) were requested to review and validate the case descriptions.

Case descriptions (step 4)

One key step of case study research is the detailed case study write-ups: case descriptions (Miles and Huberman 1994). First by choosing, focusing, simplifying, and transforming, the collected data was reduced. Both deductive and inductive reasoning were used. In first instance, a deductive approach was applied by using the list of focal points (see Appendix 2), which was derived from the literature review to collect data and to describe the four cases. In a next stage, an inductive approach was used: open coding. Open coding was used to induce factors and other relevant topics from the data, which were not covered by the list of focal points (and such were not identified in the literature review). Words, phrases and events that appeared to be similar were grouped into same category in order to emerge new relevant factors.

Next, the reduced data of each case was displayed in a similar and organised compressed way so that analysis, comparison and conclusions can be done more easily in the next step: the cross

cases analysis. This was carried out in both a qualitative way (text) as well as in a quantitative way (data in Excel spreadsheets). These case descriptions are simply pure narratives, but they are central to the generation of insight. The summarized descriptions of the four cases can be found in the following chapters.

Cross case analysis (step 5)
After writing the case descriptions, a cross case analysis was performed in order to be able to compare the four cases and to further elaborate on the characteristics and mechanism identified in each case. Similar to the case descriptions, the cross case analysis was carried out in two steps. Based on the list of focal points, the four cases were analysed and compared. The goal of this stage was to validate if the identified factors (focal points) do indeed have an impact in practice as well as if expectations of their impact (list of expectancies) can be made (deductive reasoning).

In a next stage, the four case descriptions were re-examined again thoroughly and passages of text were coded. This process is often called "axial coding" (Strauss and Corbin 1990; Huberman and Miles 2002), searching for cross-case patterns. This step of the case study research resulted in clusters of quoted phrases and tables, which led to the identification of new factors that influence the process of product innovation knowledge transfer (inductive reasoning)

Conclusions and results (step 6)
Based upon the case description and the cross-case analysis, conclusions were made at the end of the case study research in relation to the research questions.

5.3.2 Case descriptions

The next chapters provide the summarized case descriptions. Each case description commences with a short description of the national economical and industrial context (based upon literature review), the project background and setup. Next, based on the main knowledge transfer activities, each case is described in a similar way: Train the Facilitator, demonstration projects, workshop and conferences, curricula development, and lastly the use and development of design tools and methods. The case descriptions are presented in sequence of the national income of the country, starting with Tanzania (lowest GDP), followed by India, Central America and a last Croatia (highest GDP).

The first case description, Tanzania, was described more elaborately in order to provide a picture of the 'richness' of the case descriptions. In order to prevent repetitiveness for the reader, the other three cases are described in a more condensed way. These summarized versions highlight the most valuable findings of these specific cases.

Even though the four cases have many characteristics in common, there are also many differences. The differences in time frame (1-4 years), budget (€40.000-€1.000.000) and focus (for example industry or educational institutions), resulted in differences in depth of certain parts of each case description.

5.3.3 Outline of research stage 1

Within this chapter, the design-based research approach was selected as a guide for the r*esearch approach. A three-stage design based research approach has been approached* proposed: 1) preliminary research, 2) prototyping and assessment, and the 3) reflection. The first stage, preliminary research, commenced with a literature review and was completed with case study. The outline of the first stage, preliminary research, is

illustrated in Figure 5.7. The next four chapters provide the case descriptions followed by the cross case analysis (Chapter 10).

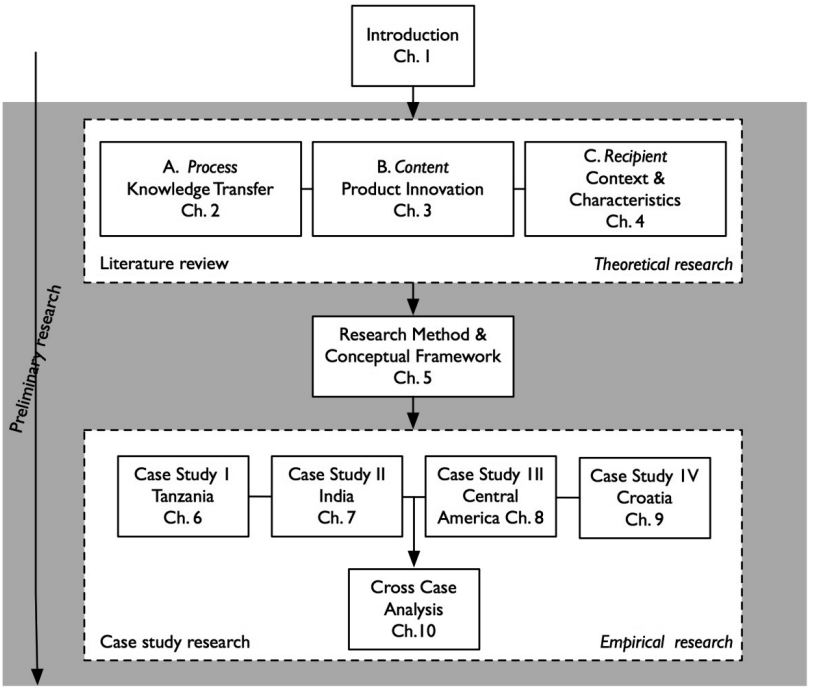


Figure 5.7: Outline of the preliminary research (Diehl 2010).

6 Case I: Tanzania

The first in a row of four case descriptions is the Tanzania case. The 'Product Innovation in Tanzania' project took place from 2000 till 2004. The project was a collaboration between Delft University of Technology (DUT) and the University of Dar es Salaam (UDSM) and was funded by the Dutch MHO programme which stimulates knowledge transfer between higher education institutions in the 'North' and the 'South'. The main aim was to develop courses on product innovation and to implement them in the UDSM curriculum as well as sensitizing the Tanzanian industry for product innovation.

The evaluation of this case is based upon project reports, student reports, published scientific papers, internal and external project evaluations and personal observations. In addition, interviews with the Dutch and Tanzanian project coordinators were conducted one year after finishing the project. In addition five refereed papers of the researcher were used (Diehl, Christiaans et al. 2001; Christiaans and Diehl 2002; Crul and Diehl 2002; Christiaans and Diehl 2003; Diehl and Christiaans 2003). The project coordinators from UDSM (Dr. E. Majaja and Dr. E. Elias) and from DUT (Dr. H.H.C.M. Christiaans) have validated the final case description. Within this and the following chapters this project will be referred to as 'Case TZ'.

Background

The main goal of the Dutch International Cooperation Program for Higher Education (MHO) is to strengthen the link between higher educational institutes in the 'South' and the Netherlands. Within this framework, around 1995, the Department of Design and Production Engineering of Faculty of Engineering (FoE) of UDSM approached the Faculty of Industrial Design Engineering (IDE) of DUT to collaborate in a product innovation for Tanzania knowledge transfer and capacity building project.

The introduction of product innovation at UDSM and industry took place in a changing economical and political context. The shift from a centralised to free market economy (from the seller's to the buyer's market) had created opportunities that are favourable for the introduction and implementation of product innovation in Tanzania (Diehl, Christiaans et al. 2001). It was expected that investments in product innovation (higher education as well as in industry) could contribute to the innovation capacity of the Tanzanian industry and thus stimulate the development of new and appropriate products in order to compete on the basis of quality and innovative products sold at competitive prices.

6.1 Context

6.1.1 The economical context of Tanzania

At the time of the project, Africa's share in world trade was small and shrinking due to the fierce competition from other regions, which enjoy faster and more sustained growth (Crul and Diehl 2002; Diehl and Christiaans 2003). Many countries in Sub-Saharan Africa, including Tanzania, did

not have any significant industrial past, dating back to pre-independence years. The existing Tanzanian industrial sector was largely created through the industrial policy adopted in the early 1960's after independence and entitled the Import Substitution Policy (ISP). These efforts were largely inward looking, based on import substitution to save foreign exchange, rather than export oriented to earn foreign exchange. The primary driver of industrialization was domestic demand volume and consumption pattern, whereby major attempts were to create industries that would integrate agriculture with manufacturing industries notably in textile, leather, pulp and paper, and wood related products (Mshoro 2000).

One of the results of this inward looking industrialization was the creation of companies that were inefficient and high-cost producers of low quality products (Mshoro 2000). During this period the companies enjoyed a monopoly of the markets as a result of deliberate government policies. There was almost no competition and consumers had very little choices. Almost any product that was produced was able to find its way to the local consumer, irrespective of its quality, aesthetics, ergonomics etc, provided it fulfils its basic function. From the company's point of view, there wasn't any incentive to innovate (Nalitolela 2003).

Since 1985, Tanzania is undergoing major economic, social and political changes. The economy has changed from a centralised to more market-oriented economy characterised by greater liberalisation and privatisation of the parastatal sector exchange (Mshoro 2000). This transformation of the Tanzanian economy from a monopolistic state control of the major means of production to a liberalized, free market economy has many implications to the consumer as well as to the local industry which enjoyed decades of monopoly of the local market. To the consumer, there is now a variety of a given type of product, and therefore the consumer has more choices. To the industry, a notable implication is that the products are subjected to competition in the market, especially from imported products. Because the consumer has options for making choices, products must be competitive in all the dimensions which are available to the consumer (Nalitolela 2003). As a result the factory production has stagnated in the past decades, and for some years many plants have been producing (far) below capacity, which resulted in some case to the closure of those industries.

The Economic Recovery Programme (ERP), which formally took off in the mid 1990s, amongst other things privatized part of the state owned companies with the objective of bringing on board strategic investors who are expected to bring with them the requisite technology, financial capital and management to revamp the industry and make them competitive. This strategy of restructuring the sector appears to have worked well with industries that have attracted acquisition by multi-national corporations (MNCs) like the beer, tobacco, energy and cement industries (Simbakalia 1999). These newly acquired companies by MNCs all have managed to turn earlier unprofitable businesses into highly successful operations (Bangens 2004). They often bring their own expertise and knowledge from abroad (Smulders 1999). The SME sector, however, which forms the backbone of the manufacturing industry of Tanzania, has not attracted the large multinationals or other international organisation as strategic investors.

6.1.2 Sectors

Tanzania has remained basically a non-industrialised country heavily reliant on agriculture (Bangens 2004). The shares of agriculture in total production, exports and employment are relatively high in Tanzania. The agricultural sector counts for 45% of the GDP, which is even high compared to the neighbouring countries as Uganda (32%) and Kenya (16%). Conforming to this, the composition of the industrial sector is dominated by agro-related (i.e. food, textiles, leather and beverage production) and related packaging (Crul and Diehl 2002; Diehl and Christiaans

2003). These industries produce agricultural inputs (fertiliser, farm tools, and construction materials) and process agricultural material products (cigarettes, canned meets, sugar, beer etc.) (Smulders 1999). The contribution of manufacturing sector to the Tanzanian GDP is only about 8% (UNIDO 2001). Manufacturing of wood & wood products, metal, paper, plastics and textiles contribute 17%, while food, beverages and tobacco contribute 71%. In other words, the manufacturing industry in Tanzania which is not related to food counts only for 1,4% of the national income (Mosha 2003). Most of the manufacturing industries are focussed on producing simple basic goods for the majority of the population (Smulders 1999).

6.1.3 SMEs

SMEs in Tanzania, as all over the world, contribute significantly to employment creation, income generation and stimulation of growth in both urban and rural areas and form the backbone of the local manufacturing industry. The sector is estimated to generate about a third of the GDP, responsible for about 50% of the industrial output and employs about 20% of the Tanzanian labour (Ministry 2002). SMEs are expected to contribute substantially to growth of the national economy (Elias and Nalitolela 2003). The manufacturing sector has a high proportion of SMEs compared to other sectors (Mahemba and Bruijn 2003). Since SMEs are important for the Tanzanian economy, but at the same time confronted with so many unique problems, they seem to be the best target group for product innovation intervention (Elias and Nalitolela 2003).

However, in spite of the rapid economical changes in Tanzania, the SME sector is confronted with some major problems, which prohibit rapid investment in them. Some of these problems are (low) education level of SME staff members, economic and financial situation in SMEs, operational management systems, poor product quality, poor packaging of finished products, poor production facilities and lack of technical and business know-how (Diehl and Christiaans 2003; Elias and Nalitolela 2003).

Most Tanzanian SMEs have only three or less levels of management, and hence limited delegation. This implies that the owners/managers of these SMEs make most of the decisions on all aspects of their businesses (Mahemba and Bruijn 2003). The planning activities tend to be of a short-term nature, generally covering a period less then one year. These findings imply that the kinds of planning used in these SMEs do not have a strategic nature (Mahemba and Bruijn 2003). The lack of local R&D and product innovation capacity adds to the complex and almost impossible struggle to 'catching up' in increasing globalized markets (Bangens 2004).

The capabilities of these SMEs in terms of innovative activities are very limited (Diyamett 2004). According to the Tanzanian Industrial Research and Development Organization (TIRDO), local SMEs mainly look for inexpensive and quick short term, pragmatic solutions, which in most cases cannot be 'called' any kind of product innovation. A larger part of the Tanzanian SMEs can be characterized by 'sit and wait to copy from neighbour' strategy with as result similar products by different production groups. Opportunity identification to keep businesses going is generally lacking (Stranders 2002; Elias 2004).

Figure 6.1: Micro-enterprises in the informal sector in Tanzania.

6.1.4 Education

Despite the government's efforts to strengthen human capabilities through increased access to formal education, Tanzania's attainments rates in secondary and higher education are among the lowest in Sub-Saharan Africa (see Figure 4.8). Additionally, the education programmes in higher learning institutions are not adequately satisfying the demand for expertise in engineering of competitive products and production processes in view of the emerging technologies and business trends (Althuis, Christiaans et al. 2004).

As a consequence of the Tanzanian policies in the seventies and eighties, engineering training at UDSM had been very traditional, focussing mainly on the technical aspects, and therefore produced graduates who are 'technology focussed'. While technology centred engineers in Tanzania may have been appropriate during the era of state control of the economy and monopoly of the local market, lack of the other non-technical skills for a 'consumer centred' engineering means that locally engineered products will find it very difficult to compete in the free market (Nalitolela 2003).

This is reflected in, for example, design education offered to engineering students. The emphasis has been on technically sound design. The fuzzy front-end innovative processes that precede and lead to the creation of the design brief have not been of interest (Elias and Nalitolela 2003).

The major deficiency in the engineering programmes at UDSM at the time of the project offered was the lack of training in integrated approach embracing marketing methods, engineering methods, ergonomics, and aesthetics and styling methods of Industrial design (Diehl, Christiaans et al. 2001). Some of the deficiencies of the traditional design engineering teaching at UDSM were (Elias 2004):

- Tendency to assign problems to students without knowledge about the origin and significance of the need;
- Limiting the graduates when it comes to real industrial (business) practices;
- Limited procedure in globalized economy;
- Poor preparation for the increased competition;
- Absence of problem-based learning approaches.

At the start of the project no product innovation kind of education was offered either on secondary or tertiary level in Tanzania. A degree in Industrial Design only could be obtained abroad. With a lack of engineers with an industrial design background in industry, the mechanical

engineer is until now the one expected to handle most product development processes in the Tanzanian industry (Elias and Nalitolela 2003).

As professor Asibo (Kibira, Turyagyenda et al. 2005) stated at the second regional conference on innovation systems and innovative clusters in Africa: "The university curricula may need to be changed or revised to touch relevant issues at all levels. Research is possible at all levels but the researcher must be ready prepared to see where the questions and answers apply. Emphasis should be put on problem-based learning as opposed to memory-based learning".

6.1.5 R&D

The level of R&D in Tanzania is still low and most R&D is carried out in governmental institutions rather than in the private sector. Government spendings on industrial R&D is very limited, which has left the few R&D institutions in an insecure situation having to rely on consultancy, training and services offered to industry. These revenues do not cater for R&D activities but solely meet operational costs of the institutions (Mwamilla 2005).

In addition there is a weak link between the few local R&D institutions and the productive sector in Tanzania. The potential manufacturers have hardly taken up the developed prototypes for commercial production. R&D institutes often developed prototypes that were technically feasible but were not economical viable (Wangwe and Diyamett 1998). Next to this industrialist do not appreciate the role of the R&D activities, and much R&D works are perceived as not addressing the actual needs of the productive sector (Smulders 1999). Research focussing on understanding industry's situation should be the starting point for setting the new research agenda (Sabano 2004).

Most of the Tanzanian research institutes primarily were set up to service the parastatal sector (Bangens 2004). Their R&D focus was to serve large industries, mainly in optimizing the production process and was based in the urban areas. This is opposed to the currently needed support: more focus on product innovation, SMEs and not only urban but also rural areas.

SMEs in the Tanzanian manufacturing sector do not have adequate in-house facilities to carry out R&D (Mahemba and Bruijn 2003). In addition a majority of SMEs in Tanzania do not have formal relationships with technology institutions and they are not aware of the opportunities that are available in the external environment, such as collaborations with other organisations such as research institutions, universities, technology centres and the government (Mahemba and Bruijn 2003; Makundi 2003). There are only a few interactions between technology institutions and the majority of the SMEs, and those are on an informal basis (Mahemba and Bruijn 2003).

The financial support, at the time of the project, for university research in Tanzania was very limited. The Tanzanian government has been allocating about US$ 30.000 annually to the UDSM (approximately US$ 50 per academic staff member). Without support of donors, hardly any research can be conducted at all at UDSM (Gaillard 2000).

6.2 Project

6.2.1 Goals and objectives

The goal of the project was to demonstrate the need for product innovation within the economical context of Tanzania (short term) and to develop a product innovation curriculum in order to create product innovation capacity by means of graduates on the med term (Elias and Majaja 2005). These aims of the project asked for a multiple approach taking into account the

need for a high level educational product innovation programme, the retraining of UDSM staff and a programme of awareness raising in Tanzanian industry. In order to achieve the set objective, the Faculty of Engineering (FoE) of UDSM, supported by DUT, formulated the following four sub-goals (Diehl, Christiaans et al. 2001):

1. To develop product innovation expertise amongst its staff members in order to enable them to conduct product innovation courses at UDSM;
2. To raise awareness in industry about the relevance of the product innovation approach through demonstration projects as well as short courses to improve product innovation skills of the industrial community;
3. To develop a communication structure in order to evaluate activities, review the vision on product innovation in Tanzania, and to further promote the concepts of product innovation ultimately in all engineering fields;
4. On the long run, to establish a product innovation degree programme at UDSM in Tanzania based upon experiences within the project.

6.2.2 Project outline

The original four-year project, referred to in this chapter as 'TZ 1', took place between June 2000 and June 2004. The main stakeholders of the project were:

Knowledge source:	DUT
Knowledge facilitator:	UDSM
Knowledge recipients:	Faculty, students, researchers, SMEs, large industries and NGO's

During the project, a wide range of activities took place to support the transfer of knowledge and capacity building at UDSM as well as the awareness creation in the Tanzanian industry. The main activities of the project have been:

- Two Train the Facilitators;
- Introduction of six product innovation courses into the curriculum of FoE;
- Two workshops for industry;
- Demonstration projects in eleven companies;
- International conference on product innovation in Africa.

The different activities are interlinked as illustrated in Figure 6.2.

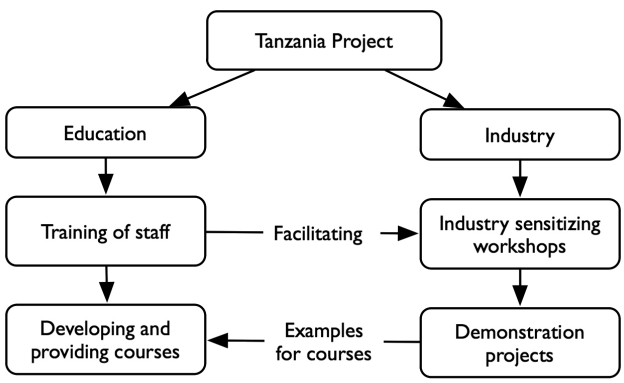


Figure 6.2: Knowledge transfer and capacity building activities within the project (Diehl 2010).

During the last year of the project, the United Nations Industry Development Organisation (UNIDO) approached UDSM with the request to extend the project by executing another two demonstration projects. This second series of demonstration projects were carried out by the trained UDSM staff, DUT staff and external consultants (alumni from DUT). Hereafter this part of the project will be referred to as 'TZ 2'.

The following figure illustrates the distribution of the project activities over time within the two projects:

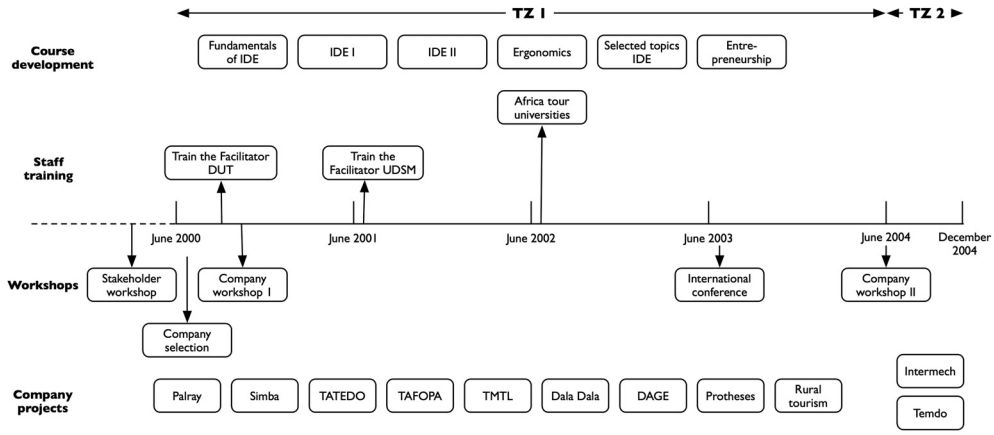


Figure 6.3: Overview of the knowledge transfer activities within the project.

6.3 Train the Facilitator (TtF)

6.3.1 Setup

As a first activity of the project, four staff members of the Faculty of Engineering (FoE) of UDSM were trained in the Netherlands by DUT staff to acquire the necessary qualifications for teaching and research in product innovation and for developing the relevant product innovation courses. The four staff members were proposed to be the facilitators in Tanzania during the next steps of the project. An important aspect of this Train the Facilitator approach in Delft was the idea that the UDSM staff should not only experience the new product innovation knowledge but also be able to apply this approach within the context of Tanzania. To intensify the experiences, based upon the problem-based learning approach, each of the four selected UDSM staff members had to bring in a Tanzanian company as case in the following three activities of the Train the Facilitator (Nalitolela, Elias et al. 2000; Diehl, Christiaans et al. 2001):

- Pre-activity: Analyse and gather information about the Tanzanian company and its product innovation strategy;
- TtF in Delft: Apply the newly gained product innovation knowledge to the company, its context, and to its specific product groups;
- Post activity: Write a product innovation strategy plan for the company. Discuss results with company management.

This problem-based learning approach worked out very well, except the last stage. After returning to Tanzania the daily activities in the office were taking up most of their time, which hampered them from working on the last part. All four staff members are currently intensively involved in product innovation teaching, research and industry projects.

During the four weeks training, UDSM staff members were mainly provided with domain specific knowledge, relatively more basic than design knowledge. Since they already did have a basic understanding of what product innovation was, it was possible to make a quick start. Afterwards the UDSM staff reported that they would have appreciated if the training also had paid attention to product innovation teaching philosophy and approach (i.e. problem-based learning). Now they acquired skills of product innovation while not yet knowing how to transfer (teach) this in an appropriate way to their students (Elias and Majaja 2005).

In the second year of the project, these four staff members provided a second Train the Facilitator course for eight other colleagues at UDSM. This course was only partly supported and facilitated by DUT staff. This was part of the objective, to switch over from international to local trainers to provide the training sessions. In this way the product innovation expertise was supposed to spread among an increasing number of UDSM staff members (Christiaans and Diehl 2002).

The eight selected participants did have no or less product innovation experience and affinity to their disposition compared to the first batch. They were provided with lectures focussing on domain specific basic knowledge and to some extent design knowledge. They were supposed to apply this in exercises, but in practice this part of the training was ignored (because of their other daily activities). This has resulted in a relative lower internalization of the product innovation knowledge into the participants. This combination of participants with less or no previous product innovation knowledge or background at the beginning in combination with a less intensive training program has led to lower learning curve (Elias and Majaja 2005).

The content of the second TtF was adjusted in several ways to the local context. Attention was being paid to what the differences are in between mechanical engineering and industrial design engineering, which was essential since most of the participants did have a mechanical engineering background. Product innovation was also situated in the economical and industrial context of Tanzania. External experts on the Tanzanian private sector were attracted to discuss the relevance and need in business practice. The provided product innovation examples were more appropriate in the sense that they were in line with the local economical and industrial activities (i.e. agro processing equipment and food products). The alterations between the first and the second Train the Facilitator are illustrated in Figure 6.4.

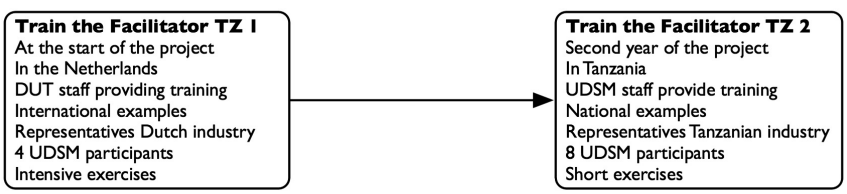


Figure 6.4: Alterations between the first and second Train-the-Facilitator (Diehl 2010).

6.4 Demonstration projects

Imparting expertise among academic staff and future designers and engineers in Tanzania was a necessary but not sufficient condition for improving innovative entrepreneurship and product development in industry. Part of the success of the knowledge transfer project would depend on the awareness in industry that the product innovation approach really contributes to economical growth and the improvement of their competitive position. Therefore, companies had to be activated to take part in product innovation training sessions and in-company demonstration

projects. Moreover, in order to enhance the effect of the product innovation approach, a sustainable cooperation had to be developed between UDSM and the local companies. Therefore, raising awareness in industry about the relevance of the product innovation approach was a major second objective. This was activated by two activities:

1. Workshops for local company managers in order to enhance the awareness among a growing number of companies;
2. Demonstration projects in Tanzanian industry focussing on the different disciplines of product innovation.

In addition the role of the demonstration projects was (Nalitolela, Elias et al. 2000):

1. To create local examples which could be incorporated in the teaching and course materials;
2. Creating job opportunities on the med-term for the first graduated students.

6.4.1 Selection

The demonstration projects in industry started in 2000 with a selection of companies. Potential companies did have to satisfy the following criteria (Diehl, Christiaans et al. 2001):

1. Tanzanian companies (not internationally owned);
2. Developing (and producing) new product (-service combinations) themselves;
3. Industrial design products for consumer or business to business;
4. Representative for the industrial sectors in Tanzania;

The first five companies and organisations for the demonstration projects were selected in a structured way at the beginning of the project. Ten companies and organisations in the surroundings of Dar es Salaam were visited of which five joined the project. During the project several other companies and organisations have been approached to join the demonstration projects, which resulted in a total of nine participating organizations.

It was not easy to identify private industries willing to join the demonstration projects. In total only five private companies participated (3 of which were owned by 'Asian-Tanzanians'). The majority of the demonstration projects took place in collaboration with R&D institutions (Temdo), NGO's supporting micro-enterprises (TAFOPA), NGO's encouraging the use of renewable energy (TATEDO), NGO's encouraging community development (rural tourism project) and government organisations (Tourism Board and MOI) (see Table 6.1).

Table 6.1: Overview of the product innovation demonstration projects.

Company	**Size**	**Kind**	**Sector**
TZ 1			
Palray	Medium	Private	Metal furniture manufacturer
Simba Plastics	Medium	Private	Plastic products manufacturer
TAFOPA	Micro	NGO	Micro-enterprises cluster project
TATEDO	Small	NGO	Renewable energy
TMTL	Small	Private	Textile industry
RT	Micro	NGO	Rural community
MOI	Small	Government	Hospital school
DAGE	Small	Private	Metal products workshop
Tourism Board	Large	Government	Government, tourism
TZ 2			
Intermech	Small	Private	Agricultural machinery workshop
Temdo	Small	Government	Agricultural R & D institute

The result of the company selection in TZ 1 provided a scattered picture of the participating organisations varying in sector, in size and in kind (see Table 6.1). It was concluded that in the follow up project (TZ 2) a more efficient approach would be needed by focussing only on the most relevant industrial sectors and a smaller number of company cases, but more intensive training and interaction (Christiaans and Diehl 2003).

Putting the sectors of the participating organisations in the 'industrial development' (see Figure 4.6) diagram provides the following picture (see Figure 6.5):

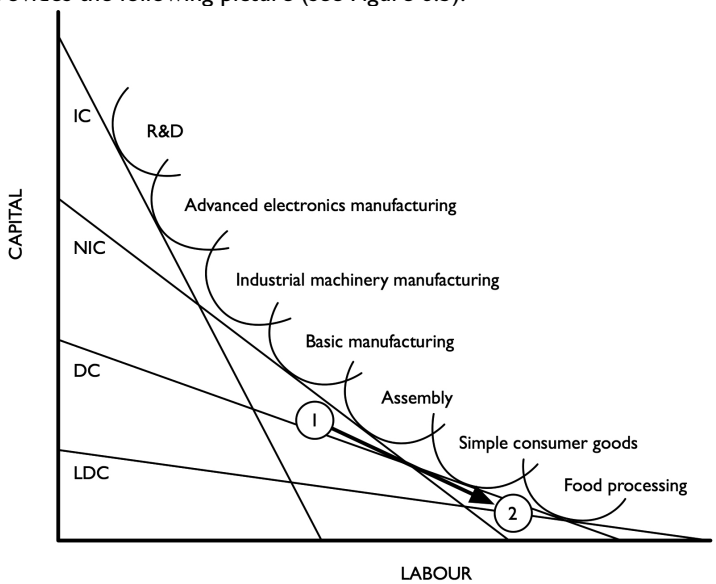


Figure 6.5: Industrial sectors for TZ 1 and the TZ 2 demonstration projects (Diehl 2010).

According to Figure 6.5 and as earlier discussed in paragraph section 4.2.3 it is expected that food processing (2) and simple consumer goods would be the most relevant industrial sectors for demonstrating the need and use of product innovation in the economical and industrial context of Tanzania (Least Developed Countries (LDC)). However, within TZ 1 a wide range of industries and organisations were selected which were situated higher up in the curve (1). This was partly due to the fact that at the beginning of the project there was not yet a clear scope of the objectives of the demonstration projects. The agro- and food- processing industries were not attended fairly at the beginning (Elias and Majaja 2005). Only in a later stage the project team came to realize that sector focus and the connection to the national economical and industrial context should be more appropriate (Elias and Majaja 2005). As a result, the second phase of the demonstration projects (TZ 2) were focussed on the agro- and food-processing sector (2).

6.4.2 Student involvement

The main facilitators of the demonstration projects in the industry projects were DUT students supported by their supervisors of UDSM and DUT. In total 19 senior DUT students joined the demonstration projects. For these DUT students it was rather challenging to introduce product innovation in the local companies where culture, technology, people, education and economic differed a lot from their own national industrial and economical context (Nalitolela 2002). Most of them participated by means of a 'practical internships' during a period of 3 months, which is

relatively short compared to the 6 months graduation projects that were mainly applied in the Central America and Croatia demonstration projects.

The three months involvement of the DUT students were often too short to realize the needed knowledge transfer, capacity building and real changes in the companies (Christiaans and Diehl 2003). To change the mentality or attitude inside a company towards a more innovative environment consumes more time, energy and other resources (like financial) than just the 3 months projects of the students.

In some cases after the initial demonstration project, a second follow up project took place. This continuation of knowledge transfer and support in the innovation process led in most cases to more tangible product results and more knowledge transfer and capacity building. Several projects in sequence could intensify and continuate the knowledge transfer (Christiaans and Diehl 2003). Some examples are:

RT 1: Setup → RT 2: Implementation
TB 1: Development route map → TB 2: Commercialisation
TMTL 1: Product strategy and concept → TMTL 2: Detailing and prototype
TATEDO 1: Development solar drier → TATEDO 2: Marketing of solar driers

6.4.3 Results

All demonstration projects did contribute to the goal of the project, creating awareness for product innovation in the Tanzanian industry. Most companies gained awareness on the need of product innovation and the basic understanding of the product innovation approach. The evaluations provide a scattered view, with most companies showing a limited awareness on 'know-what' level and only a few companies having developed capabilities up to a 'know-how' level (Christiaans and Diehl 2003). Some of the organisations did already have some basic product innovation knowledge by which they could make a quick start (TEMDO, TATEDO, Simba and Intermech).

But how successful were the product outcomes of the demonstration projects? The success of the product can be indicated by the fact whether the newly developed products or services came into production and if they were being sold. From the eleven projects four ended up at the stage of drawings and seven were elaborated into working prototypes (see Table 6.2). Three projects resulted into a product that was launched in the local market.

Table 6.2: Overview of the product success of the TZ demonstration projects.

Company	**Product**	**Result**
TZ 1		
Palray	Innovation management and new furniture line	Concept drawings
Simba Plastics	Development of plastic selling booth for East Africa	CAD drawings
TAFOPA	Packaging and graphical design for food products	Concept drawings
TATEDO	Development of a solar food dryer and marketing	In the market
TMTL	Development of a mosquito net tent for tourists	Prototype
RT	Set up of cultural tourism and marketing	Prototype tested in practice
MOI	Developing of aids for disabled people	Prototype
DAGE	Development of kick bike	Prototype
Tourism Board	Development of a 'Dala Dala' tourist map	In the market
TZ 2		
Intermech	Redesign of cassava processing machine	In the market
Temdo	Redesign of oil expeller	CAD drawings

In general it was observed that companies appreciate working prototypes more than technical drawings. This is greatly influenced by the education level of the respective company staff (Nalitolela 2002). For example, Simba Plastics, which possesses of a relative higher educated staff and larger middle management, could be satisfied with good technical (3D) drawings. However for small and micro enterprises, with relatively low educated staff (like DAGE) it is essential to come to physical one to one size prototypes (which they can copy). The lower the educational level of the company, the more important a physical and tangible output is.

6.4.4 Innovation level

Most demonstration projects did have an (for the economical and industrial context) ambitious innovation level in mind. As can be observed in Figure 6.6, the innovation strategy of the first series (TZ 1) of demonstration projects (*the italic ones in Figure 6.6*) was in all cases aiming at new markets and/or new products. This is a relatively risk-full approach (see section 3.3), especially taking mind the lack of experience in product innovation and the limited capabilities of the participating companies.

	Current Products	New Products
Current Market	Temdo	***TATEDO***, *MOI TAFOPA, Palray,* ***Intermech***
New Markets		***TTB***, *DAGE, SIMBA, RT, TMTL*

Figure 6.6: The product innovation strategies of the demonstration projects (Bold = successful into the market).

These for the local context radical innovation approaches were too ambitious for the participating companies and did not fit to their current product innovation needs and capabilities. After the first series of demonstration projects (TZ 1), the team had gained more experience and insights in the potential for product innovation in the local companies. As a result, the second series of demonstration projects (TZ 2), Intermech and Temdo focussed on a more incremental innovation approach by redesigning or benchmarking the current products of the companies (Elias and Majaja 2004). This innovation level fitted better to the characteristics and current needs of the companies. It was concluded that the team did not take enough into account the differences in between the companies and the related expected output (i.e. micro enterprises versus large industry). The possibilities of the potential outcome should be analysed beforehand in view of the type of enterprise and the education level (absorptive capacity of its staff) (Nalitolela 2002).

6.4.5 Absorptive capacity

Part of the success of the knowledge transfer and the developed products depends on the absorptive capacity and the capabilities of the organisation and its staff (see section 2.7). Mahemba and Bruijn (Mahemba and Bruijn 2003) found that innovative SMEs in Tanzania are more likely than their non-innovative counterparts to employ graduates, scientists and engineers. This implies that adequate knowledge and skills in SMEs are prerequisites in facilitating the innovation adoption process. They also observed that there is a low level of awareness among managers of the importance of human resources in their organization (Mahemba and Bruijn 2003). In order to get more insight in these aspects an overview has been made of levels of management, their education level, and the experiences with product innovation in the companies (i.e. if they have recent experience with product innovation).

Table 6.3: Overview of the 'absorptive capacity' of the participating organisations.

Name	Size	H	M	L	P/C/R	PI	Pr	Experience
TZ 1								
Palray	Medium	3	2	1	C/P		*	Good manufacturing experience
Simba	Medium	3	3	1	P	*	*	Own design department, designer from India
TAFOPA	Micro			1	C		*	
TATEDO	Small	3	3		R			Experience with international consultants
TMTL	Small	3		1	C		*	Business experience
RT	Micro			1	-			
MOI	Small	3	2		R			Application and teaching
DAGE	Micro	1		1	C/P		*	-
TB	Large	3			G			-
TZ 2								
Intermech	Small	3		1	P	*	*	Director studied design in UK
Temdo	Small	3	3		R		*	

H= Higher management, M= Middle management, L= Work floor,
4= High skilled, 3= Medium-skilled white-collar, 2= Medium-skilled blue-collar, 1= Low-skilled
P/C/R= product company, capacity company, research organisation
PI= Product innovation experts in organisation
Pr= Production capacity (the company has its own production facilities)

TATEDO, MOI and TEMDO are all research-oriented organizations and possess of highly educated staff but no production facilities. TATEDO and TEMDO have experience in developing products. They are expected to be able to absorb new product innovation knowledge however not capable to produce the products themselves. This group captured mainly domain specific basic and design knowledge during the demonstration projects.

Simba and Palray, the two large medium-sized enterprises, do have three or more levels of management of which the two highest have medium to high educational level. They differ in the fact that Palray did not develop new products for several years and is mainly leaning on its production capacity. Simba on the other hand develops continuously new products and posses of a product development department. Within the demonstration projects they where able to capture domain specific knowledge (more design than basic) as well domain independent process knowledge.

TMTL and Intermech are both SMEs with a high-educated management and low educated work floor staff. Middle management is lacking. The director of Intermech studied design engineering in the United Kingdom and possesses of well-developed product development skills. Intermech continuously improves current and develops new products. TMTL is more skilled in business innovations. These companies mainly received domain dependent basic knowledge.

TAFOPA, the Rural Tourism project and DAGE all deal with informal micro enterprises with low educated staff and no or just one management level. The absorptive capacity and the capabilities of these organizations are low. Very little can be expected of product innovation knowledge transfer. They did not capture any substantial knowledge.

6.4.6 Expectations of the companies

The expectations of the participating companies with regard to the demonstration projects were diverse. One company might consider the outcome of the project of valuable contribution to its product development, whereas a second company merely saw the project as a transfer of knowledge or an efficient way of information gathering without any commercial motive. This greatly affected the way a firm looked back to the demonstration projects, calling a project

successful or unsuccessful depending on their expectancies (Nalitolela 2002; Stranders 2002). In addition the companies did not have to contribute financially to the demonstration projects, which made the threshold low to participate, but also created a lower commitment and interest of the management. Since it was for free, it didn't matter in some cases if the projects were successful or not, and if they contributed to capacity building of the company or not.

6.4.7 Awareness for the need of innovation

The next Figure 6.7 shows the evaluation of the participating organizations on the fact 'if they are aware of the need for change' and 'awareness of what and how to change' in relation to product innovation (see also section 4.3.4). This partly shows a similar kind of grouping. The more experienced companies, NGOs and research institutions can be found in the upper right quadrant. The medium sized enterprises are partly aware of the need for change but have not yet the awareness of What and How to do. Finally the micro enterprises are in the lower part of the figure. They differ in the fact that the cluster organised micro-enterprises (TAFOPA) and NGO related micro-enterprise (Rural Tourism) are more aware of the need than those without support (DAGE).

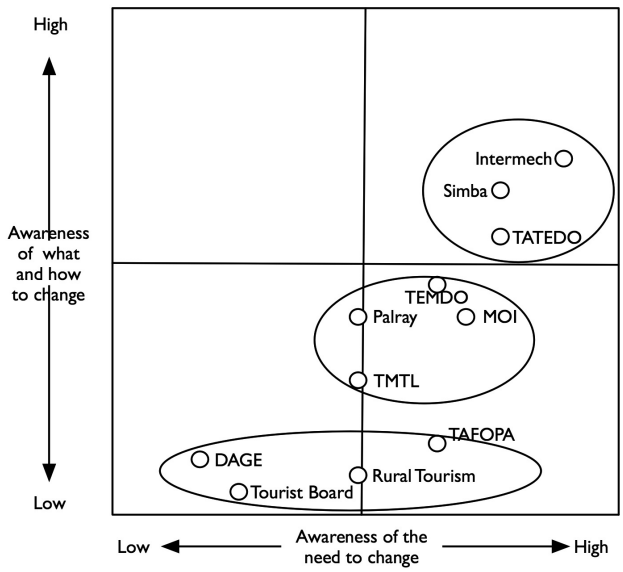


Figure 6.7: Positioning of the demonstration companies on their awareness for the need and how to change with regards to product innovation (Diehl 2010).

6.4.8 Changes in second project

Based on the learning experiences with the first series of demonstration projects (TZ 1) the setup for the second series of demonstration projects (TZ 2) was drastically changed. Some of the adjustments were (Bijma and Diehl 2004; Nalitolela 2004) (see also Figure 6.8):

- More clear picture of the objective of the demonstration project;
- Priority given to agro- and food processing companies;
- More intensive meetings, starting with a take-in meeting discussing goals of the project and selecting product followed by in-company workshops;
- Focus on improvement options for current products (incremental innovation level);
- Identifying not only product improvement options but in the meantime also process improvement options;

- Presentation of the results to the company itself and other companies within the same sector (dissemination).

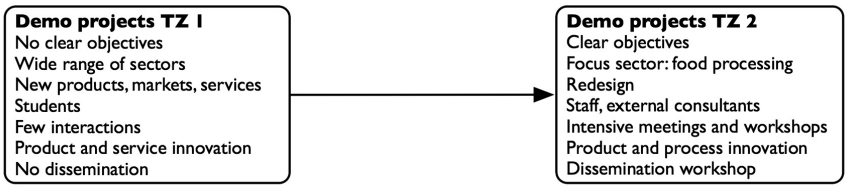


Figure 6.8: Differences in approach between demonstration projects TZ 1 and TZ 2 (Diehl 2010).

6.5 Workshops

Throughout the project, two company workshops and one international conference have been organised. The first workshop took place at the beginning of the project (November 2000) and the second one by the end of the project (June 2004). The target group of both workshops were industry, however in practice to a large extent the audience mainly existed of academics, R&D organisations and NGO's.

The aim of the first two-days workshop was to raise awareness among companies on the potential contribution of the product innovation approach to their economical growth. During this workshop multi-disciplinary teams have been working on the development of product innovation business plans for local problem owners (Diehl, Christiaans et al. 2001). Six groups were formed around an enterprise or NGO. The participants went during the two days time through the total product innovation process. The focus was on radical innovation in a sense that the theory and exercises were focussed on new products, new businesses and new markets. Rather theoretical lectures were given, illustrating mainly examples of western consumer products.

The second workshop, at the end of the project was in several ways different. The one-day workshop was mainly facilitated by the UDSM staff and was meant to update the industry about the results of the project. While during the first workshop the DUT team executed most of the presentations and training activities, during the second workshop the local UDSM team mainly took care of this. The theoretical content of the presented product innovation approach shifted from radical to incremental innovation approaches: the focus was more on redesigning products and product benchmarking. Furthermore the explained examples were based mainly on local Tanzanian cases instead of international ones and related to the industrial sectors, which are relevant of Tanzania (food processing, metal workshops). This illustrated the adaptation of the content of the workshop towards the local needs. The content of the workshop and the way of knowledge transfer became more appropriate and in connection with the local economical context (see Figure 6.9).

Figure 6.9: Differences in approach between workshop I & II (Diehl 2010).

The workshops demonstrated that industrialists appreciate the usefulness of product innovation. They were enthusiastic about product innovation and grasped and applied the product innovation principles quite fast during the workshop (Elias and Nalitolela 2003). However, a follow up visit by the UDSM academic staff to nearly all of the participating firms has shown that for the most part of them did not yet impart the new product innovation skills in their daily activities (Nalitolela 2002; Stranders 2002; Elias and Nalitolela 2003; Mshoro). The workshop proved to be suitable to make the participants aware about product innovation, but did not provide enough skills to enable them to do it themselves within their own organisation.

6.6 Education

6.6.1 Course development

In order to address the need to equip the B.Sc. graduates from the FoE of UDSM with knowledge and skills on competitive product innovation, the curriculum has been enhanced, so that students are trained on an integrated approach to product innovation. Six new product innovation courses were proposed for the UDSM undergraduate curriculum to fill gaps in knowledge in important areas of product design, innovation management, marketing and entrepreneurship. These six newly developed courses are:

- Fundamentals of product innovation;
- Product innovation 1;
- Product innovation 2;
- Ergonomics;
- Introduction to entrepreneurship;
- Selected topics product innovation;
- Techno-entrepreneurship.

Each of the four trained staff members from the first TtF batch has developed and teaches one of the six new product innovation courses. The department of Business Management provides the two other courses related to entrepreneurship. The objective of the six product innovation courses is to equip the students with product innovation knowledge and skills to the 'know-where, know-when' level (see section 2.3) (Elias and Majaja 2005).

The first course 'fundamentals of product innovation' introduces the students to 'know-what' and 'know-why' of product innovation in the context of Tanzania supported by local examples and study cases. The course has a focus on providing domain specific 'basic knowledge' to the students. Additionally the students are being trained in basic design skills like sketching by hand and creativity techniques.

Product innovation 1 deals with product innovation and how to apply it. The course exists of lectures with many examples, exercises and a mini-project. The mini-project is based upon the teaching method of the course 'Design 5' at DUT. The students are provided with a case description based upon a real existing Tanzanian small or micro enterprise. The students analyse the internal and external environment of the enterprise resulting into a SWOT-matrix. Based upon these findings they propose a product innovation strategy for the company, develop concepts and write a short business plan. Focus of the course is on domain specific design knowledge'. Additionally this course provide domain specific basic knowledge on ergonomics and aesthetics (Elias and Majaja 2005). Product innovation 2 builds upon this created basic product innovation skills and continues with additional innovation management approaches which have to

be applied by the student in another mini-project which is focussed on medium sized enterprises and large industries.

The ergonomics course deals with the ergonomics aspects of the working environment as well as those related to products and cognitive aspects. Also this course is rich of practical examples of practice and contains a mini project. Within the mini project the students evaluate the ergonomics aspects of the facilities of the UDSM campus and come up with improvements (see Figure 6.10).

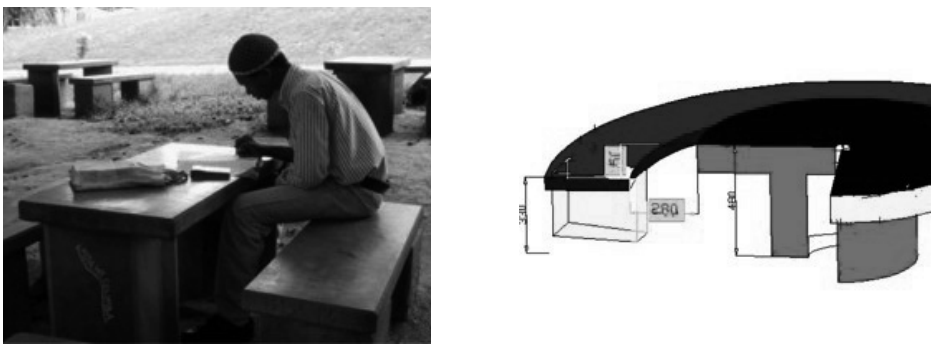


Figure 6.10: Students analysing and improving the ergonomics aspects of the facilities of the UDSM campus (Majaja, Elias et al. 2003).

Within the sequence of the three design courses the capability of the students move from 'know-what' to 'know-how' and the accent shifts from domain specific basic knowledge to domain specific design and domain independent process knowledge.

6.6.2 Teaching approach

The product innovation project has changed the way of thinking and teaching for both the teachers and students tremendously. The new product innovation courses did not only introduce new content into the curriculum but also, for the context, a radical different approach towards teaching. Many aspects of constructivism and problem-based learning (see section 2.8) have been integrated into the new courses by means of real context based mini-projects, providing local context and practice based examples and 'learning by doing'. Students used to get as assignment for example to design a gearbox, but now they are encouraged to first identify the real problem and need (problem finding) before starting to develop solutions.

The new product innovation courses have a multidisciplinary approach connecting the different basic knowledge disciplines with the design practice. The difference in teaching approach between the traditional FoE UDSM courses and the new product innovation courses can be well illustrated by the example of the ergonomics course. This course is provided by two lectures, one trained in product innovation and applying the problem-based learning approach and the other one teaching in the traditional way. Within the problem-based learning part of the course the basic knowledge is mixed with design knowledge, students execute mini-projects, many example of the context and daily practice are provided and a wide variety of ergonomics topics are presented and discussed. The traditional lecturer, focuses in his part of the course only on one specific theoretical subject within the ergonomics discipline, namely 'light'. He teaches the students to the level of atomic molecular parts of the eye. A deep theoretical focus, with knowledge very little connected to the practice and other disciplines (see also section 4.4.1).

As discussed in section 4.2.6, based upon the cultural dimensions of a country, a expected profile of the teaching approach can be made (Hofstede 1986). The traditional teaching at UDSM fits rather well in the cultural teaching profile of Tanzania.

Table 6.4: Hofstede's indices for the 5 cultural dimensions for the Netherlands and East Africa (Hofstede 1991).

	PDI	**IDV**	**MAS**	**UAI**	**LTO**
Netherlands	38	80	14	53	44
East Africa	64	27	41	52	25

The higher power distance (PDI), stronger collectivism (IDV) and higher masculinity (MAS) in Tanzania influences the traditional education by means of for example (Hofstede 1986):

- Teacher-centred education (high PDI);
- Student expect teacher to initiate communication (high PDI);
- Student expect teacher to outline paths to follow (high PDI);
- The students expect to learn how to do (low IDV);
- Individual students will only speak up in class when called upon personally by the teacher (low IDV);
- System rewards students' academic performance (high MAS);
- A student's failure at school is a severe blow to his/her self-image (high MAS).

The newly introduced product innovation courses based upon constructivist approaches are in that sense a revolution for the educational context. Using the same model of Hofstede, the new product innovation approach at UDSM can be described as the opposite (Elias and Majaja 2005):

- Student-centred education (low PDI);
- Teacher expects student to initiate communication (low PDI);
- Teacher expects students to find their own paths (low PDI);
- Students expect how to learn (high IDV);
- Individual students will speak up in class in response to a general invitation by the teacher (high IDV);
- System rewards students' social adaptation (low MAS);
- A students' failure at school is a relatively minor accident (low MAS).

The new teaching approach has been received very positive by the students and seems also to contribute to better-educated students. Since the change of the education approach, the students perform better than other departments by the end of theirs studies. The product innovation approach contributes to the self-development of the students (Elias and Majaja 2005).


asian paints
Tractor

7 Case II: India

The Indian European Ecodesign Program (IEEP) was a three-year project aiming at the promotion of Ecodesign (sustaibale product innovation), exchange and development of Ecodesign knowledge, methodology and expertise in India involving people from scientific and business background. IEEP was financed by the EU Cross Culture Program and was a collaborative project of the Indian Institute of Technology Delhi (IITD) in India, the National Institute of Engineering and Industrial Technology (INETI) in Portugal and Delft University of Technology (DUT) in the Netherlands.

The evaluation of this case is based on data gathering by a detailed analysis of the original project proposals, semester technical reports, mid-term evaluation, student reports and results of workshops and demonstration projects. At the end of the IEEP project it was evaluated extensively by an external evaluator (Crul 2002). Furthermore 7 refereed papers of the researcher and the IEEP team were analysed for additional findings (Vergragt, Diehl et al. 2000; Diehl, Soumitri et al. 2001; Soumitri and Chaudhuri 2001; Soumitri and Diehl 2001; Diehl and Mestre 2002; Diehl, Soumitri et al. 2002; Diehl and Mestre 2003). The external reviewer Dr. M. Crul has validated the case description. Within this and the following chapters this project will be referred to as 'Case IN'.

Background

The IN Case took place under the umbrella of the EU India Economic Cross Cultural Programme. This program was initiated by the European Commission with the aim to foster civil society links and networks between India and the European Union. The overall objective of the programme is to promote interaction between India and the European Union by enhancing mutual knowledge and facilitating direct contacts between the two regions. The EU Cross Cultural Programme aims to (Maresch 1997):

- Develop links between Indian and European universities, media and cultural organisations;
- Help raise the profile of India in the European Union and of the European Union in India following a two way interdisciplinary approach and;
- Help strengthen a two way dynamic, cultural and economic networking between the two regions.

7.1 Context

7.1.1 Economical and industrial context of India

Until the 1990's India was a protected market economy and the Indian industrial environment was traditionally identified by its regulative and protective characteristics. Thereafter the market changed from a protected environment to a competitive due to globalisation and economic liberalisation in India (Lind 2007). Till that time, the Indian economy was inward looking and protected from internal and external competition. In the absence of competition, firms did not

develop the technological capability needed for penetrating the global market. These decades of protective environment also reduced the risk taking capacity of the enterprises (Kacker 2005). Especially the traditional SMEs are still adapting to the new situation, learning how to innovate, compete and export (Lind 2007). The picture provided is from 1999-2002, the time of the project. Since then a lot has changed in the economical and industrial development of India and many dynamic ICT and R&D based firms started their successful business.

After China, India is the country with the largest population (more than 1.1 billion people). As a result the Indian society contains a wide diversity and many extremes. First there are the economic extremes: high-rise office buildings can share the same street with tin-shack markets whose vendors sleep on the sidewalk at night; water buffalos share the road with BMW's; dung fuels many fires while compressed natural gas fuels all the buses and rickshaws of Delhi (Faludi 2006). This is also reflected in the industrial and economical development. The industries can vary from capital and knowledge intensive high tech ICT industries in Bangalore and Hyderabad to the labour-intensive low-skilled informal sector of micro enterprises in Western Bengal or the informal settlements of Mumbai. From that perspective it is complex to provide a comprehensive view of the industrial development at the time of the project.

7.1.2 SMEs

In India, SMEs play a vital role in the economy. They constitute more than 80% of the total number of industrial enterprises, have a 40% share in industrial output and they contribute nearly 40% to the export from the country. They are the biggest employment providing sectors after agriculture (CII 2004; Kacker 2005; Lind 2007). However, availability and cost of buying advanced technology is one of the most frequently listed obstacles for traditional Indian SMEs to become more innovative (Lind 2007). As a result, traditional Indian SMEs suffer from the problems of sub-optimal scale of operation and technological obsolescence.

In traditional Indian SMEs the structure is more like a family, where the power is centralized to a patriarch who has to be pleased by his employees (Lind 2007). Often just one or two people control the organisation, even in moderately large sized firms employing several hundred workers. These managers are mainly busy handling many day-to-day problems that demand immediate attention, e.g. payroll, inventory, finances, personnel, suppliers, and customer demands. Clearly, there is little chance for them to think about making major changes or risk taking, which is essentially required for the innovation process (CII 2004).

Product innovation in Indian SMEs

Lind (2007) studied the use of product innovation methods in SMEs in the Indian electronics sector. Formal education with regard to product development methods is unusual among product developers in Indian SMEs. Most designers are self-taught. With regard to the product development process a manager at one of the interviewed SMEs said that the lack of not to have very sophisticated methods is typical for Indian SMEs: "Quite frankly, we don't really use - maybe that's the case with most SMEs - a very structured tool. Our tool is more [...] a checklist". This 'checklist' product innovation process is often standardised which means that there are sets of rules and checklists of how to go about. The smaller companies use even fewer methods due to economic reasons.

Based upon her research, Lind concluded that Indian SMEs would benefit from product innovation methods that ask for a minimum of training hours. These methods have to be easy to

learn since formal training is rare. The product innovation methods should generate answers that are easy to understand and communicate (Lind 2007).

Within the perspective of introducing Ecodesign in Indian SMEs, the management has a large influence on the environmental work and awareness in a company. Support from top management is indispensable since this is where decided on resources. Educating and engaging managers in environmental issues and Ecodesign are therefore natural first steps in introducing Ecodesign in India.

7.1.3 Education

Industrial Design at tertiary education level (universities) at the time of the project (1992-2002) was mainly taught at the National Institute of Design and at the Indian Institutes of Technology (IITs). Nowadays there are over twenty industrial design schools. Formal industrial design education in India dates from the early 1960's. The initial framework of design as formulated in the curriculum of those days was based on a conception of the 'needs' of the country, its populace. The accent was on craft, rural development and a focus on increasing the quality of goods generated by the SMEs (Soumitri and Diehl 2001). At the time of the project most of the Industrial Design Schools still did have their accent on Industrial Design and crafts and less on product innovation. Industrial Design education at IIT Delhi dates only from 1994. Because of the changed industrial and economical context the programme of IIT Delhi was set up with a commitment to have a greater relationship with the mass industry.

7.2 Project

The Indian European Ecodesign Program was a three-years collaborative project of the Indian Institute of Technology Delhi (IITD), the Delft University of Technology (DUT), Netherlands and the National Institute of Engineering and Industrial Technology (INETI), Portugal.

Knowledge source:	DUT, INETI (Europe)
Knowledge facilitator:	IITD (India)
Knowledge recipients:	Faculty, students, researchers, SMEs, large industries and design consultants (India)

7.2.1 Goals and objectives

The original objective of the IEEP project was to have a reach out to the total country (CICAT 1997). It was decided however during the kick-off meeting that this objective, to really create an active network of Ecodesign professionals for all over India, was too ambitious. It was believed that with a limited geographic scope, the Delhi region, the changes for success would be higher. Delhi itself has more than 16 million inhabitants, about the population of the Netherlands. In order to meet the set objective, the following sub-goals were formulated:

1. Exchange and development of Ecodesign knowledge and expertise between India and Europe;
2. Provide Indian industry with well-trained local professionals knowledgeable of Ecodesign and with international exposure, experience and contact;
3. Successful proof of Ecodesign in demonstration projects to create interest from local industry;
4. Creation of a strong Ecodesign network with a focus on the Delhi region.

The proposal focussed initially primarily on the following two target groups:

- Academia and R&D: Faculty and students of IIT Delhi, graduate and postgraduate engineers of other universities and research establishments (targeted 200 staff and students;
- Corporate and business houses: 4 SMEs with demonstration projects, 100 Indian companies reached through awareness actions and workshops.

7.2.2 Project outline

The specific EU funding program had a strong focus on enhancing links and networks. Accordingly, the IEEP project aimed at the development of Ecodesign capability, through the exchange and development of Ecodesign knowledge and expertise and by forming a strong network among design professionals, academia and industry (Diehl, Soumitri et al. 2001). The project was a combination of intervening at the knowledge creation level (i.e. universities and design schools), at manufacturing companies' level and at the design consultants (where business opportunities are generated) (Soumitri, Diehl et al. 2002). This resulted in the following proposed and achieved product innovation knowledge transfer activities:

Table 7.1: Overview of the IEEP knowledge transfer activities.

Capacity building activities	**Proposed**	**Achieved**
Two-week Train-the-Facilitator at DUT	1	1
Demonstration projects in companies	4	9
European students to India	8	8
Indian postgraduates to Europe	5	8
IITD / DUT sandwich PhD	1	0
Trained Ecodesign staff members of IITD	5	2
Awareness and dissemination activities		
Workshops at IITD	5	5
Two days expert workshop at INETI	1	1
Two days international conference at IITD	1	1
Ecodesign manual	1	0
Ecodesign course	1	1
Fact sheets	4	0
Published papers	0	10

These activities were spread over a three-years (1999-2002) time period as illustrated in Figure 7.1:

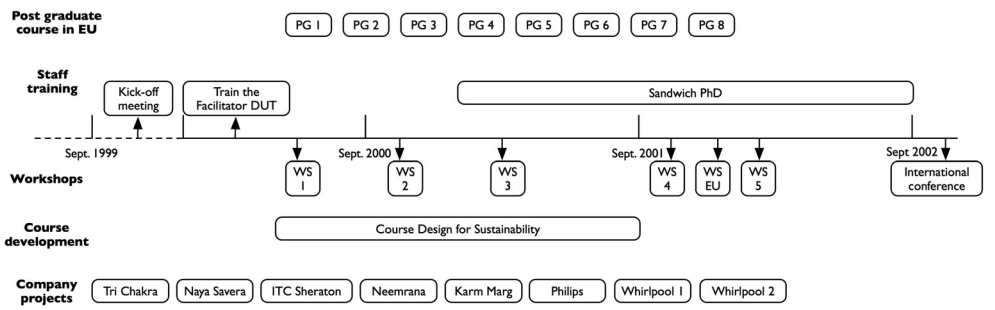


Figure 7.1: Timeframe and activities of the IEEP project (Diehl 2010).

7.3 Train the Facilitator (TtF)

The two-weeks Train the Facilitator took place in March 2000 in Delft. In total four representatives from INETI and six from IITD participated. The participants from IITD represented academic staff, design consultants and company representatives. To build up

knowledge on Ecodesign, the course programme existed of lectures, case studies, exercises, computer sessions and company excursions. The TtF programme (see Table 7.2) treated the different levels of innovation varying from incremental towards more radical innovation approaches like product service systems and system innovation.

Table 7.2: Programme of the Train the Facilitator at DUT.

Day	Topic	Knowledge source
1	Introduction to Ecodesign	DUT
2,3,4	Ecodesign design methodologies, tools and hands-on exercises	DUT/INETI
5	IIT Ecodesign related experiences in India	IIT
6	System innovation	DUT
7	Company excursions	DUT
8	Strategies and approaches to get companies on board	DUT/INETI
9	Optional	
10	Evaluation of the course and action plan	

Except from day 2, 3 and 4 (redesign of a West European water cooker) the program was dominated by presentations and less by practising the newly gained knowledge. The content of the TtF did have a strong focus on domain specific basic knowledge (see section 3.6). This was a good fit to the characteristics and needs of the IITD participants. Since they all did have an industrial design background, they already learned and practised product innovation. The INETI participants, on the contrary, with a more research background did not have any earlier experience in product innovation. In a later stage of the project the INETI staff did have to manage several of the Ecodesign demonstration projects. Because of their lack of domain specific design knowledge they encountered several problems. More domain specific design and domain independent process knowledge in the TtF for the INETI staff would have been helpful.

7.4 Demonstration projects

Demonstration projects in industry were expected to be one of the effective ways to explore the real needs for the development and use of an Ecodesign methods and tools within the Indian industry. In order to do so four Ecodesign demonstration projects in Indian SMEs executed by Dutch and Portuguese students were planned.

7.4.1 Selection

In total seven companies were selected for the demonstration projects. Compared to the other three cases the IN case did have a less structured company selection procedure. The companies and organisations were approached based upon earlier connections with IITD and DUT. One of the reasons for a restricted selection procedure was the limited budget to visit a large range of companies to identify the appropriate ones. The seven selected companies were:

Table 7.3: Participating companies and organisations in the demonstration projects.

Company	Size target group	Type of enterprise	Sector
Neemrana Fort Hotel	Large	Large	Hotel / tourism
ITC Welcome Group	Large	MNC	Hotel / tourism
Philips India	Large	MNC	Electronics
Whirlpool India 1	Large	MNC	Electronics
Whirlpool India 2	Large	MNC	Electronics
Naya Savera	Micro	NGO	Waste collection and recycling
Tri Chakra	Micro	NGO	Urban mobility (rickshaws)
Karm Marg	Micro	NGO	Homeless children

Even though the objective of the project was to reach SMEs, the eventual target group was either large enterprises or indirectly through NGO's micro entrepreneur (see Figure 7.2). The

selected group of demonstration companies existed of 2 MNCs (electronics), 2 international hotel chains and 3 NGOs in the field of waste management, mobility and homeless children.

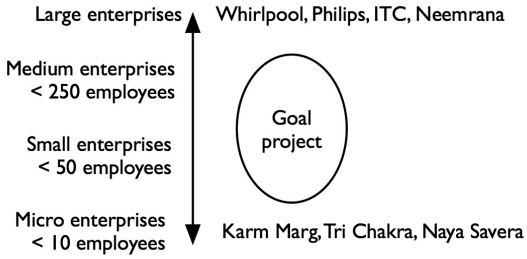


Figure 7.2: The size of the target enterprises of the demonstration projects (Diehl 2010).

All the large companies were international and most of the projects took place in the region of Pune, instead of the intended Delhi region. Only the NGOs were Indian and their projects were in the Delhi region. The project team was not successful in getting SMEs, the target group for the demonstration projects, on board. As a result no SMEs joined the demonstration projects. For several reasons it was very difficult to convince Indian companies to participate in the Ecodesign demonstration projects:

SMEs: Traditional SMEs at the time of the project were not oriented towards product innovation and investments for green measures. They were not habituated to voluntarily incorporate environmentally friendly decisions in their set up. Investment in terms of manpower and finances (initial expenditure as Ecodesign usually ends up being a cost cutting exercise for the product) was a complete no-no. For example according to the Electronics Industries Association of India (ELCINA), Ecodesign initiatives in the electronics industry is unusual and most SMEs probably do not know what Ecodesign is (Lind 2007). Even though this would be even more a good reason to get traditional SMEs on board within the project, the project team was not successful.

Large industries: Though interested in learning new techniques and tools they were not interested in putting efforts in developing Ecodesign capacities. The attitude being: yes it is good but we do not have the time. The multinationals (at the time of the project) were mostly dependent on their headquarters (in other countries) to supply them with new concepts; they were not in a position to make any (radical) changes. For example Maruti – a large Indian automobile company was dependent on its Japanese counterpart – Suzuki to provide design details for their cars (Soumitri, Chaudhuri et al. 2003).

7.4.2 Student involvement

Students from the Netherlands (DUT), Portugal (INETI) and India (IITD) carried out the demonstration projects. The students were in all cases involved as an intern student (variant A, see Table 10.13). The time span of most of the demonstration projects, 2-3 months, was comparatively short to the other cases. In addition the supervision of the international and local experts was rather limited. For example no in-company workshop were organised and only 1 supervisor would be involved. One of the constraints was the distance. Half of the demonstration projects took place at a location far away from the local facilitator, IIT Delhi (no travel budget).

The participating students were mainly trained in new product innovation, looking for new product market innovations (product innovation level 3) for SMEs and large industries. Within the demonstration projects they were confronted with the opposite: a need of to support for example benchmarking (product innovation level 1), or for target groups like micro enterprises and the tourism sector for which they were not trained.

7.4.3 Results

The eight demonstration projects resulted in different outcomes: products as well as product service systems (i.e. campus recycling). Only two projects were totally implemented, the rickshaw and campus recycling project. Both NGO type of projects were supported not only by the student projects but as well as with a wide range of other support activities (i.e. IITD staff, US AID). Two projects (Whirlpool 1 and Neemrana Fort Hotel) were implemented partly. The other four projects did end-up in prototypes. The results of the demonstration projects in term of success in the market are rather limited (see Table 7.4).

Table 7.4: Overview of the results of the demonstration projects.

Company	**Product /Service**	**Result**
Neemrana Fort Hotel	Sustainable Tourism	Partly implemented
ITC Welcome Group	Environmental review	Not implemented
Philips India	Benchmark of radios	Not implemented
Whirlpool India 1	Redesign of refrigerator	Prototype of housing, packaging in production
Whirlpool India 2	Development of rural refrigerator	Eight prototypes and field tests
Naya Savera	Campus recycling	Implemented
Tri Chakra	Rickshaw	Implemented
Karm Marg	Products from waste	Prototypes

7.4.4 Innovation level

The demonstration projects had a wide range of product innovation strategies. Table 7.5 illustrates the demonstration projects positioned in the Ansoff Matrix. The projects are equally distributed over three of the four quadrants as well as the successful ones (bold).

*Table 7.5: Overview of the innovation strategies of the demonstration projects. (**Bold** = in the market, Underlined = prototype, Normal = just concept idea.*

	Current products	**New products**
Current markets	Whirlpool 1, Philips, **Neemrana**, ITC	**Tri Chakra,** Kharm Marg
New markets		Whirlpool 2, **Naya Savera**

From the table it becomes clear that the international large companies were taking incremental and low risk strategies towards Ecodesign. The NGO type of organisations were much more open for more radical product innovation strategies. Only Whirlpool attempted within the second demonstration project a more radical approach. This was mainly due to the personal motivation of the manager.

The innovation levels (see section 3.2) of the demonstration projects show a distributed picture. On the one hand a benchmark focus in the hotel and electronics sector and mainly 'function – level' innovations within the NGO projects.

Table 7.6: Innovation approaches of the demonstration projects.

	Company	**Ecodesign Approach**	**Innovation Level**
1	Neemrana Fort Hotel	Benchmark	1
2	ITC Welcome Group	Benchmark	1

3	Philips India	Benchmark	1
4	Whirpool India 1	Redesign	2
5	Whirlpool Inida 2	New product	3
6	Naya Savera	Product Service System	4
7	Tri Chakra	New product	3
8	Karm Marg	New product	3

A series of demonstration projects within one company demonstrated to be more effective to reach higher innovation levels. For example at Whirlpool within the first project design students worked together with the Whirlpool team on incremental innovations (level 1) on an existing refrigerator. With the gained insights and experiences more radical steps were taken during the second project. Together with a student from IITD a total new concept (product innovation level 3) for rural refrigerators (new market) was developed.

7.5 Workshops

Since developing links and networks as well as creating awareness were the main objectives of the EU Cross Cultural program (the funding source of this project) workshops and conferences played an important role within the IN case. In total five workshops, an international conference and an expert workshop have been organized within the IEEP project.

7.5.1 Workshop setup

To make the introduction of Ecodesign successful in the Delhi surroundings it was important to involve all different kind of stakeholders (universities, mass-industry, SMEs, NGOs and government) to create local awareness and to initiate Ecodesign demonstration projects. For this purpose five thematic workshops were organised in India, each of them targeted at a specific audience (see Table 7.7).

Table 7.7: Overview of the five workshops (Vergragt, Diehl et al. 2000)

	Topic	**Target group**	**Product innovation level**
WS 1	General Ecodesign	Companies, Professional designers, Academic staff	Level 1 product improvement Level 2 product redesign
WS 2	Sustainable Futures 2020	NGO's, Government, Academic staff	Level 3 new products Level 4 product service systems
WS 3	Ecodesign in Practice 1	SME's Professional designers	Level 1 product improvement
WS 4	Ecodesign in Practice 2	Large enterprises Professional designers	Level 2 product redesign Level 3 new products
WS 5	Ecodesign Education	Academic staff	All levels

Based upon experiences in earlier projects, for each target group appropriate Ecodesign innovation level(s) and topics were identified. The Ecodesign innovation levels ranged from incremental improvements and adjustments of existing products (product innovation level 1), to innovation at product service systems level in which new products and services arise, including necessary changes in the related infrastructure and organizations (product innovation level 4) (Vergragt, Diehl et al. 2000).

For SMEs for example, it was concluded that the content of the workshop should be focussed on product innovation level 1, benchmarking, which is close to the incremental innovation level of their daily practice (Vergragt, Diehl & Soumitri, 2000). NGO's, which are operating often on a functional or system level were connected to Ecodesign innovation levels 3 and 4. Their projects often involve many stakeholders a go beyond the product system (i.e. product service systems).

Depending on the target group it was considered what a good balance could be between lectures, exercises and discussion was. For the large enterprises (WS 4) it was preferred to explain more 'why' (convincing the management), to show best practices from India and abroad as well as to discuss the potential within their company. For the NGO's, government and academics staff (WS 2) the setup of the workshop was focused on what, why and how. SMEs on the other side were directly confronted with exercises (how) on their own products to demonstrate what the benefits could for their own business (why).

The two-days workshops attracted on average 25-50 participants. In most workshops a good mix of actors was reached. However, in general it was difficult to attract representatives of industry to the workshops, even more for the second day (Crul 2002).

Table 7.8: Overview of the characteristics and results of the 5 workshops.

Work -shop	**Days**	**Partici-pants**	**Host**	**Presentat-ions (%)**	**Exercises (%)**	**Know-what**	**Know-why**	**Know-how**
WS1	2,5	30-50	IIT	70	30	*		
WS2	2,5	30-40	IIT	25	75	*	*	*
WS3	2	25-50	PHCCD	40	60	*	*	*
WS4	2	30-40	CII	70	30	*	*	
WS5	2	25-35	NID	80	20	*		

The achieved knowledge transfer per workshop differed from know-what to some basic know-how. Three factors did have an influence on the learning effect of the workshops. The best knowledge transfer results were achieved when the participants, 1) did preparations beforehand the workshop, 2) if there was a focus in the workshop and 3) if there were a high percentage of exercises as part of the total program. This was especially the case in WS 2 and WS 3.

7.6 Education

At the start of the IEEP project none of the Industrial Design Schools in India, except IITD, offered courses dealing with the product innovation in combination with environment. At IITD at that time the course 'Design for Sustainable Development' figured as an elective (Diehl, Soumitri et al. 2001). Right after the first workshop, IITD staff started to adjust and improve the course Design for Sustainable Development for two target groups: 1) Industrial design and engineering students at IITD 2) other industrial design educational institutes in India such as IITB and NID.

The original course at IITD did have its roots in 'Design for Need' and the 'public domain'. Because of the potential interest of industries in Ecodesign, the mission of IITD to support the needs of the SMEs and big industry, and the expertise of the European partners it was decided to add a component on Ecodesign of consumer products (Soumitri and Diehl 2001). This led to a new course with design methodology based upon the European experience with Eco(re)design in industry and sustainable system approaches, and on the other hand the Indian experience with need-oriented design (Crul 2002). The significant aspect of the course is that the issue of Ecodesign is handled at two levels, at product level (product innovation level 1,2 and 3) and at the system level (product innovation level 4). In the system level the students get an exposure to handling problems at the city or community level. At the product level, Ecodesign tools from European UNEP Ecodesign Manual (see section 3.7) and the INETI Life Cycle Design (LCD) checklist have been integrated in the course materials (level 1 & 2) (Soumitri and Diehl 2001; Crul 2002).

7.7 Post-graduates

As part of the project proposal, five postgraduate traineeships of each 4 months were planned in Europe. Due to visa problems, the duration of traineeships was shortened to 2 months. The decrease from 4 to 2 months did have a negative impact on the learning effect of the courses. The time period became too short for the Indian postgraduates to get acquainted to the topic, to develop new alternatives and try to apply them. As a result the postgraduate courses became more a theoretical desk-top research and less problem-based learning in practice. It was proposed to compensate the decreased course time in Europe with a month of reflection report writing in India afterward. In practice this did not work out, back home they were absorbed by their daily activities.

7.8 Tools

Within the different project knowledge transfer activities of the IEEP project, European Ecodesign approaches and tools were applied and evaluated. The tools applied were mainly derived from the UNEP Ecodesign manual (see section 3.5) and the INETI LCD Checklist. During the project the methods and tools were evaluated in different settings (i.e. workshops, demonstration projects) and with different target groups. Some of the findings were:

Workshops with industry

During the third and fourth workshop, exercises with company representatives were done with the MET-Matrix, LCD checklists, disassembly sessions and the Ecodesign Strategy Wheel (ESW). The LCD checklist method needed more time to come to results compared to the MET-Matrix & ESW combination. On the other hand some groups did have problems to prioritize the environmental impact within the MET-Matrix. Both methods have shown to be useful to come to practical results within only half a day workshop with participants that are new to the subject.

Especially during the third workshop, it was concluded that economical aspects are of high importance for SMEs. As such it was decided to add a 'Cost column' to the MET-Matrix in order to cover not only the environmental aspects along the lifecycle of the product but also the life cycle costs (LCC). For the SMEs, the lifecycle thinking approach was an eye-opener and the practical hands on exercises were much more appreciated compared to the theoretical ones. To have locally produced products as subject and the ability to disassemble them has shown to be an advantage to make the learning experiences more appropriate and substantial. The SMEs were especially interested in how to learn from competitors (benchmarking)

Demonstration projects in Large industry

Within the demonstration projects in the larger industries the LCD checklists methodology was well accepted since it was in line with other standard product development methods inside the company. Within a short time it was possible to indicate with the team specific areas in the product life cycle that needed an intervention (Diehl, Soumitri et al. 2001).

For the use of the MET-Matrix it was necessary to consult regular specific experts with more knowledge on certain stages of the life cycle of the product. Compared to the LCD-checklist it took more time to come to results, but the results were more detailed (like names of toxic substances, origin resources of energy etc.) It was recommended to use this tool for workshops within the company with the total product development team and with an Ecodesign expert as facilitator (Diehl, Soumitri et al. 2001).

To complete the environmental analyses quantitative tools like LCA (Simapro) and simplified LCA (Eco-Indicator 99 standard list) have been applied. Compared to the other tools, Simapro

was extremely difficult to use in the Indian context within the time frame of the project (5 months). The collection of data was time consuming and the databases were not appropriate for the Indian context. The tool is not recommended for fast results in these kinds of projects. The Eco-Indicator 99 standard material lists were more helpful to provide a quick indication of the Eco-Indicator of materials. If an LCA is really needed it is recommend to consult experts in this field (Diehl, Soumitri et al. 2001).

The Ecodesign Strategy Wheel (ESW) was well accepted within the company project since enables the team very easily to visualize the current and desired environmental profile of the product on the short and long term. This way the team and management could deliberate about the strategic decision like which of the 8 ESW strategies should be dealt with first. The ESW strategies proved to be a useful facilitator to create improvement options during brainstorms and other creativity sessions (Diehl, Soumitri et al. 2001).

It was concluded that not one method or one set of tools would fit for the context of all Indian enterprises. As such it was decided to develop a toolkit rather than a rigid method & tools.

8 Case III: Central America

"Ecodiseño Centroamerica' (Ecodesign in Central America) was a product innovation knowledge transfer project on the introduction and dissemination of Ecodesign in Central America. The programme was a first attempt in this local context to introduce Ecodesign on a larger scale in SMEs in Central America. The original project period was two years (1998-2000). Because of the promising results during these first years, the project was extended with two more years (2000-2002).

The evaluation of this case is based upon project reports, M.Sc. student graduation reports, internal and external project evaluations and the PhD thesis 'Ecodesign in Central America' (Crul 2003) written by the project coordinator, Dr. M. Crul. In addition four refereed papers written by the project team as have been used to evaluate this case (Crul and Diehl 1999; Crul and Diehl 1999; Diehl, Crul et al. 2001). The project coordinator Dr. M. Crul has validated the case descriptions. Within this and the following chapters this project will be referred to as 'Case CA'.

Background

At the start of the project (1998), Central America knew peace for at least several years in all countries of the region. It was a period of (re)building society and local economy in an arena of strong globalisation: at the end of a period of strong economic growth worldwide and at the beginning of the following economically adverse period.

Analysis of sixteen leading industries across Central America at that time found general levels of environmental performance to be low (INCAE/CLACDS and Harvard-HHID 1999), but concern over this situation was growing in the region. The need was acknowledged to include environmental variables into business strategy to improve global competitiveness and to attract foreign investment for industry. Those companies exporting to the United States and Europe faced even stricter environmental legislation, demands for environmental management systems, ISO and Ecolabels and other environmental recognition schemes. In several studies it was made clear that more environmentally sound products also were a high priority for the future development of the Central American industry. One of the priorities stated in a Costa Rican needs assessment made by UNIDO, and later confirmed by the Ministry of Science and Technology of this country was capacity building on Ecodesign (Athie, Beardsley et al. 1995; MICIT and CEGESTI 1995).

To support this process of capacity building in Ecodesign, especially in SMEs, CEGESTI (a Costa Rican non-profit consultancy) together with Delft University of Technology (DUT) initiated the 'Ecodesign in Central America' project. The project activities took place mainly in Costa Rica, Guatemala and El Salvador, and were financed by the Dutch Embassy in Costa Rica.

8.1 Project

8.1.1 Goals and objectives

The central purpose of the project was to improve the competitiveness and environmental aspects of products developed and produced by local SMEs, thus practising and adapting the Ecodesign concept in the region. The original project period was two years (1998-1999). Because of the promising results during these first years the project was extended with two more years (2000-2002). The aim of the first part of the programme (CA 1) was the building of regional capacity for the dissemination and implementation of the concept and practice of Ecodesign in SMEs in Costa Rica, Guatemala, El Salvador, Honduras and Nicaragua. The three key objectives of the first two years of the project were:

1. Demonstration of the feasibility of Ecodesign in a number of industrial cases;
2. Awareness building on Ecodesign via publications, seminars etc. among different stakeholders in the region;
3. Capacity building on Ecodesign in the region in a number of industrial and intermediate organizations.

The opportunity to formulate new activities for the extension period of the project (CA 2) gave the chance, learning from the experiences of the two first project years, to improve and widen the scope of the project. The objectives of the first period remained valid also in this phase. Next to these, new objectives for the second period became:

1. Expansion of Ecodesign from single products to chain, sector and service approaches;
2. Expansion of capacity building towards young professionals and university staff;
3. Targeted awareness raising and networking activities for each of the participating countries.

8.1.2 Project outline

DUT together with CEGESTI in Costa Rica, coordinated the project. The project was executed mainly in SMEs in Costa Rica, Guatemala and El Salvador, with workshop participation also from Honduras and Nicaragua. Local counterparts provided expertise and support to the project (Diehl, Crul et al. 2001; Crul 2003). This resulted in the following setup of the knowledge transfer process:

Knowledge source:	DUT
Knowledge facilitators:	CEGESTI, industry organisations and universities
Knowledge recipients:	SMEs and local students

Knowledge transfer activities

To generate experiences, to build up capacity and to demonstrate the potential benefits of Ecodesign in Central America, a series of demonstration projects were initiated and a range of dissemination activities were implemented. An overview of the knowledge transfer activities of the project is provided in Table 8.1.

Table 8.1: Overview of the knowledge transfer activities.

Capacity building and demonstration activities	**CA 1**	**CA 2**
Train the Facilitator	1	1
Demonstration projects	9	5
Local workshops	1	3
Dissemination activities		
Fact-sheets	9	5
Regional Ecodesign manual	1	-
Web-site	1	-
International conference	1	-

These knowledge transfer activities were spread over the total four year duration of the program (see Figure 8.1)

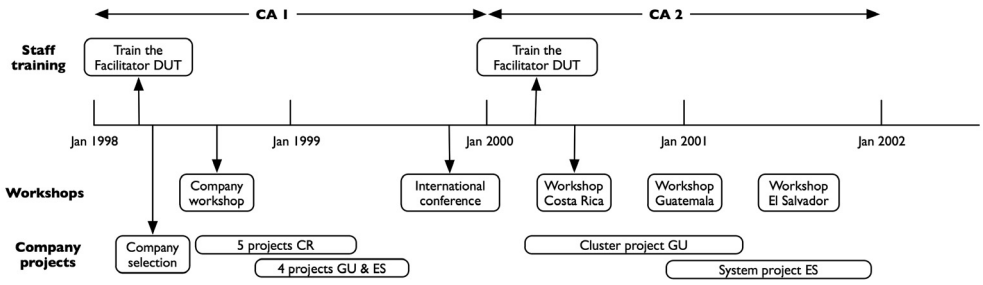


Figure 8.1: Knowledge transfer activities over time.

8.2 Train the Facilitator (TtF)

The first two-week intensive Training-the-Facilitator took place in Delft with twelve participants of all Central American counterparts. This TtF course was focused on the concept, methodology and practical experiences with Ecodesign, and gave the counterparts the basic capacity to facilitate and perform Ecodesign projects in their local industry independently. The focus of the course was on domain specific 'basic knowledge'. No specific attention was being paid to the domain specific design and domain independent process knowledge' (see Figure 3.7). The participants applied the new gained knowledge through 'hands-on' exercises on Western electronic products (i.e. vacuum cleaner). The lectures and exercises were concentrated on redesign and development of new products (product innovation level 2 & 3).

The second TtF took place as well in Delft. The potential participants for this second TtF did have to come up in advance with a proposal and industry partners for projects. The best proposals and partnerships were selected. This element of competition has led to a selection of high quality counterparts. The second TtF did have more attention for value chains and function & system innovation (product innovation level 3 & 4).

8.3 Demonstration projects

Demonstration projects played an important role within the CA case and were one of the key activities.

8.3.1 Selection

The first step in the selection process of companies was the identification of relevant sectors within the region. Competitiveness and sector study reports were used in order to select relevant sectors (Athie, Beardsley et al. 1995; INCAE/CLACDS and Harvard-HHID 1999). In addition the research team did a qualitative analysis on the different sectors within the manufacturing industry. A number of criteria were applied for the sector selection, the most important ones are (Crul 2003):

General criteria for sector selection:

1. Representative and important sector for the country/region;
2. Large share of SMEs in the sector;
3. Relevant environmental impact;
4. Proven potential for Ecodesign (elsewhere in the world) in the sector.

The selected sectors were: agro/food and related packaging, metal working/machine manufacturing, electronics, furniture and plastics. Next, a number of general and specific criteria were developed to select suitable companies within the sectors:

General criteria company selection:

1. Small- or medium-sized company;
2. Representative company for the sector;
3. National or regional owned company, not (partly) dependent on a multinational company or group of companies;
4. Interest/willingness to participate in an Ecodesign project;
5. Own product development department or staff member in the company;
6. Necessity and opportunities for environmental improvement of the product.

Specific criteria company selection:

1. The company has the ability to execute the Ecodesign project (management, focus on product development, actual plans for product(re)design);
2. There are possible business opportunities with eco-(re)designed products;
3. There is an organised and structured production process.

On the basis of these selection criteria, shortlists of companies (10-15 per country) to be visited by counterparts and DUT staff were generated. This resulted in the following selection of companies:

Table 8.2: Overview of the selected demonstration companies.

Company	Country	Size	Sector
CA 1			
Waiman	Costa Rica	Small	Metal workshop for refrigerators & food preparation equipment
Heliconia	Costa Rica	Small	Grower and exporter of tropical flowers
Panel-ex	Costa Rica	Medium	Manufacturer of office furniture systems
Mafam	Costa Rica	Medium	Manufacturer of cookies and corn-based snacks
Venus	Guatemala	Medium	Manufacture of sugar-based candies
REA	Guatemala	Small	Manufacturer of coffee processing equipment
Mobelart	El Salvador	Small	Manufacturer of kitchen furniture
Kontein	El Salvador	Medium	Manufacturer of plastic bottles
Bendig	Costa Rica	Medium	Metal workshop producing coffee processing equipment
CA 2			
Av. Naturalis	Costa Rica	Small	Natural tourism agency organizing rafting tours
Turbomac	Guatemala	Small	Metal workshop producing metal stoves

Inmepro	Guatemala	Medium	Manufacturer of kitchen equipment
Executiv	Guatemala	Medium	Manufacturer of metal office furniture
El Jobo	El Salvador	Small	Cooperative producing dairy products

Due to the stepwise selection process of the companies – from preferred sectors to short listed companies to selected companies – only those companies were selected for demonstration projects in which the potential for a successful project was high. The type of companies selected proved a good spread over the preferred sectors. With the results of these demonstration companies a large multiplier in a next step could be reached in those sectors.

8.3.2 Process

The demonstration projects were organized in a stepwise schedule, which allowed for the whole sequence of phases from the Ecodesign methodology to be executed. The following persons and activities facilitated the Ecodesign demonstration projects in the companies:

- Start-up workshop with managers of several companies;
- 1 day workshop at the company with the project team and involved staff;
- Project of DUT graduation student – 7 months involvement, of which two months preparation in the Netherlands;
- Regular meetings with the project team from CECESTI, DUT and local counterparts;
- 1 day final workshop to summarise the results and to discuss the follow up activities;
- Delivering of final report by the student and DUT team.

This high level of facilitation by local and international experts and students, especially during the first phase of the CA 1 project did have positive and negative effects. This 'flying start' did produce quick results – most first phase companies produced a prototype within eight months from the start. Information and experience became available quickly and could be applied in the design process as well as in the project dissemination. On the other side, all this support made it perhaps too easy for the companies. The weak point of this intensive approach was that the transfer of skills to the company is lower because of high external help. Although the companies had to invest their own time and expertise in the project as well, and had to pay (part of) the costs of the students this intense help to the project is still virtually for free.

Most companies, after a watchful start, became enthusiastic, several of their staff got involved more and more, learning from the project and taking the lead in it. Some companies reacted more cautiously and 'followed' the developments within the project, with less extra involvement, and the initiative was left with the external project team. But students and experts leave again, and this expertise is discontinued. One expects that in the second type of company, the end of the demonstration project also means that Ecodesign activities slow down to a full stop quickly. That was indeed the case in those companies. The decision by the companies to go ahead with other products or other activities related to Ecodesign was very limited.

Differences between CA 1 and CA 2

For multiplication of the number of Ecodesign projects in more companies another approach was needed, because time and money investment per demonstration project was too high for widespread multiplication. As a result more emphasis in CA 2 was put on the local counterparts. The management of CA 2 was in hands of CEGESTI, more local facilitators were trained and local students were involved in the demonstration projects. For example in the case of the metal sector, the demonstration projects took place in a cluster of companies instead of an individual company. This lead to more efficient multiplication: less external involvement per company was needed. The focus of redesign of products towards system thinking and chain approaches was another new feature of CA 2. Table 8.3 illustrates the changes in project approach:

Table 8.3: Changes in the project approach.

	CA 1 (1998-1999)	**CA 2 (2000-2002)**
Management	DUT (Netherlands)	CEGESTI (Costa Rica)
Company projects	Individual	Clusters or value chains
Students	DUT students	Local students supported by DUT students
Local facilitators	Fewer and no selection	More and special selection
Innovation level	2,3	3,4

8.3.3 Student involvement

DUT MS.C. graduation students carried out all nine CA 1 demonstration projects, no local students were involved. A shift from high involvement of Dutch graduate students in the first phase, to a mixed involvement of fewer Dutch students and more local students took place in the second phase (CA 2). This will keep the expertise in the region and allow for further involvement of local universities in the capacity building process. This transition towards the use of local graduation students instead of Dutch students in the second phase of the project worked out quite well.

8.3.4 Product results

The fourteen demonstration projects in Central America led to successful results. Nine products out of fourteen were actually introduced on the market. Three others resulted in working prototypes and only two were not materialized. In four companies there was no tangible result on the market from the project. The developed products can be found in Table 8.4.

Table 8.4: Results of the demonstration projects

Company	**Country**	**Product**	**Result**
CA 1			
Waiman	Costa Rica	Refrigerator	On market
Heliconia	Costa Rica	Export packaging flowers	On market
Panel-ex	Costa Rica	Office furniture	Prototype only
Mafam	Costa Rica	Packaging and distribution cookies	Prototype only
Venus	Guatemala	Packaging and distribution candies	On market
REA	Guatemala	Coffee processing unit	On market
Mobelart	El Salvador	Kitchen furniture	On market
Kontein	El Salvador	Plastic bottles	Prototype only
Bendig	Costa Rica	Coffee processing unit	On market
CA 2			
Av. Naturalis	Costa Rica	Rafting tour	On market
Turbomac	Guatemala	Household stove	On market
Inmepro	Guatemala	Industrial stove	Planned
Executiv	Guatemala	Office desk	Design only
El Jobo	El Salvador	Cream	On market

8.3.5 Innovation level

In the case of Central American industry, most SMEs companies are at the beginning of the learning curve (Crul 2003) (see section 4.3.4). The deliberate choice for improving and redesigning their current products approaches, matches well with the general level of innovation (incremental) and product development know-how in the target group of SMEs in Central America (Diehl, Crul et al. 2001). As a result the emphasis of the demonstration projects was put benchmarking and redesign (product innovation level 1 & 2) of products, in which optimisation takes place mostly on the product level. In six cases, Panelex, REA, Kontein, El Jobo, Inmepro and Executiv, a product was designed that differed so much from the old, that it can be categorised as a new product design. However, of these six only the products of REA and El

Jobo were put on the market. Those projects, which aimed at incremental innovation for existing markets, were the most successful (see Table 8.5).

*Table 8.5: Overview of the innovation strategies of the demonstration projects. (**Bold** = in the market, Underlined = prototype, Normal = just concept idea.*

	Redesigned existing product	**New product**
Existing market	**Waiman**, **Heliconia**, Mafam, **Bendig**, **Venus**, Mobelart, **Aventuras**, **Turbomac**.	Panel-Ex, Kontein, Executiv, **El Jobo,** Inmepro, **Rea**
New market		

In some of the projects of the second phase (CA 2), a first start is made with efforts on a system level (product innovation level 4). Two projects had a wider systems' scope – as a logical result of the project requirements of the second phase: the product service system (PSS) project at Aventuras and the value chain project at El Jobo.

8.3.6 Product innovation process

For many of the companies, this was not only their first Ecodesign project, but also the first experience with formalized systematic product innovation (Crul and Diehl 1999; Diehl, Crul et al. 2001). Most companies in Central America rely on a rather non-structured informal design process based on practical experience. None of the participating companies has staff formally educated in product development. Information on the product development process is often not formalised and documented, and exists usually in the experience of one or two persons (Crul and Diehl 1999). Exceptions are Bendig, Kontein and Mobelart (the relative bigger medium sized companies). Strategic planning is only done in those companies and the food companies Mafam and Venus.

For example at Waiman, the product development is a trial and error process. The starting point for changes in the product design are questions from customers, ideas from the employees or competitors. These ideas are 'tried' and if they seem to be an improvement, they will apply the 'innovation' in the next products. This 'trial and error' process is not formalised (Hoornstra 1998).This implies, that companies that embark on the Ecodesign path also have their first learning experience with a more formalized, structured design process.

The more 'innovative' SMEs tend to go further and faster in the adoption of Ecodesign (Crul 2003). In companies that already had some design experience (Mobelart, Kontein and Bendig), the structured approach was more quickly integrated into existing systems, and there is a higher chance that this improved design process can be replicated independently from external advisors.

The redesign process in most of the companies can be primarily seen as a benchmarking or copying type of innovation process. The improvement directions were derived from examples of competitors or comparable products from Europe or the United States (Crul 2003). Common strategies that were followed for this were either a lower price strategy, usually competing with products that were imported, or an improved product quality strategy competing with other regional producers. Products of the competitors were observed in shops and fairs or are bought and (if applicable) dismantled. Pictures and description from the Internet or catalogues were used for identifying design improvements. For example at Panel-Ex, new ideas are rooted in benchmarking. The new product ideas are found in furniture magazines from the U.S. and Germany. The team adjust the Western examples to the production facilities of the company as well as slightly to the context of Central America (Baas 1998).

In many cases, the renewed product was first designed inward looking, then it was investigated how the market responded. Also in the bigger companies like Panel-Ex the development or improvement of products does not start with market research but by input from clients and or employees (in that case production related) (Baas 1998).

For the majority of the companies it can be concluded that the information searching behavior was restricted to the necessary information for the benchmark study. The knowledge use is focussed on the information necessary for the product development process inside the company itself, with additional information from the competitors' products. R&D or new knowledge is not generated, existing (external) knowledge not commonly tapped. There is no culture in the companies to disclose additional information. It can be concluded that this type of information must be brought in by external advisors, and in low complexity form (Crul and Diehl 1999; Crul 2003).

8.3.7 Management and staff involvement

One of the factors that influence the success of the Ecodesign approach in almost all the demonstration projects is the person of the manager. In all successful demonstration projects, the belief and enthusiasm from the manager is clear. In the small companies, such as REA, Mobelart, Waiman and Heliconia, the manager was primarily, directly and strongly involved in the project. But also in the bigger companies the influence of a project 'champion' in higher management was the key factor.

A structured innovation approach requires a structured and consistent type of management of the company. The role of the management and management systems in most companies was twofold, especially in the smaller companies. One the one hand, lack of structural planning of the activities, limited allocation of resources and manpower, poor management of information flows and overall project management was a barrier for the continuity within the projects. On the other hand (over) structuring can also be a barrier for innovative actions. The informal and top-down type of management of the smaller companies had advantages as well. Communication lines between the managers and the external team (especially the in-company student) were usually extremely short, creative sessions and direct feedback on ideas easily arranged, flexibility of the process very large. Larger companies such as Kontein and Venus do have a structured management process. Top management of these companies was directly involved in the project, which guaranteed high priority and avoided delays or bureaucratic procedures (Crul 2003).

In general there is a high power distance in the companies (see section 4.2.6) and as a result reluctance of the management to delegate its authorities, responsibilities and decision-making. The consequence is that the management has to do, next to the daily management all the product innovation activities itself like for example the (time consuming) information gathering and market research. Only the bigger companies like Panel-Ex delegate partly the information gathering. In addition, in most of the (smaller SMEs) there is a lack of strategic planning and vision. Decisions are made rather impulsive. In this context it is difficult to make a decision upon the appropriate product innovation strategy (Wijnans 1998).

Most of the internal communication within the companies is verbal and not written and documented. They are rather command driven (giving orders) and information goes mainly top-down and not the other way around. Product development within the participating companies is hardly or no teamwork (Baas 1998). Only in the case of solving production (not product) problems teamwork takes place.

8.4 Product innovation methods and tools

Next to the demonstration projects, one of the main objectives of the CA 1 projects was to develop product innovation methods and tools tailor made to the local economical context.

During the first phase of the projects (CA 1) the UNEP Ecodesign manual (Brezet and Hemel 1997)(see section 3.7) was applied in all demonstration projects. This approach was evaluated continuously in order to adapt and improve it for the context of SMEs in Central America. The UNEP Ecodesign approach assumes that the user is already acquainted to product innovation (domain specific design knowledge). In the European context, most companies starting with Ecodesign do have a structured product innovation system in place and many medium sized and large companies employ professional industrial design engineers. However in the context of SMEs in Central America it often proved the opposite. Besides, the UNEP Ecodesign manual approach focuses on redeisgn and new product development (product innovation level 2 & 3) but not on benchmarking (product innovation level 1). In practice many SMEs in Central America indicated the need for benchmark tools. These two aspects were experienced as a weakness during the demonstration projects.

The tools presented in the European UNEP Ecodesign approach were experienced by the SMEs as conceptually complex and required a lot of insight into both environmental problems and product innovation. For example, the description of the Ecodesign Strategies Wheel (ESW) (see section 3.7) was considered to be rather abstract and conceptual, and support was often needed from the external facilitators. Likewise the tools for the environmental analysis were difficult to apply. It was possible to fill the simple qualitative MET matrix (see section 3.7), but any attempt to get more detailed information for quantitative analyses was difficult.

As such it was concluded that the Ecodesign tools should not be vague or leave space for many interpretations, since this could lead to insecurity (Diehl, Crul et al. 2001). The experiences with checklist-type tools were good when used as a starting point in the SME company projects. A combination with simplified checklist-type (like for the checklist for the MET-matrix or the rules of thumb for the ESW) of tools is recommended for self-use in the companies. It builds a basic understanding in the company for Ecodesign principles that can be followed by more conceptual thinking that is necessary for continuation of the process (Diehl, Crul et al. 2001)(CEGESTI 1999,Diehl et al 2001).

Improved tools

Based upon the experiences with the tools and methods in practice, the DUT / Cegesti project improved them which resulted in the new Ecodesign in Central America manual (Crul and Diehl 1999). In order to make the manual more optimal for the regional context the following changes were proposed (Crul and Diehl 1999; Diehl, Crul et al. 2001):

1. More emphasis on structured product innovation;
2. Redesign focus instead of new product design;
3. Benchmark approach added instead of design from scratch;
4. Simplified tools;
5. Use of regional examples;
6. Focus on internal drivers because of the absence of external drivers for Ecodesign;
7. In Spanish.

<u>1. Structured product innovation</u>

In the Ecodesign in Central America manual more attention is given to the product innovation process (domain dependent design knowledge) via description and tools for the design steps that

are taken for granted in the European version (Crul and Diehl 1999). For example the SWOT analysis has been added and is explained in detail.

2. Redesign focus

More strongly focused at redesign options and improvement directions (product innovation level 1 & 2), both in the practical projects and in the examples and tools presented in the manual.

3. Benchmark approach

In the appendix of the manual a benchmark approach (product innovation level 1) was added. A step-by-step approach was formulated to benchmark competitors' or foreign products and process the information in such a way that constructive improvement options can be derived from it.

4. Simplified tools

A number of simplified tools were developed in several of the case studies, and tested in the companies. Usually, those tools included checklists, rules-of-thumb and questionnaires for the company to use.

5. Focus on internal drivers

The 'low urgency level' of external (environmental) drivers meant, that when introducing Ecodesign in the region, environmental arguments had to be coupled with internal drivers like cost reduction, market growth and quality improvement arguments. In the manual, the element of internal drivers was emphasized more clearly and analysis in cost reduction opportunities was given more priority.

6. Regional examples

The European UNEP Ecodesign manual is illustrated with many examples of Ecodesign worldwide – mainly of industrialised countries and the connected typical sectors. For a regional Central American manual to be effective, it has to be illustrated with regional example, more appropriate for the local socio-economical context. On the basis of the experiences with the company case studies, the Ecodesign manual for Central America includes mainly regional examples especially of relevant economical sectors.


STONE NO:

9 *Case IV: Croatia*

The last of four case descriptions is the Croatia case. The 'Product Innovation in Croatia' project took place from July 2004 till June 2005 (one year). During this period three Croatian SMEs were involved in the project to build up their product innovation capacities and to demonstrate the relevance of production innovation for their sector in Croatia..

During the project an intensive evaluation of the transfer of product innovation knowledge to Croation SMEs was executed by the DUT expert team with the support of a DUT MSc. graduation student (Boschloo 2005). During and after the project all people directly involved in the product innovation knowledge transfer project were interviewed: company management and co-workers, HUP, Dutch and Croatian students, and the DUT experts. In addition the project reports, evaluation reports, MSc. thesis reports of the in-company projects (Karskarel 2005; Most 2005) as well as two refereed papers (Christiaans, Diehl et al. 2006; Christiaans, Diehl et al. 2006) have been used to evaluated this project. The project coordinator Dr. H. Christiaans has validated the case description. Within this and the following chapters this project will be referred to as 'Case CR'.

Background

Croatia is one of the 'countries in transition' in Central and Eastern Europe (CEE). The realisation of the necessity of innovative activities in companies in CEE has been increased by two key factors (Racic 2004):

- There has been *an exhaustion of growth and productivity improvements* based on defensive restructuring and non-investment reallocation of resources. Since competition on the basis of low wages is an unfavourable and unsustainable strategic option for most of these economies, their long-term competitiveness requires *technological advancement* and the development of *innovative capacities*.
- Most of these countries are being *integrated into the European Union* (EU). The EU not only states the development of a knowledge-based economy as crucial policy goal for its current members but also requires from the candidate countries to demonstrate the same orientation (Racic 2004). Croatia is one of these candidates and is confronted with the challenge to *increase the competitiveness and the innovative capacities* of its enterprises.

To support this process, the Dutch and Croatian Ministries of Economic Affairs agreed in 2002 to launch a capacity building project in Croatia to improve and stimulate the competitiveness of SMEs and to prepare them for the competition of the European Market. Initially Nehem International set up a 'managerial' benchmark project with a focus on improving the administration, finances and production capacities of the participating companies. After a successful first phase, a second phase was launched by Nehem International, which included Delft University of Technology as partner, with the possibility for the participating companies to extend the managerial benchmarking with capacity building in product innovation. This resulted in three in-company product innovation demonstration projects in Croatian SMEs.

9.1 Context

9.1.1 The economical and industrial context of Croatia

Croatia is a 'country in transition' and was during 50 years part of the former Federative Socialist Republic of Yugoslavia whose economic system was based on socialist self-management and on the social ownership of production factors. During this era of socialism there was no or barely trade with Western countries. The main market was Yugoslavia itself. After the split up of Yugoslavia, big part of this market got lost.

After Croatia gained independence in 1991, its transition into a market-driven economy has led to considerable structural changes (Christiaans, Diehl et al. 2006). These have been characterized by the shift from social to private industry, from industrial to service economy, from large to medium and small companies, the redirection from mostly (internal) Yugoslav markets to the more developed European markets as well as by the shift from a supply driven economy into a demand-led one (Bakotic 2005). This radical shift of business requests different ways of operating and managing the enterprises as well as necessitates other kind of skills and competences of the employees at all levels within the firms.

Countries in transition have in common the fact that the value added is stagnating at a level, which is only a fraction of that in the EU, return on capital is low and does not allow investment in new technologies (Bastic 2004). In terms of relative wages, Croatia is faring badly in comparison to the rest of CEE, which undermines the competitiveness of several traditional export oriented sectors (e.g. textiles and apparel industries). Contrarily salaries in industrial production in neighbouring Slovenia are approximately 60% higher than in Croatia, but since productivity is almost twice as high, the unit cost of labour in Slovenia is lower (Rutkowski 2003).

Meanwhile retarded levels of technological capacity and product and process innovation have not provided an alternative route to competitiveness for Croatia (Racic 2004). Moreover, an inflexible labour market, underdeveloped capital market and insufficiently supportive policy mechanisms have even encouraged dislocation of certain activities to other CEE countries (Racic 2004). In addition, the development of the industry in Croatia has greatly suffered from the war in the nineties during which the total production was decreased by one third.

9.1.2 SMEs in Croatia

After years of communistic control, centralized planning and state control of all economic activities, part of the SMEs have tended to flourish. These SMEs have mainly been established during the last 15 years. They are found by the restructuring of large enterprises, which were state owned. Another group of them was established after the introduction of market oriented economy and encouragement of entrepreneurship. In general the last group, the newer SMEs, are relatively modern and well organized. Their company documentation is well structured and they operate efficiently. The older SMEs, the majority, however are burdened with their socialist past and overcoming a decade of standstill.

All of these SMEs have similar problems regarding getting loans, lack of managerial knowledge and experience and inadequate or indefinite corporate strategies. Finances have emerged as the most pressing problem for new and expanding SMEs. Firms depend heavily on internal sources of funds (retained earnings), and, if external finances are obtained, this will mostly come from private (non-market) external sources of finance (Mrak 2000).

The majority of the Croation SMEs do not change their size very much (Bakotic 2005). Growing medium sized enterprises are the ones, which have resources (human capital, financial sources and strong R&D function), developed competitive advantages, and well-defined and adequate growth strategies relying on achieved competitive advantages (Bejakovic and Lowther 2004).

Product innovation in Croatian enterprises

Croatian companies that possess production facilities often do have low or no intensity of R&D or product development activities (Svaljek 2005). These kinds of 'capacity companies' (see section 4.3.4) highly depend on production orders and material prices. Competitiveness is mostly attained by low prices and less by new designs, product innovation or new manufacturing methods (Bejakovic and Lowther 2004; Bastic 2004). The majority of the innovations of the Croatian companies are of low novelty (Svaljek 2005).

Those Croatian companies that attribute more importance to 'speed-to-market' adopt advanced new product development processes more often. There is an indication that in many Croatian companies product development process exists only formally, but it does not function properly (Svaljek 2005). Big Croatian companies innovate more often than the smaller ones. Also exporting companies are more active and successful in their innovation approach (Svaljek 2005).

Management of Croatian SMEs

Another obstacle to Croatian SMEs grow is the managerial barrier. In most SMEs, owner and managerial or leading function are joined in the same person. These managers are predominantly not capable of applying modern management (like to be a mentor/coach, working in collaborative teams, valuing interdisciplinary decisions etc.) in practice. The control function of management is the first priority for them (Bakotic 2005). The main elements of all these obstacles are lack of knowledge, experience and professionalism. This lack is usual for managers in SMEs in Croatia and it is a consequence of transition, and the different values used in the past economic system, the inappropriate privatization process, and the generally inadequate education of managers, especially entrepreneurs, who found companies without experiences, or sufficient understanding of economic variables and relations (Bakotic 2005).

Teamwork is also a significant problem in Croatian SMEs. The managers do not think that teamwork is necessary in the organization. They have an aversion to delegating authority, they are uncomfortable about managing team meetings, or they do not want to spread data and information. This causes lack of trust in the organization, poor communication, and finally, poor employee efficiency.

Human resources in Croatian enterprises

A study into the competitiveness of Croatia's human resources (Bejakovic and Lowther 2004) pointed out that the employees in Croatia do not have the skills, knowledge, and abilities necessary to enable Croatian companies to develop globally competitiveness products and services and to compete the European Union. In general the Croatian workforce is old, inflexible, inadequately educated and trained, and lack necessary foreign language, and information and communication technology skills. They do not have knowledge and skills required for modern competitive economy, and the education and training systems have not yet taken adequate steps to remedy this situation.

9.1.3 Education in Croatia

Bejakovic et al. (2004) concluded from their research that the Croatian education system is not producing graduates with some of the most important skills for the 21st century knowledge

economy: technical/ICT, language and communication, learning ability, teamwork, capacity for self-management, problem identifying and solving, and analytical skills. This is because Croatian education at all levels is too subject specific, learning is too passive and too teacher-oriented, and teachers are not properly trained (Bejakovic and Lowther 2004).

The educational programs in the countries in transition (particularly those based upon Austro German model) are more oriented toward the rote memorization of course materials than on independent analytical/critical thinking and deduction and the innovative approach, a typical objectivism approach of teaching (see section 2.8) (Bejakovic and Lowther 2004).

There is a big gap between university and industry. Students do not get no or very limited in practice experience in industry during their study period. Student do not execute a lot of internships in companies which see them as obstacles (Boschloo 2005). As a result, in combination with an objectivism type of education (See section 2.8), students leaving the university have no or limited practical experience. Graduates are not enough skilled, not open for new technologies and mono-disciplinary trained. Companies first have to invest a few years in their capacity building before they become effective.

9.2 Project

9.2.1 Objectives

The objective of the project was to offer a template for case studies in which Croatian companies demonstrate to be successful in applying product innovation in their daily practice. The specific goals of the project were:

a. To raise the awareness among Croatian SMEs about how they can become competitive, not only through financial efficiency but also through improvement of their products and production processes;
b. Implementation of product innovation processes in the participating Croatian companies;
c. Developing suitable advises and products for the participating companies.

9.2.2 Project outline

The one year project was carried out in collaboration with HUP, the Croatian Employers' association. In order to realize a sustainable long-term effect of the knowledge transfer it was decided to invite consultants from the Croatian Consultants Organization (UPS) and students from the Zagreb University to join the workshops and demonstration projects. They were thought to, in addition to HUP, to spread the gained product innovation knowledge in the future and to raise awareness among other companies. This resulted in the following setup of the knowledge transfer process:

Knowledge source:	DUT
Knowledge facilitators:	HUP (Croatian Employers' Association) & UPS consultants.
Knowledge recipients:	Croatian SMEs & students.

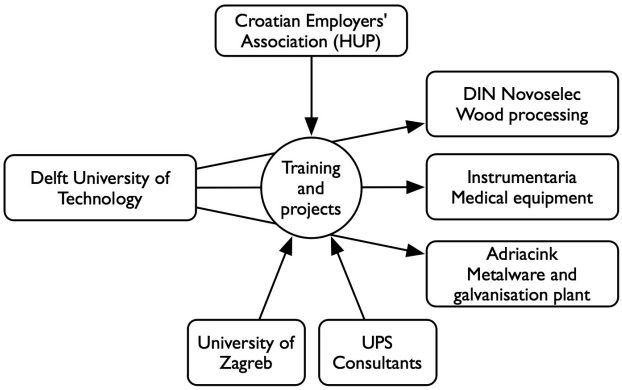


Figure 9.1: Setup of the knowledge transfer process of the product innovation project.

The project consisted of 8 stages (see textbox 9.1). The project started with a company selection. Next, during a period of eight months three in-company product innovation projects were carried. Each demonstration project was supported by three in-house company workshops. The project was concluded with a dissemination workshop (Christiaans 2004). Figure 9.2 illustrates the distribution of the project activities over time.

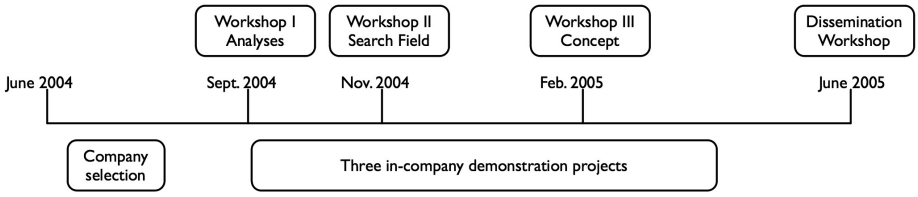


Figure 9.2 Time frame of the CR case.

The stages of the Product Innovation in Croatia projects :

<u>Stage 1: Preparation in The Netherlands (experts)</u>
- Prepare training materials;
- Selection of three companies;
- Selection of students.

<u>Stage 2: Workshop I 'Analysis' (experts)</u>
- To introduce the product innovation approach;
- To train the participants in the methods to analyse their company;
- To exchange experiences between the participating companies;
- Introduction of the students;
- Individual meetings with the companies.

<u>Stage 3: Analysis phase (students)</u>
- Analysis of the internal and external aspects of the company with SWOT analysis, portfolio analysis and other product innovation tools.

<u>Stage 4: Workshop II 'Product (Service) development' (experts)</u>
- To discuss the outcomes of the analysis phase;
- The consequences for the next phase;
- To train the participants in methods regarding the conceptualisation of ideas;
- Individual meetings with the companies.

<u>Stage 5: Concept development phase (students)</u>

- Development of new concepts.

Stage 6: Workshop III 'Elaboration and Detailing' (experts)

- To discuss the outcomes of the conceptualisation phase;
- Individual meetings with the companies.

Stage 7: Elaboration and Detailing phase (students)

- Working out the details of the concepts.

Stage 8: Description of the case studies (experts)

- Fact sheets;
- Final dissemination workshop.

Textbox 9.1: The eight stages and proposed activities of the CR case.

9.3 Train the Facilitator (TtF)

The company workshops were meant as training sessions for the proposed facilitators: HUP and UPS consultants. There were no specific additional training sessions for the facilitators.

The first workshop took place at HUP involving the three participating companies, the local consultants, HUP and the DUT graduation students and experts. The second and third workshop took place at the each of three factories, in order to be close to the products and production facilities as well as to involve more staff from the companies. Nevertheless, the participation stayed very limited to the higher management. This made the workshops rather trainer intensive, 3 DUT experts and one MSc. graduate student for 2 to 8 company participants.

The original role of HUP was to approach companies and to facilitate and monitor the knowledge transfer process. In practice HUP only facilitated the workshops by means of physical aspects like location, equipment and food & drinks. HUP did not get content-wise involved nor product innovation capacity was built up within the organization. The responsible staff was contracted temporary and left after the project. HUP as an organization was not committed to the product innovation project.

In addition it was expected that local consultants from UPS would be interested in getting acquainted to the product innovation approach in order to be able to apply this knowledge in their future in-company projects. However, they were only prepared to take part if they were paid for their participation; they were not willing to invest their own time. Their further participation stopped after the first workshop. As a result no product innovation capacity has been built up among the UPS consultants.

9.4 Demonstration projects

9.4.1 Selection

The fifteen participating companies of the 'managerial' benchmark project were offered the possibility to extend the gained administrative and managerial capacity with capacity building in product innovation. During the first month of the CR case a shortlist of six interested companies was visited to evaluate their suitability and readiness for product innovation. This lead to the selection of the following three companies (Boschloo 2005; Christiaans 2005; Karskarel 2005; Most 2005):

Table 9.1: Overview of the selected demonstration companies.

Company	Size	Kind
Adriacink	Medium	Manufacturing and galvanizing semi-finished metal products
DIN	Medium	Timber and wood processing industry (mainly furniture and parquet)
Instrumentaria	Medium	Manufacturer and distributor of metal medical instruments and utensils

Figure 9.3: Production plant of Instrumentaria (left) and Adriacink (right).

9.4.2 Student involvement

Both Adriacink and DIN were each assigned with one DUT graduation student during 6 months. Two successive DUT internships students (each for two months) joined Instrumentaria. Croatian students from the Faculty of Mechanical Engineering and Naval Architecture and from the School of Design were involved in the projects. The Dutch and Croatian students collaborated in order to enable the exchange of knowledge and experience to build up capacity of a new generation product innovation professionals. The Croatian students, compared to the Dutch ones, were more passive and took less initiative (see 9.3). In practice their activities were limited to facilitate the Dutch students and to translate (Boschloo 2005).

One of the observed limitations of the use of students as a carrier of product innovation knowledge was their perceived status by the employees in the company. For example, the engineers of Adriacink were not very excited with the idea that they (seniors) were being expected to learn from a student (junior).

Figure 9.4: Creativity workshop at Adricink.

9.4.3 Product results

Two of the three demonstration projects (Adriacink & DIN) resulted in a working prototype. The project at Instrumentaria resulted in a 2D concept. The resulting products were appropriate for the current production facilities of the companies and no additional large investments were

needed to start prospective production. They were a potential good addition to their existing product portfolio. Not too radical innovative, not too complex and for the local market.

Table 9.2: Results of the Croatian product innovation demonstration projects.

Company	Product	Result
Adriacink	Boat cradle for marinas	Prototype, demo at fair
DIN	Modular furniture set for small apartments	Prototype
Instrumentaria	Tray for surgeons	2D Concept

The prototype of the boat cradle (Adriacink) was received with positive reactions on the Croatia Boat Fair and some company contacts had already indicated to be interested in placing an order. The impression is, however, that the product will be sold on demand, possibly tailor-made for each specific customer. Also within DIN, mass production of the design has not been planned yet. Consequently, without plans for series production including a sales- and distribution network, a marketing strategy and an optimized production that results in a stock of readily produced products, the actual change from a 'capacity company' to a 'product company' (see section 4.3.4) is still not yet achieved.

9.4.4 Innovation level

Based upon the earlier gained experiences in the product innovation knowledge transfer projects (i.e. the previous case descriptions), the project approach (Christiaans 2003) anticipated on incremental levels of innovation. Previous to this project within these companies either there were no product development activities (capacity company) or the engineering departments of the companies were imitating products from the competition (benchmarking) or making small improvements in previous designs.

At the outset of the demonstration projects, the students aimed at developing more radical innovative product concepts (since they were encouraged to do so during their study at DUT). Soon however it became clear that this more radical innovation approaches were not suitable for the current development stage and capacity of the participating companies.

In order to fit the level of innovation to the capacities of the companies it was decided to go for more incremental solutions. Adriacink developed a, for them new product for a new market, but still mainly business to business (yacht clubs). DIN developed new modular furniture systems for a new market. Finally Instrumentaria redesigned one of their products for their current market in order to make it more state of the art.

Table 9.3: Product – market innovation strategies of the demonstration projects (underlined = prototype).

	Current product	New product
Current market	Instrumentaria	
New market		Adriacink, DIN

9.4.5 Company characteristics

The three selected companies for the demonstration projects posses many of the characteristics of Croatian SMEs as described in literature (see section 9.1.2). Their 'typical' Croatian characteristics are summarized in Table 9.4:

Table 9.4: Overview of the characteristics of the three participating companies.

	DIN	Instrumentaria	Adriacink
From supply-driven → demand-driven	Yes	Yes	Yes
Workforce old, low skilled, inflexible	Yes	Yes	Partly
SME out of former state-owned enterprise	Yes	Yes	Yes

Manager and owner combined	Yes	No	Yes
Capacity versus product company	Capacity	Capacity and product	Capacity
No formal product development process	Yes	Yes	Yes
R&D department	No	No	No
Engineering department	No	Yes	Yes
Experience with product development	No	Benchmarking	Limited
In stage of restructuring the company	Yes	Yes	Yes
Export of low technology goods	Yes	Yes	Yes
Big power distance between the staff levels	Yes	Yes	Yes
Dependent on production orders and materials prices	Yes (wood price)	Yes	Yes (metal price)

All three participating companies were merely capacity companies (see section 4.3.4) heavily relying on their production capacity and manual labour. They had no or limited experience with product development, distribution and selling products directly to the end-user market. In addition their commercial departments did not have sufficient marketing skills to explore new market opportunities.

The participating companies did have a lack of (adequate) middle management. Consequently the higher management was most of the time involved in the daily management. In addition, the companies were in a stage of restructuring. As a result they did have no or limited time to develop a clear vision and connected (product) innovation strategy. They were newly established SMEs forthcoming out of former state-owned companies (see section 9.1.2). A high power distance characterised the management structure (see section 4.2.6). In general there was a marginal communication between the departments, dominated by top-down direction. The lower ranks were not supposed to argue with the higher management and as a result they were not open with their opinions. This made it difficult to involve them into the product innovation process. Open communication and opinions are preconditions for product innovation, teamwork, and fast results.

The work floor employees often worked their lifetime (average age sometimes above 50) in these companies and were not used to take responsibilities and initiatives. There was big resistance against change. The modern management on the other hand saw much more possibilities for change and innovation.

In general there was a lack of financial and human resources in the companies and the management requested for fast solutions. As a result the engineers did have to come up with fast solutions. None of the companies did have a R&D or product development department, but more a kind of engineering department. The engineers were used to apply benchmarking approaches and change small improvements. They did not aim at developing new products for new markets. The development teams in these companies did not take much effort to analyze the potential market or users systematically, nor did they develop several other alternatives solutions in order to come up with the best design. The development process was more an 'engineering' and detailing approach. The responsible staff for product development was internally focussed.

9.4.6 Management and staff involvement

The management of the companies initiated the participation in the demonstration projects and they were the most convinced about the need for product innovation inside their organisations (see Table 9.5). With exception of one company (DIN), the other two expected to get their employees (middle and lower management) involved in the process.

The attitude of the lower and middle management, however, towards the product innovation knowledge transfer was the opposite. Most of the employees have been working in the company since before the privatization. They were used to the socialistic system in which there were no incentives to take initiative or responsibility. All of a sudden they were expected to change their attitude without a clear personal incentive (Boschloo 2005). As a result they had no interest to expand their view outside of their own area of expertise.

Table 9.5: Participation of the different staff levels in the project.

	Director	**Management**	**Engineers**	**Work floor staff**
Adriacink	Yes	Yes	Yes	No
DIN	Partly	Yes	No	No
Instrumentaria	Yes (left after the project)	Yes	Partly (but left during the project)	No

The higher management, especially those responsibly for the product portfolio benefited the most of the transfer of product innovation knowledge. They were the most close to the demonstration projects and felt it was useful to gain knowledge about product innovation.

The management of each company did have different objectives with the demonstration projects. For example Adriacink wanted to create product innovation capacity at its engineering department. DIN, alternatively wanted first to explore the product innovation approach at management level in order to decide later on either to outsource these kinds of activities or to build up their own in-house competencies (Christiaans 2005).

The companies indicated that they had obtained sufficient insight in product innovation to be able to instruct future employees. However, at this moment product innovation has not yet been implemented nor has the knowledge been internalized. It was concluded that much more efforts are needed to change the staff attitude and to get them on board in the product innovation process.


YAMAHA

10 Cross case analysis

The previous chapters have described and analysed four product innovation knowledge transfer cases in Tanzania, India, Central America and Croatia. Within this chapter, the cross case analysis, the outcomes of the four separate cases are being compared in a systematic manner. This with the goal to come to consistent conclusions based upon the four cases together and to answer Research Question 1. First the setup of the cross case analysis will be introduced in section 10.1. Next the cross case results of the project setting (10.2), Train the Facilitator sessions (10.3), and the demonstration projects (10.4) will be discussed. Section 10.5 illustrates how the product innovation takes place in the involved companies followed by the cross case outcomes related to the organised workshops and dissemination activities (10.6). This chapter will end with discussing the general applied knowledge transfer process activities (10.7) and conclusions (10.8).

10.1 Setup of the cross case analysis

After exploring and analysing the four cases, a cross-case analysis is performed in order to be able to compare the cases and to further elaborate on the characteristics and mechanisms identified in each case. The cross-case analysis provides, in addition to the theoretical insights retrieved from the literature review, understanding of how the transfer of product innovation knowledge takes place in practice (RQ 1). The cross-case study offers the possibility to validate the conceptual framework, the identified focal points and expectations in everyday reality. In addition, it offers the opportunity to identify other factors (not yet identified by the literature review) that influence knowledge transfer as well. Furthermore, it is expected that the cross case study will result into a list of guidelines how to improve the product innovation knowledge transfer process (RQ 2).

Likewise the case descriptions, the cross case analysis has been carried out in two steps. The starting point is the set of indications derived from the literature review of how product innovation knowledge transfer is taking place (i.e. the conceptual framework, list of focal points, and list of expectancies). First, on the basis of the list of focal points the four case descriptions are analysed and compared. The goal of this stage is to evaluate the conceptual framework and to validate if the identified factors (focal points) do have indeed an impact in practice as well as if expectancies of their impact (list of expectancies) can be made (deductive reasoning). In a next stage, the four case descriptions are re-examined by cross-axial coding in order to identify new (additional) focal points and expectancies that influence the product innovation knowledge transfer process as well as guidelines to improve the process (inductive reasoning).

The outcomes of the deductive and inductive reasoning will be presented mixed. The cross case analysis starts, with analysing and comparing the project settings followed by the main knowledge transfer activities (Train-the-Facilitator, demonstration projects, workshops and developed tools and methods). This is in the same sequence as in the case descriptions. Next, the characteristics of the participating companies as well as their product innovation process are being typified and

compared. At the end, a general evaluation of the product innovation knowledge transfer process is made.

After each part of the cross-case study the main finding are being expressed by:

- One of the *expectancies* can be confirmed (indicated by *E-number*);
- A *new focal point* that influences the knowledge transfer process has been identified (indicated by *New focal point*);
- A *new expectancy* related to the knowledge transfer process has been identified (indicated by *New expectancy*);
- A *guideline* to improve the knowledge transfer process has been indentified (indicated by *Guideline).*

At the end of this chapter an overview will be provided of which focal points and expectations could be confirmed in practice as well as which new focal points, expectancies and guidelines were identified.

10.2 Project funding, objectives and target groups

First the funding, main objectives and proposed target groups of the four product innovation knowledge transfer project are being discussed. All four product cases were financially supported by external funding organisations as well as by 'own investment' of DUT. Table 10.1 provides an overview of organisations that partly funded the project. They were either Dutch or EU funding bodies.

The background of the funding organisations as well as the characteristics of the specific funding programs did have a direct impact on the envisioned target group, the objective of the knowledge transfer activities as well as on the content of the knowledge transfer (see Table 10.1).

Table 10.1: Overview of funding organisations and their impact on the selection of the target group, objectives and content.

	TZ	**IN**	**CA**	**CR**
Funding organisation	Dutch Government Nuffic / MHO	European Union Cross-Cultural Program	Dutch Government Dutch Embassy in Costa Rica	Dutch Government Ministry of Economical Affairs
Main target group	Higher education	Multiple	SMEs	SMEs
Main objective	Curriculum development	Linking networks, awareness raising	Capacity building, demonstration	Demonstration, capacity building
Content	Product innovation	Ecodesign	Ecodesign	Product innovation

For example, in the CA and CR case the funding programs were focused on SMEs and as such the target group became SMEs. Large industries and NGOs were excluded. Alternatively two of the funding programs (IN and CA case) did have reduction of environmental impact as line of approach, from that perspective the knowledge transfer package was supposed to include not only production innovation aspects but as well environmental approaches (i.e. Ecodesign). As a result two cases have as priority target group SMEs, one higher education institutions and the last one multiple. Content-wise two cases are focussed on product innovation and two on Ecodesign (product innovation & environment).

The four cases did have similar kind of the knowledge transfer goals like awareness raising, demonstration, capacity building and dissemination. The emphasis and priority of certain goals

differed in between the projects. Table 10.2 highlights the importance of the different knowledge transfer goals within each of the four cases.

Goal	TZ	IN	CA	CR
Demonstration	+	+	++	++
Awareness raising	+	++	+	+
Capacity building at university	++	+	-	-
Capacity building in industry	-	+	++	++
Dissemination	-	++	++	-
Curriculum development	++	+	-	-

Table 10.2: The importance of the knowledge transfer goals within the four cases (++ = very important, + = important, - = not important).

To fulfil these specific knowledge transfer goals, for each project a different set of knowledge transfer activities was selected (see Table 10.3). The TZ case, for example, with as main goal curriculum development focussed on course development and capacity building at the university. Alternatively the IN case with as main goal awareness raising, linking networks, and dissemination as such organised a wide range of workshops. The CA and CR cases, both focussing on demonstration and capacity building, concentrated most of their efforts on in-company demonstration projects.

Table 10.3: The main knowledge transfer activities within the four cases. The grey cells highlight the emphasis of the projects.

Knowledge transfer activities	TZ1	TZ2	IN	CA1	CA2	CR
Train the Facilitator (TtF) courses	2	-	1	1	1	-
Demonstration project(s)	9	2	8	9	5	3
Local public workshop(s)	2	-	5	2	1	2
Workshop in EU	-	-	1	-	-	-
Traineeship(s) in EU	-	-	8	-	-	-
Developed courses	6	-	1	-	-	-
International conference	1	-	1	1	-	-

The funding program has a direct impact on the goals, content (What) and type of the knowledge transfer activities (How) as well as on the selection of the target group (Who). ***New focal point***

10.3 Train the Facilitator (TtF)

The upcoming paragraphs will discuss and compare the knowledge transfer activities. This paragraph describes the setup and results of the executed Train the Facilitator (TtF) sessions. Within three cases one or two TtF sessions took place. The main goal of the TtF sessions was to develop local capacity to facilitate the demonstration projects as well as to initiate and guide future local product innovation projects.

Motivation for facilitators

In one case (CR) no facilitators were trained. Two types of facilitators were foreseen: the Croatian employers association (HUP) and local consultants. HUP was however not the initiator of the knowledge transfer project (in the other three cases the main local partner was one of the initiators). They were not directly interested in the topic and just functioned in a facilitating role. As a result no HUP staff was trained. The second target group, local consultants, were offered only new knowledge and no additional incentives like a fee, future guaranteed work in the field or travels. As a result they were not interested and motivated.

There should be a clear interest and incentive present in order to attract and train motivated facilitators. Offering only product innovation knowledge is not sufficient. If there is a lack of positive attitude, it is difficult to transfer the knowledge to the prospective knowledge facilitators. ***E27***

TtF setup

The setup of the TtF sessions differed in duration, amount of participants, location and trainers. The different setups of the TtFs are summarized in Table 10.4.

Table 10.4: Configuration of the Train the Facilitators courses.

TtF setup	TZ1	TZ2	IN	CA1	CA2	CR
Location	Delft	Local	Delft	Delft	Delft	-
Trainers	DUT	Local	DUT	DUT	DUT	-
Participants	4	8	6	12	12	-
Duration (weeks)	4	2	2	2	2	-

Most TtFs did have a duration of 2 weeks, with as exception the first TZ TtF which took 4 weeks. The longer duration of the TtF provided the opportunity to integrate more and longer exercises. Within both the CA and TZ case, two TtFs took place. In the CA case both TtFs did have a similar kind of setup (2 weeks, location Delft, trainers from DUT). In the TZ case, the four trained staff members of the first TtF were responsible for the training approach and content of the second TtF, which took place in Tanzania. In addition, local experts were invited to provide lectures. This way with less resources (no travel to and accommodation in Europe, no contracting expensive international experts) and a more appropriate content (adjusted by the Tanzanian trainers to the local socio-economical and educational context) and a bigger audience (in this situation 8 new trainers) could be reached. A disadvantage of providing training at the local institutions (in this case the university) is the fact that the participants after the training sessions went back to their daily work routine. As a result they did not have time to work on exercises to internalize the newly gained knowledge.

The most (resource) efficient way to organize follow-up TtFs is to involve local (earlier trained) staff and to let the TtF take place locally. ***Guideline***

TtF didactic approach

The didactic approaches like for example the intensity of the exercises and the use of problem-based learning approaches differed per case. Table 10.5 summarizes the content and didactic approaches of the TtFs.

Table 10.5: Didactic approaches of the Train the Facilitator (Y = Yes, N = No, H = High, L= Low, M = Medium).

Didactic approaches	TZ1	TZ1-2	IN	CA1	CA2	CR
Problem-based learning (PBL)	Y	Y	Y	Y	Y	-
Exercises with local products	Y	Y	N	N	N	-
Exercises based upon local companies	Y	Y	N	N	N	-
Intensity of exercises	H	L	M	M	L	-
Preparation in advance	Y	N	N	N	N	-

All TtFs did take problem-based learning (see section 2.6) as the basic approach for the training. The participants did have to operate as 'problem owners' and did have to solve 'real problem situations' during the training. The learning-by-doing setup of the TtFs was an adequate approach to get the participants in a short time acquainted to the for them new knowledge. In the IN and CA case, the participants were solving problems related to Western companies and products (like i.e. Western Philips vacuum cleaners). Using Western examples could help creating insight

in the use of the methods and tools but not yet how to place this in their own daily professional context. Only in the TZ case, the participants were asked to identify a local company in advance and to use this company and its product portfolio as a start for the exercises during the TtF. This last approach, using examples of companies and products from their own context, did have a bigger and deeper learning impact: they mastered the newly learned approaches as well as could link them directly to their local practice.

Problem-based learning approaches were used intensively in all four TtFs. The PBL approach was quickly adopted by the participants and resulted in fast learning results. ***E5***

Use, if possible, real 'problems' from their own working context (for example local companies and products). ***Guideline***

The knowledge content of the TtFs differed not only in focus (product innovation versus Ecodesign), but also on what type of knowledge was offered. Table 10.6 provides an overview of the type of product innovation knowledge provided to the participants during the TtFs.

Table 10.6: Type of product innovation knowledge content provided during the Train the Facilitator sessions (Y = Yes, N = No).

Type of product innovation knowledge content	**TZ1**	**TZ2**	**IN**	**CA1**	**CA2**	**CR**
Domain specific basic knowledge	Y	Y	Y	Y	Y	-
Domain specific design knowledge	Y	Y	N	N	N	-
Domain independent process knowledge	Y	N	N	N	N	

The TtFs did have a strong emphasis on domain specific 'basic knowledge' and less attention for domain specific 'design knowledge' and domain independent process knowledge (see section 3.4). Only the two TtFs in TZ discussed and applied more intensive the knowledge and skills of the design discipline (design and process knowledge). In the CA and IN case it was assumed that the participants would have sufficient background knowledge and experience with product innovation (design and process knowledge). This is similar to the assumption in the UNEP Ecodesign Manual (see section 3.5). In practice most of the participants possessed limited or no design and process knowledge. As a result it was more difficult for them to apply the gained domain specific basic knowledge in practice as well as to facilitate in a proper way the product innovation process within the demonstration projects.

All three types of product innovation knowledge are needed to be successful. ***E7***

Assess the participants prior to the TtF on their preceding product innovation experience and knowledge, and adjust the knowledge content and exercises of the TtF accordingly. Alternatively select participants that fulfil a certain specified product innovation knowledge profile. ***Guideline***

The TZ case was focussed on new curriculum development. This meant in practice that not only new topics (knowledge content) would be introduced at UDSM, but also a new way of teaching (knowledge transfer) (from objectivism toward constructivism education approaches). During the TtFs no attention was being paid on didactic issues and training skills. Afterwards it was concluded that including training in teaching skills in the TtF would have been of highly added value. Providing the participants with skills to teach and train other people within the organisation is not only of relevance within the context of a university. Also in industry, the participants will need ability to transfer the gained knowledge to colleagues or other companies.

Provide the participants of the TtF not only with knowledge content but also with skills to transfer the gained knowledge to others. ***Guideline***

During the TtFs the participants were introduced to and trained on different levels of product innovation (see Table 10.7).

*Table 10.7: Innovation level content of the Train the Facilitator sessions (** = Main focus, * = Lesser focus).*

Innovation levels	TZ1	TZ2	IN	CA1	CA2	CR
Innovation level 1 Product improvement		*				-
Innovation level 2 Product redesign	*	**	*	**	*	-
Innovation level 3 New product	**		**	*	**	-
Innovation level 4 New function fulfilment			*		*	-

The first TtF of the TZ case was focussed on level 3: new products. During the project itself it was concluded that local companies were more in need of support on product innovation level 1 and 2. As a result the second TtF in Tanzania did have a stronger emphasises on small product improvements, learning from competitors and redesigning existing products of the local companies. The IN case did have a wide range of potential beneficiaries; consequently the TtF did have training components at three innovation levels. The participants were trained on product innovation level 2 and 3 to support the local industry and at product innovation level 4 to collaborate with local NGOs and government bodies. The first CA TtF was concentrated on level 2, which fitted well to the needs of the participating demonstration companies. Since the second phase of the CA case did have an orientation on higher innovation levels, the content of the training was adjusted accordingly (level 2, 3 & 4).

Assess before the TtF which product innovation levels are adequate for the final local knowledge recipients. Adjust the content of the TtF accordingly. ***Guideline***

Incremental product innovation levels should predominate the content of TtFs. Especially when the final knowledge recipients are SMEs in low-income countries. ***E21***

Examples and cases

In most of the TtFs sessions examples and cases were used of the earlier experiences with product innovation of the knowledge source (DUT) in developed countries. The follow-up TtFs in CA and TZ were an exception on this. Based upon the results of the demonstration projects of the first phase of these cases, local examples and cases were developed and shared with the participants. The local examples, compared to the Western examples, worked out much more convincing for the local participants as well as evoked more discussion in between the participants about the application of product innovation in their local practice. Alternatively examples from similar socio-economic contexts were used. For example the outcomes of the demonstration projects in the agricultural sector in Central America functioned well as examples during the second TtF in Tanzania.

Use during the TtF as much as possible examples of local companies. Alternatively use examples from regions with a similar socio-economic development. ***Guideline***

10.4 Demonstration projects

Within each case, in-company demonstration projects were used as a method for product innovation knowledge transfer. The goals of the in total 36 demonstration projects were at least

two-fold: To demonstrate the relevance of the product innovation approach for the local context as well as capacity building within the participating organisations. The upcoming paragraphs will describe the setup and outcomes of the demonstration projects

The final product results of the demonstration projects varied from just ideas and concepts toward working prototypes and successful implementation into the market. The detailed results of the 36 demonstration projects are described in Appendix 3. Table 10.8 provides a summary of the product innovation results of the demonstration projects.

Table 10.8: Product results of the demonstration projects (percentage in terms of the total amount of demonstration within each case).

Final result	TZ1	TZ2	IN	CA1	CA2	CR
Ideas	-	-	1 (13%)	-	-	-
Concept	3 (33%)	1 (50%)	1 (13%)	-	1 (20%)	1 (33%)
Prototype	4 (44%)	-	3 (37%)	3 (33%)	1 (20%)	1 (33%)
Market	2 (22%)	1(50%)	3 (37%)	6 (66%)	3 (60%)	1 (33%)

They CA1 case resulted into the most products successful into the market (66%). The other demonstration projects in CA ended up at least into a working prototype or mock-up. The demonstration projects in the TZ1 case demonstrated an opposite result. Only 22% of the demonstration projects resulted into a successful product in the market. Most of the projects in the TZ1 case ended up at a concept or prototype stage. The CR and IN case provide a scattered picture varying from just product ideas till some products launched into the market. The success of the product results of the demonstration projects cannot be explained based upon just one critical factor. The product success of the demonstration projects is based on a combination of the facilitation (knowledge transfer process), proper product innovation strategy (knowledge content), the objectives of the project and the capabilities of the participating companies (characteristics of the knowledge recipient). These aspects will be explored in the following paragraphs.

10.4.1 Objectives of demonstration projects

Even though the objectives of executing demonstration projects were defined in the project proposals, often new ones came up in the mind of the project team or the order of priority changed during the execution of the project. Objectives of the demonstration projects could be for example:

- To demonstrate the need of product innovation;
- To create awareness;
- To build product innovation capacity within the company;
- To build up capacity within the local knowledge facilitating team;
- To provide students with experiences in working in a company abroad;
- To develop promotion and dissemination materials;
- To develop teaching materials.

In the CA and CR case the objectives of the demonstration projects and their order of priority according to the project team were rather clear (demonstration and capacity building within the companies). The objectives and their order of priority of the demonstration projects in the TZ and IN case were less transparent (developing teaching materials, awareness raising, demonstrating the need for product innovation, and capacity building). The companies themselves also did have several objectives and expectations of the demonstration projects, varying from just getting some insights (awareness) towards serious capacity building. For example in the CR case two companies (Instrumentaria & Adriazinc) wanted their staff to gain

serious experience and capacity, the other one just aimed at basic understanding of the product innovation process (DIN). The same holds for the role of the students within the demonstration projects. Since they were the central person in the demonstration projects they were expected, from a project perspective, to take care of multiple objectives. For example, achieving fast demonstration results as well as building capacity within the company. In addition, they did have their own personal objectives like getting work experience in another cultural and to get their MSc. degree.

Because of this interest entanglement between the different stakeholders as well as different expectations within the demonstration projects, they did not always led to successful results.

Make the objectives of the demonstration project and their priority for all involved parties (company, students and (inter)national experts) clear and communicate it in between them. Create a shared vison. ***Guideline***

10.4.2 Selection of demonstration companies

The first stage of the demonstration projects was the selection of the companies. This selection was done in 3 out of the 4 cases by means of a stepwise procedure (see Table 10.9)

Table 10.9: Overview of the steps of the selection of demonstration companies.

Selection steps	TZ1	TZ2	IN	CA1	CA2	CR
Country assessment	Y	N	N	Y	N	N
Sector selection	N	Y	N	Y	Y	N
Criteria for selection first demonstration projects	Y	Y	N	Y	Y	Y
Criteria for next demonstration projects	N	-	N	Y	Y	-
Shortlist of companies before final selection	Y	Y	N	Y	Y	Y

The CA case did have the most comprehensive and structured company selection procedure starting from a national and sector level towards a shortlist of potential successful companies. The IN case, on the opposite, is characterised by a more 'random' selection procedure. In TZ, in first instance a structured approach similar to the CA case was applied to select the first 5 companies. The companies that joined later on were more rather based upon personal contacts of the team members, than on a selection procedure. In CR case the choice was limited to the pool of companies that joined the earlier Nehem Benchmark project. Within the four cases in total 36 'demonstration' companies have been selected. A detailed overview of the characteristics of these companies can be found in Appendix 3.

Given that the selected companies are supposed to be one of the main carriers to demonstrate the usefulness of product innovation in the local context, the selection of them should be:

I. In line with the goals of the project proposal (for example a focus on SMEs);
II. Representative for the local economical activities (for example certain industrial sectors).

In line with the goals of the project proposal

For each case the project proposal indicated the amount and type of organisations to target as well as the region in which they should be based (see Table 10.10).

Table 10.10: Summary of the proposed and executed demonstration projects (dark cells indicate conflict with the project proposal).

Proposed in proposal	TZ1	TZ2	IN	CA1	CA2	CR
Demonstration projects	5	2	4	9	5	3
Target group	All	SME	SME	SME	SME	SME
Region	Tanzania	Tanzania	Delhi	CA	CA	Croatia

Executed in practice						
Demonstration projects	9	2	8	9	5	3
In large companies / MNCs	-	-	5	-	-	-
In medium sized companies	2	-	-	5	2	2
In small sized companies	2	1	-	4	3	3
In NGO's	3	-	3	-	-	-
In government / research institutes	2	1	-	-	-	-
In line with project proposal						
Covering the proposed region	N	Y	N	Y	Y	Y
Type of demonstration organisations	Y	Y	N	Y	Y	Y

All cases executed the requested amount of or even more demonstration projects as proposed in the project proposals. The type of selected demonstration organisations in the TZ, CA and CR case fit into the proposed project profile. Only in the IN case, the team was not able to attract the main proposed target group (SMEs). In both the IN and TZ case it was hard to convince SMEs to participate in the demonstration projects. As a result not SMEs but NGOs and research institutes in the TZ case and MNCs and NGOs in the IN case became the main target group.

The CA and CR case did have a proper coverage of the proposed regions. Because of travel budget constraints, the TZ1 demonstration projects were situated only in the capital (where the main local partner was based). In the TZ2 case, more budget was available and as a result organisations outside the capital could be included to the demonstration projects. The IN demonstration projects were proposed to take place in the Delhi region, however in practice most of the demonstration project took place elsewhere in the country.

Representative for the local economy

The expected industrial activities in the four cases based upon their economical development (see section 4.2.3) have been illustrated on the left side of Figure 10.1.

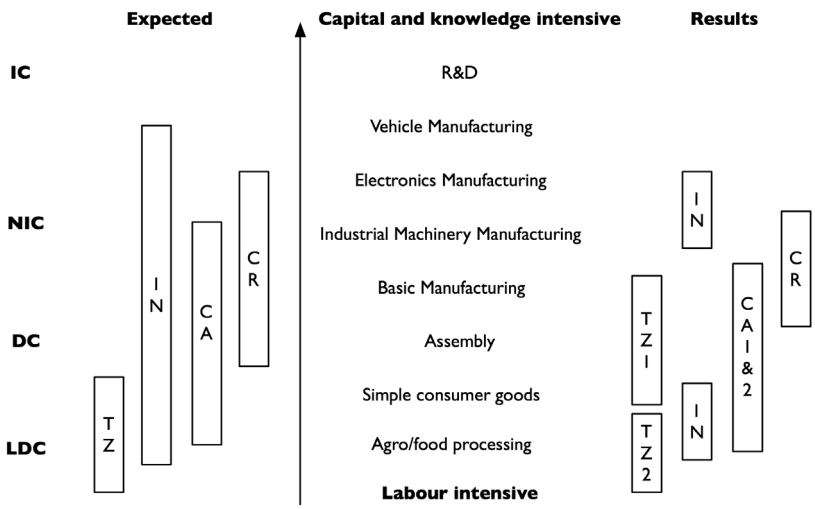


Figure 10.1: Expected industrial activities based upon the economical development (left) and the selected demonstration projects (right) (Diehl 2010).

On the right side of see Figure 10.1 the industrial activities of the selected organisations are illustrated. Particularly the first series of demonstration projects in TZ 1 were not representative

for the local economical development. The agro- and food-processing sector (which is responsible for 71% of the local industrial activities) was neglected (see Table 10.11). The TZ 2 case however, was to a large extent more connected to the local economical and industrial development and entirely focussed on agro- and food-processing industrial activities. The IN demonstration projects took place either in the capital and knowledge intensive sectors (at the top within electronics MNCs and the service sector) or down in the labour intensive sectors (NGO's operating in the informal sector). The industrial activities in between were lacking (no participating SMEs). The CA and CR cases represented well the local industrial and economical development. The figure illustrates that with the increase of the national income (from left to right) the industrial activities shift towards more capital and knowledge intensive activities. The only exception is India.

All participating SMEs can be characterized low-skill and labour intensive. ***E9***

Assess the representative economical and industrial activities in the country and select the demonstration companies accordingly. ***Guideline***

The diagram of Kogut (see section 4.2.3) can provide a quick indication of the relevant industrial activities. ***Guideline***

The demonstration projects in the CA case covered the project objectives as well as the regional economical and industrial activities in the best way. However, it should be noted that this case did have the most financial and human resources available for the selection of demonstration organisations selection. A proper selection of companies is time and resource consuming.

A structured step-by-step selection process of demonstration companies results into a representative collection of demonstration projects for the project goals as well as the local economical context. ***Guideline***

Sectors

The next Table 10.11 provides an overview of the distribution of the demonstration projects over the three main economical sectors.

Table 10.11: Distribution of the demonstration projects over the three main economical sectors.

Demonstration projects in:	**TZ1**	**TZ2**	**IN**	**CA1**	**CA2**	**CR**
Agro or agro-related sector	1	2	-	3	1	-
Industry sector	5	-	4	6	3	3
Service sector	2	-	4	-	1	-

Most demonstration projects (21) took place in the industry sector. Surprisingly the amount of projects that took place in the service sector (7) was almost equal to the amount in the agro-related sector (8). In the IN case even half of the demonstration projects were service related. Most of the service projects were in the tourism sector, one of the growing sources of income for developing countries.

Last but not least the demonstration projects can be categorized if they took place in the formal or informal sector. Table 10.12 highlights the distribution of the demonstration projects.

Table 10.12: Distribution of the demonstration projects over the informal and formal sector.

Demonstration projects in:	**TZ1**	**TZ2**	**IN**	**CA1**	**CA2**	**CR**
Formal sector	6	2	5	9	5	3
Informal sector (through NGOs)	3	-	3	-	-	-

In the TZ and IN case (the lower income ones) more than one third of the participating companies were operating in the informal sector. These were mainly micro-enterprises supported by local NGO's or government institutions. Since the informal sector, especially in low-income countries, is responsible for a large part of the production, income generation and employment (see section 4.3.2.), it sounds more logical to include them too in product innovation knowledge transfer projects demonstration projects.

In low-income countries not only participation of companies operating in the formal sector but also in the informal sector can be expected. ***E13***

10.4.3 Setup demonstration projects

Within all demonstration projects, except one (Tembo), students played a key role in transferring the product innovation knowledge to the companies. DUT students (sometimes in collaboration with local students) participated in the demonstration projects either as an internship in their 3rd or 4th year of their study or as their graduation project at the end of their master studies (5th year). Compared to graduation projects the internship projects did have a shorter duration as well as were less intensive guided by DUT and local staff. In addition the internship students were less experienced and spent limited or no time before and after the local stay to prepare and report the project. Table 10.13 provides an overview of the characteristics of the two variants of student projects.

Table 10.13: Characteristics of the two variants of student projects.

	Variant A **Graduation project**	**Variant B** **Internship project**
Duration (months)	6-8	2-4
Supervision by DUT staff	3 staff members (each 40 hours)	1 staff member (8 hours)
Years of finished study at university level	5	3-4
Experience student	More experienced	Less experienced
Goal	To get degree and experience	To get experience
Preparation in NL	Intensive	Almost not
Intensive reporting of process and results afterwards	Yes	No

An overview of the involvement of the two variants of student projects in the demonstration projects is summarized in Table 10.14.

Table 10.14: Involvement of the two variants of student projects in the demonstration projects.

	TZ1	**TZ2**	**IN**	**CA1**	**CA2**	**CR**
Variant A: Graduation students	-	-	-	7	-	3
Variant B: Internship students	20	3	10	3	3	2

As can be concluded from Table 10.14, the CA1 and CR case were dominated by variant B (student graduation projects). The TZ, IN and CA2 case were carried out by internship students (variant B), no graduation projects were involved.

In addition to the student involvement, depending on the goals and budget of the case, the demonstration projects were supported by in-house workshops as well as intensive guidance of

the DUT and local experts. Table 10.15 provides a summary of the setup and support of the demonstration projects.

Table 10.15: Setup of the facilitation of the demonstration projects.

	TZ1	TZ2	IN	CA1	CA2	CR
Mainly Variant B				Y		Y
Mainly Variant A	Y	Y	Y		Y	
Intensive guidance DUT experts				Y		Y
Intensive guidance local experts				Y	Y	
Three in-house workshops with experts				Y	Y	Y

Intensive facilitation by graduation students (variant A) in combination with workshops and guidance of the DUT and local experts in the CA and CR case led to the most successful product results (market introduction) within a short period. Though this setup for the demonstration project was also the most resource intensive (staff and financial).

The intensive facilitation in the CA and CR case also did have some drawbacks. Some of the participating companies became lazy since most of the work was done for them. As a result they got less involved in the product innovation process within their company. In these projects the demonstration of the product innovation process was successful, however the capacity building within the organisation limited.

An intensive facilitation of demonstration projects leads in general to more successful product result. However it does not guarantee as well a successful capacity building (internalization of the knowledge). ***Guideline***

Capacity building

Based upon the available documentation an estimation has been made of the capacity building in product innovation competences within the companies during the demonstration projects. These results have been summarized in Table 10.16.

Table 10.16: Capacity building during the demonstration projects.

	TZ1	TZ2	IN	CA1	CA2	CR
Capacity building	1 (11%)	1 (50%)	3 (37.5%)	6 (66%)	2 (40%)	1 (33%
No capacity building	8 (88%)	1 (50%)	5 (62.5%)	3 (33%)	3 (60%)	2 (66%)

From this table it can be concluded that only a few companies build up capacity in product innovation during the demonstration projects. The CA1 project was in that perspective the most successful. The selection of proper companies (technological capability and sufficient absorptive capacity) and intensive guidance led to a majority of companies with increased product innovation capacity. The TZ1 case was not able to build up a critical mass of new product innovation capacity within industry. During the second phase (TZ2) better results were achieved by selecting more suitable companies as well as more intensive guidance. Within the IN case especially the MNCs (with higher educated staff) did build up more capacity. In general, those companies with higher educated staff were able to pick up the new knowledge within one demonstration project. The others need more time and support.

Duration of demonstration projects

Students are relatively inexpensive compared to (inter)national consultants. As a result students can facilitate the product innovation process within a company during a longer period (compared

to the short interventions of the (inter)national experts). The duration of their participation in the demonstration projects varied from 2 (variant B) up to 8 months (variant A). This is an efficient and effective way to demonstrate the use of the product innovation approach within a company. However the work of the student does not guarantee systematic knowledge transfer and capacity building within the company. They (likewise the inter(national) experts) leave after the project and companies should not depend on them only.

In most cases the period was too short to demonstrate the need for product innovation as well as to build simultaneously capacity within the company. Only a limited amount of companies continued afterwards on their own. One in-house demonstration project was often not sufficient to make a significant change. Longer timeframes or a series of demonstration projects will be needed. Especially the last option, a series of in-house demonstration projects proved to work out well in SMEs in for example TZ.

Product innovation knowledge transfer (to SMEs) takes time and the knowledge within the company only can grow gradually. Capacity building hardly can be done in a short period (one demonstration project). ***E18***

A series of follow up projects can facilitate gradually product innovation knowledge transfer. ***Guideline***

Not only the capacity building was influenced by the time of intervention by student and external experts, also the level of product innovation. Product and systems innovations are usually part of a longer term 'learning curve' in the company, which frequently starts with redesign of products in the first place. A series of demonstration projects can lead to more higher levels of innovations. This is what happened in for example Intermech (TZ) and Whirlpool (IN). During the first demonstration project they became acquainted with benchmark (product innovation level 1) and redesign (product innovation level 2) approaches and build up capacity as well as awareness. In the follow up projects more radical innovation levels (new products, product innovation level 3) took successful place.

By introducing product innovation gradually in organisations, step-by-step more higher (radical) product innovation levels can be achieved. ***E18***

Local students

In addition to the DUT students, local students were involved in the demonstration projects (see Table 10.17).

Table 10.17: Involvement of local students in the demonstration projects.

	TZ1	TZ2	IN	CA1	CA2	CR
Local students	4	-	4	-	3	4

In the TZ and CR case these students executed part of the analyses in collaboration with the DUT students. In the IN case, local students were responsible for three of the eight demonstration projects. Within in the first part of the CA case no local students were involved while in the second part (CA2) they were the majority (under guidance of DUT students).

The advantage of involving local students is the fact that they have a better insight and understanding of the local context as well as know often better where to find certain kind of information. In addition they could help to overcome language barriers while interacting with external stakeholders and with the company staff. However, because of their educational

background in the TZ, CA and CR case (more objectivistic compared to the DUT students, as well as cultural differences), the local students were often not able to operate independent of the DUT students. They needed detailed assignments (see section 4.2.6) in order to point out what was expected from them. As a result the local students functioned more as an assistant for the DUT students.

Students in developing countries are often educated in an objectivistic way. They are not trained to solve 'ill defined' problems independently. They need specified tasks instead of 'open design briefs'. ***E6, E19***

10.4.4 Results demonstration projects

The results of the demonstration projects of the four cases can be compared on amongst others the product innovation level, product innovation strategy, and the sustainability focus.

Product innovation level

Within the demonstration projects different product innovation levels were applied. Table 10.18 summarizes the applied product innovation levels. A more detailed overview can be found in appendix 3.

Table 10.18: Product innovation levels of the demonstration projects.

Product innovation level	TZ1	TZ2	IN	CA1	CA2	CR
1 Product improvement	-	-	3	1	-	-
2 Product redesign	-	1	1	5	3	1
3 New product	9	1	3	3	2	2
4 New function fulfilment	-	-	1	-	-	-

Within the TZ1 case the companies only operated at product innovation level 3, new products. This is a higher innovation level than expected. The IN case provides a distributed picture spread over the four product innovation levels with an emphasis on product innovation level one and three. The CA case resulted into a concentration on product redesign projects (level 2) while the CR case operated slightly more in the field of new products (level 3).

Product innovation strategy

In addition, the product innovation strategies have been summarized according to the Ansoff matrix in Table 10.19. The product success of each demonstration project has been indicated in the same table (bold = in the market, underlined = prototype, normal = (concept) idea).

Table 10.19: Overview of the innovation strategies of the demonstration projects (Bold = in the market, Underlined = prototype, Normal = just concept idea).

TZ case

	Current products	**New products**
Current markets	Temdo	Palray, **Intermech**, Moi, Sido, Tatedo
New markets		**TTB**, DAGE, SIMBA, RT, TMTL

IN case

	Current products	**New products**
Current markets	Whirlpool 1, Philips, **Neemrana**, ITC	**Tri,** Kharm Marg
New markets		Whirlpool 2, **Naya Savera**

CA case

	Current products	**New products**
Current markets	**Waiman**, **Heliconia**, Mafam, **Bendig**, **Venus**, Mobelart, **Aventuras**, **Turbomac**.	Panel-Ex, Kontein, Executiv, **El Jobo,** Inmepro, **Rea**
New markets		

CR case

	Current products	**New products**
Current markets	Instrumentaria	
New markets		**Adriacink** DIN

Improving current products for current markets (the upper left quadrant) is relatively less risk full compared to the other three strategies. In practice new products for either the current (medium risk) or new markets (high risk) dominate the TZ case. The outcomes of the IN case are distributed over 3 of the 4 product innovation strategies (low, medium and high risk). The CA case resulted mainly into improved products for the current market (low risk) or developed new products for current markets (medium risk). Finally, the CR case resulted in new products for the current (medium risk) or new markets (high risk).

As can be concluded from Table 10.19, the low risk approach projects of the CA case resulted in the most successful products into the market. The more radical approaches within the CA case, new products for current markets, were much less successful. The TZ case, demonstrating more risk full innovation approaches, resulted only in a limited amount of successful projects.

Demonstration projects with a low risk (or incremental) innovation approach lead to more successful product results into the market. ***E20***

People Profit Planet

The results of the demonstration projects have been evaluated content wise on the three pillars of sustainability: People, Profit and Planet. The cells with a bold border in Table 10.20 indicate the original focus of the four cases. The TZ and CR cases were originally focussed on product innovation and to make the local industry more competitive (profit). The IN and CA cases were 'Ecodesign' knowledge transfer projects and concentrated on economic (profit) as well as ecological (planet) aspects. The results in practice of the demonstration projects can be found in Table 10.20.

Table 10.20: The original focus of the cases (bold cells) and the focus in practice (in numbers) of the demonstration projects.

	Profit	Planet	People
TZ	10 (91%)	4 (36%)	6 (55%)
IN	8 (100%)	8 (100%)	4 (50%)
CA	14 (100%)	14 (100%)	1 (7%)
CR	3 (100%)	-	-

As expected all demonstration projects except one (MOI, prostheses for disabled in Tanzania) have a 'profit' element as well as all Ecodesign projects have a 'planet' focus. Striking is the fact that half or more of the demonstration projects in the TZ and IN case did have in addition a social (People) component. The local economical and social context asked for product innovation solutions for social problems as well.

In low-income countries it can be expected that the product innovation demonstration projects will have strong(er) focus on the social (people) component. ***E24***

10.5 Product innovation process

Next to the product results and product innovation strategy, the product innovation process within the demonstration projects have been assessed by looking at the role of the management, other staff and the product development process itself.

10.5.1 Management

The attitude of the management in the companies towards the goals of the demonstration projects was very important. They initiated most of the demonstration projects and as a result they were aware and motivated. The success of the demonstration projects depended for a serious part on the commitment and attitude of the manager and his or her decisions to allocate staff and resources to work on the demonstration projects as well as to support the team mentally and participate in the decisions.

Commitment and a positive attitude of the management is a key issue for the success of the demonstration projects. ***E27***

In the less successful demonstration projects the style of management was often one of the barriers, especially in the smaller companies. Frequently the managers were also the owner of the company (or main shareholder). They often did not delegate the responsibility of the daily management and the product development process to the middle management. There are several reasons for this lack of delegation. High power distance (see section 4.2.6), especially in Croatia (73), India (77), East Africa (64) and Guatemala (95), is one of them. Another characteristic of these companies is the lack of middle management. In this situation there is only one or two high or medium educated managers besides low educated work floor staff (especially in East Africa).

As a result of the lack of delegation, the management was taking all the decisions and was overloaded with the daily tasks and did have no time for developing a med- or long-term vision and strategy. The focus of the management was on the daily struggle and short-term (tomorrow) pragmatic solutions. Because of this and other reasons these companies do often have a lack of a clear future vision and strategy. This lack of vision made it difficult for the facilitating team to

decide upon what kind of product innovation strategy fits the best to the current situation of the company.

Cultural differences in management style (i.e lack of delegation) in SMEs in developing countries can be a barrier for the success of the demonstration projects a s well as the capacity building. ***E19***

Small- and the smaller medium-sized enterprises often lack middle management. This can hinder the product innovation process. ***New expectancy***

Work floor staff

Within the demonstration projects the management frequently expected from the work floor staff to participate actively in the product innovation process. In several of the projects, especially in the CR and TZ case, the workforce was relatively old and not proper educated and trained for product innovation. In addition, because of the management style they did have no or limited experience with taking initiatives and handling responsibilities. Their lack of experience and skills as well as often no clear incentives to actively participate (not they, but the management initiated the projects), resulted in a non-collaborative, defensive attitude of the work floor staff. The high power distance in most companies resulted in a lack of teamwork and bottom up initiatives (ideas from the work floor), which are essential elements of successful product innovation.

Cultural differences in management style as well as a lack of a clear incentive and a lack of product innovation experience and skills can be a barrier to involve the work floor staff in the product innovation process. ***E19, E27***

10.5.2 Product development

Next the product development process within the demonstration projects has been evaluated by looking at the product development capacity, product development approach and the knowledge gathering process. First the internal product development capacity is described by the design and engineering support within the participating companies (see Table 10.21).

Table 10.21: The presence of (design and) engineering departments within the companies.

Department	TZ1	TZ2	IN	CA1	CA2	CR
Design and engineering department (mainly MNCs)	1	-	2	1	-	-
Only engineering department (mainly larger medium-sized)	2	1	-	2	2	3
None of them (mainly small- and smaller medium-sized)	6	1	5	6	3	-

Only the larger medium-sized and multinational companies (Philips, Whirlpool, Panel-ex and Simba) did have their own design department in combination with an engineering department. Some of the bigger SMEs did have an engineering department. The other SMEs, especially the smaller ones operated without both of them and the staff responsible for product development is usually not formally educated and is self-taught. Most of the participating SMEs did not have a 'structured or formalized' product development process. Especially in the smaller companies the product development is often in the mind of the manager (implicit) or a trial and error process (i.e. Waiman).

The design and engineering capacity in most SMEs is (very) limited. Only the larger medium-sized enterprises posses of an in-house engineering department. The existence of in-house product design departments is even more limited. The staff responsible for product development is usually not formally educated and is self-taught. ***E12***

There is no or very limited structured or formalized product development process in the smaller enterprises. ***New expectancy***

One of explanations is the fact that a serious part of the participating companies can be labelled as 'capacity companies', which have limited experience with (structured) product development. Table 10.22 categorises the demonstration companies according to their product development and production capacities.

Table 10.22: Product development capacity and production capacity within the companies.

	TZ1	TZ2	IN	CA1	CA2	CR
No production, no product development capacity	4 44%					
Capacity company	2 22%		1 13%		1 20%	2 66%
Capacity company with limited product development experience	1 11%			3 33%		1 33%
Product development capacity but no production capacity	1 11%	1 50%	1 13%			
Product or service development company with production capacity	1 11%	1 50%	6 74%	6 66%	4 80%	

Most of the participating organisations in the TZ1 case did not have experience with product development. In addition, some of them also did not have experience with production (for example NGOs and government bodies). Within the follow up project (TZ2), companies with more experience in both fields were selected. Capacity companies did dominate the CR case. These capacity companies did have the disadvantage of a lack of experience in product development as well as in other steps of the value chain (i.e. distribution and marketing). Before introducing new product innovation strategies within their company, they first had to learn and adopt the basic design skills. In addition, they had often not their own marketing, distribution and sales channels, which had to be created and consolidated before they could enter (successfully) the market with their own products. The IN and CA cases were dominated by companies with product companies with their own production capacity and distribution channels.

Capacity companies will need more support in acquiring first the basic product development skills as well as marketing and distribution capacity before starting on new product innovation projects. ***E23***

The smaller companies often used a very limited amount of product innovation tools. They had inadequate resources and often a low(er) educated staff. In combination with their limited experience they preferred to work with simple tools like checklists. Even medium sized companies relied a lot on checklist type of tools. Only some of the bigger medium sized (i.e. Simba and Kontein) and international companies (i.e. Whirlpool and Philips) did have more sophisticated product innovation methods and tools in use.

Some of the applied product innovation and Ecodesign tools during the demonstration projects were to complex for use in especially the smaller companies. In the situation that they will have to use the tools independently, they have to be simple (not complex), request limited time (to learn as well as to use), and should lead to direct results. In addition cultural aspects also can play a role. Especially in countries with a high Uncertainty Avoidance Index (i.e. Central America, see section 4.2.6), people preferred checklist type of tools. The more complex tools have to be facilitated by external facilitators like consultants.

Small companies prefer simple (easy to learn and easy to communicate) checklist type tools. More complex tools have to be facilitated by external facilitators. ***New expectancy***

Benchmarking

Table 10.23 provides an overview of the use of product benchmark as product development approach (product innovation level 1) within the demonstration projects.

Table 10.23: The use of benchmark approaches within the demonstration projects.

Use of a kind of benchmark approach	TZ1	TZ2	IN	CA1	CA2	CR
Yes	3	2	4	9	5	3
No	6	-	4	-	-	-

It is obvious that in most or is some cases all demonstration projects benchmark approaches were used. Most of the participating companies were used to copy and benchmark in their daily product development process. In many of the successful demonstration projects a kind of benchmark approach was applied. The single deviation is the TZ1 case, only in a minor part of the demonstration projects benchmark methods were applied.

A majority of the companies uses benchmark approaches to develop new products. ***E22***

Prototype

In most demonstration projects it was observed that it is very essential, especially in the lower educated companies (the smaller ones and those in the more low-income countries), to reach to the level of at least a prototype as final result of a project. The lower educated companies are not used to produce from technical drawings (CAD) or 3D renderings. Reports also often end-up in the drawer. One to one prototypes offer the opportunity for the company to 'copy' the product as they are used to.

Demonstration projects should (especially for the smaller companies) result into tangible end-results like (working) prototypes. ***Guideline***

Internal focus

The product innovation process within the companies was generally 'internally focussed'. The course of action was technology and production process driven (inward looking) and not based upon the external factors like the market, neither were external knowledge sources like R&D institutions and universities approached. This counted even for the bigger SMEs'. Only when the product was developed, market tests were done. Export oriented companies looked more intensively to the (export) market.

Within the two Ecodesign cases (CA & IN) there were mainly internal Ecodesign drivers (because of a lack of external drivers like legislation and consumer demand). Only exporting companies did look more intensively after external drivers (at the EU and USA export market). Consequently the information search during the Ecodesign process was also mainly internally focussed on the company itself and its products.

In both cases the hindrance for internal information gathering is the limited documentation and administration within the companies. Most information and knowledge in the smaller companies are implicit in the manager, verbal and not explicitly written down. Also externally it is often difficult to get access to reliable and up-to date information, statistics and (i.e. market and environmental) data.

The product development process in most participating demonstration companies is inward looking, focussing on their own knowledge, production and products. The only exceptions are some of the export-oriented companies. ***New expectancy***

10.5.3 Capability and awareness for product innovation

Lastly, the capability and absorptive capacity of the participating companies have been evaluated. Starting with capability the companies have been categorised in Table 10.24 based upon on their technological capabilities.

Table 10.24: Level of technological capabilities in the participating organisations.

Level	TZ1	TZ2	IN	CA1	CA2	CR
1. Low technology and micro enterprises	4		1			
2. Minimal technology SME	3	2	2	3	3	1
3. Technology competent enterprises	2		1	5	2	2
4. R&D rich enterprises			3			

In the TZ case, seven out of nine of the companies fit into the category low or minimal technological capabilities. They were in a bad financial situation and in need for restructuring. The best approach for them would be to first re-organize and upgrade their production facilities and stabilize business (improve quality and efficiency), to create awareness of the scope and benefits of innovation and first to introduce basic skills (see section 4.3.4). To go directly for new products and markets (as done in the TZ 1) demonstration projects was one bridge to far at this stage. These companies were not yet ready for product innovation activities. The IN case demonstrates a distributed picture of the level of the participating companies. Those on level 4, R&D rich enterprises are the MNCs like Philips and Whirlpool. Both the CA and CR case do have participating companies on level 2 and 3. They were more ready for product innovation and to build up in-house product innovation capabilities (see section 4.3.4). Especially to redesign their own products or to develop new products close to their current business.

Especially in low-income countries, SMEs posses of low technological capabilities. They are not yet ready for product innovation and need first restructuring of the production facilities and administration. ***E16***

Assess the companies on their technological capabilities prior to the demonstration projects and adjust the product innovation level of the knowledge transfer accordingly. ***Guideline***

Awareness of need for and how to innovate

Next, the participating companies have been positioned according to their awareness of the need to change and awareness of how to change (see Figure 10.2). Based upon their position they can be categorised in four types of firms varying from 'don't know that they don't know' till 'high capability and absorptive capacity' (see section 10.21). The following four diagrams illustrate the position of the 36 demonstration companies.

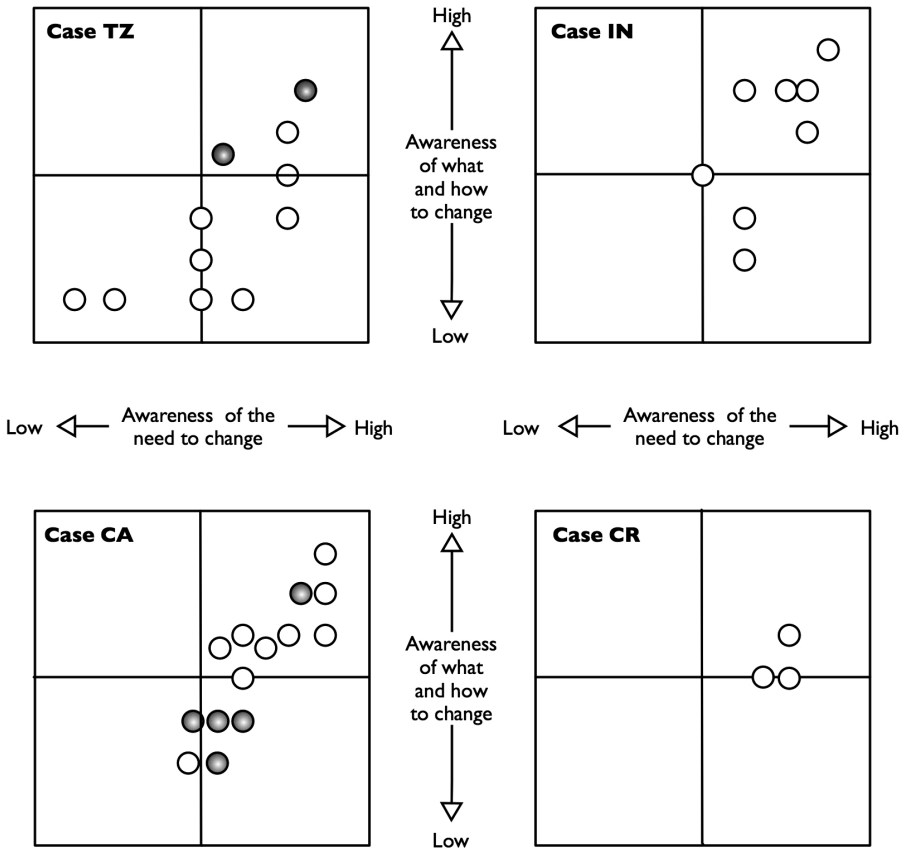


Figure 10.2: The awareness of the participating companies (dark balls indicate companies in the second phase of the case (i.e. TZ 2 and CA 2)) (Diehl 2010).

Companies operating in the lower quadrants dominate the TZ case. They are not aware of how and what to change. The IN case is characterised by two clusters. In the upper right corner the electronic MNCs and international hotel chains. They are aware of the need for product innovation as well as have ideas how to do so. The second cluster mainly consists of NGO's. They are aware of the need but do not know exactly what to do. In the CA case all companies are aware of the fact that they have to change, and most have an idea how to do so. The CR case shows three companies in more or less equal situation. In total about half of the participating companies were not aware for the need for change or how to change. Taking in consideration that the more suitable companies were selected, it can be expected that in practice even more companies might be in this situation.

A large part of the SMEs is not aware of the need for change, neither how to change. ***E17***

Educational level and absorptive capacity

Absorptive capacity is needed to grasp and manage new knowledge. The level of education of the company staff plays an important role in this. The average education level of the staff within the participating companies has been summarized in Table 10.25. Details per company can be found in Appendix 3.

Table 10.25: Average education level of staff (4= high skilled, 3= medium-skilled white-collar, 2= medium-skilled blue-collar, 1= low-skilled). IN case: In between brackets the score if the MNCs would be excluded.

Education level of staff	TZ	IN	CA	CR
Higher management	3	4 (2.5)	3.5	4
Middle management	2 or no	3 (2)	2.5	3
Work floor	1	1 (1)	1.5	2

A direct relation can be observed between the GDP and education level. From left to the right the GDP of the countries increases as well as the education level of the staff. Exception is the IN case (higher level of education) because of the MNCs involved. In between brackets indicated the education level if the MNCs are excluded.

SMEs in low-income countries have in general low educated staff and as such a limited absorptive capacity. ***E15***

10.6 Workshops and dissemination activities

Next to the Train-the-Facilitator courses and in-house demonstration projects, workshops and dissemination materials were another mean for knowledge transfer that was used in all four cases.

Workshops

Within each case several workshops and in most cases also in addition an international conference were organised to create awareness, to build up some basic understanding as well as to disseminate the results to the different stakeholders (see Table 10.26).

Table 10.26: Amount of workshops and conferences organised.

	TZ	IN	CA	CR
Workshops	2	6	4	2
International conference	1	1	1	-

Workshops proved to be an adequate tool to create awareness and basic understanding of product innovation. However in order to bring product innovation into practice in industry, other more intensive approaches seem to be necessary, like in-house demonstration projects.

Especially in the IN case, the workshops played a central role within the project. Since the main goals were networking, creating awareness and dissemination, in total six workshops for different target groups were organized. Compared to the other cases, within the IN case more efforts were put in structuring and executing the workshop. According to the target group, the contents and setup were determined.

In general it was difficult to attract companies to participate to the workshops and conferences. Only industry representatives (i.e. sector organisations or chambers of industry) usually joined. It was relatively easier to get commitment from academics, students, consultants, NGO's and government representatives. For these target groups a few days workshop seems to be an appropriate and efficient way for knowledge transfer. Companies preferred more either short (half a day) workshops or in-house dedicated workshops, which are (much) more resource intensive (relative small audience), but seem to be more appropriate for them.

The different goals of the workshops and target groups resulted in distinct workshop configurations. The awareness workshops were dominated by presentations and group

discussions. Those workshops focussing on some basic capacity building were more interactive with a focus on exercises and teamwork.

Depending on the target group as well as the goal of the workshop different workshop configurations should be taken into consideration. ***Guideline***

Developed explicit knowledge transfer materials

In order to share and disseminate the gained experiences and newly developed tools and methodologies, explicit materials like product innovation manuals and demonstration project fact sheets had to be developed. The four cases differ a lot on this aspect (see Table 10.27).

Table 10.27: Developed explicit knowledge transfer materials.

	TZ1	TZ2	IN	CA1	CA2	CR
Fact sheets demonstration projects	-	-	-	9	4	-
New product innovation manual	-	-	-	1	-	-
Web-site	-	-	1	1	-	-
New product innovation courses	6	-	1	-	-	-
Conference proceedings	1	-	-	-	-	-

In most cases the explicit materials were developed only at the end of the project. The CA case was an exception on this. Already in an early stage explicit materials like fact sheets of the demonstration projects were produced. For the CR case no materials have been developed (fact sheets were planned) and as a result the outcomes and learnings also could not be disseminated (except by academic papers). The TZ case was focussed on curriculum development, and from that point of view the focus was on developing teaching materials. For six new product innovation courses teaching materials, syllabi and PowerPoint presentations were developed. Even though in the proposal video's, web-sites and fact sheets were mentioned, they did not come into reality. At the end of the project an international conference took place with proceedings. The IN case produced for each of the five workshops a CD-Rom with the presentations. But limited effort was made to disseminate the results. No fact sheets or a design manual was materialized (even though there were some drafts, but they were never finalized). In this perspective a lot of the gained experience and knowledge has lost because of a lack of making the knowledge explicit (several trained staff members left the organisation or even the country shortly after the end of the project.

Only the CA case developed thorough explicit training and dissemination materials. In an early stage fact sheets were made from the first demonstration projects. They were helpful for promoting the project, to make stakeholders aware as well as served as local examples during the upcoming workshops. The local examples of industrial sectors relevant for the local industry worked more convincing compared to the earlier used Western examples. In addition at the end of CA1 a new Ecodesign manual for Central America was developed based upon the gained experiences within the local demonstration projects. This manual was used for the demonstration projects in the follow up project (CA2).

The fast development of fact sheets in CA provided not only convincing examples for the local context but also for the DUT product innovation knowledge transfer projects in developing countries. For example, at the beginning of the TZ case Western examples were presented, but later on examples from CA (more comparable kind of industrial sectors and product innovation levels) were used.

The use of local examples relevant for the local socio-economic development works more convincing than western examples. Use as much as possible local examples relevant for the local industry. Alternatively use examples from other regions with comparable socio economic context (south-south). ***Guideline***

10.7 Knowledge transfer process

After evaluating the different product innovation knowledge transfer activities one by one, in the end of the cross case analysis the overall knowledge transfer process will be evaluated. The knowledge transfer activities of each case have been categorised according to the four general types of knowledge transfer (see Table 10.28).

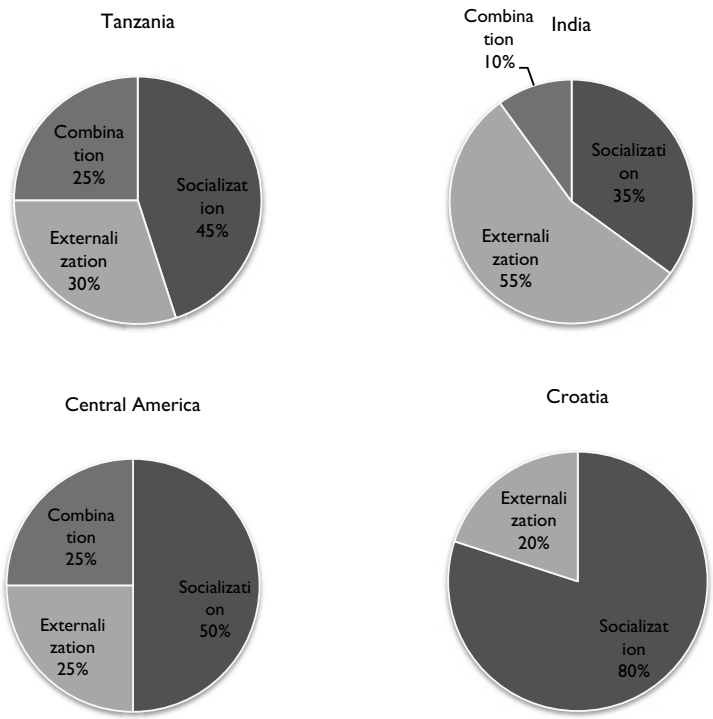
Table 10.28: Overview of the type of applied types of knowledge transfer processes.

Type of knowledge transfer	**TZ**	**IN**	**CA**	**CR**
Socialization: tacit → tacit knowledge	Demo projects TtF	Demo projects TtF	Demo projects TtF	Demo projects
Externalization: tacit → explicit knowledge.	TtF Workshops Conference	TtF Workshops Conference	TtF Workshops Conference	TtF Workshops
Combination: explicit → explicit knowledge	Course materials	Course materials	Manual Factsheets	-
Internalization: explicit → tacit knowledge	-	-	-	-

The demonstration projects were typical socialisation knowledge transfer activities were students and (inter)national experts shared their product innovation experiences with the companies and facilitators on a person to person basis (tacit-tacit). The Train the Facilitator session combined personal training (socialisation) with lectures and hand-outs (externalisation). Part of the knowledge of the trainers was transferred tacit-tacit and partly tacit-explicit. The workshops and conferences were dominated by lectures (externalisation). By means of developing manuals, course materials and factsheets earlier codified experiences were combined for future use (explicit-explicit). As can be concluded most of the knowledge transfer processes were tacit knowledge related.

The tacit component is dominant in the product innovation knowledge transfer in all four cases. ***E1***

In consultation with the project coordinators of the four project coordinators an estimated distribution of the four knowledge transfer processes per case has been made (see graph 10.1).



Graph 10.1: Overview of distribution of type of knowledge transfer process per case (Diehl 2010).

As can been concluded from Table 10.28 and graph 10.1 the socialization and externalization knowledge transfer processes dominated the cases. The TZ and CA case did have in addition also a serious effort in 'combination'. Several explicit outputs have been combined into explicit materials like course materials and manuals in order to transfer the knowledge independent to others in the future. Since in the IN case workshops played a major role, externalisation, by means of lectures, PowerPoint presentations, hand outs and papers were dominant. The CR case mainly existed of the socialisation process, the in-house demonstration projects.

Socialisation and externalisation knowledge transfer processes are dominant. ***E2***

Looking into more detail into the specific knowledge transfer mechanisms used within the four cases, Table 10.29 provides an overview.

Table 10.29: The use of people-based and information-based transfer mechanisms.

	TZ	**IN**	**CA**	**CR**
People based				
TtF	Yes	Yes	Yes	-
Demonstration projects	Yes	Yes	Yes	Yes
Workshops	Yes	Yes	Yes	Yes
Conference	Yes	Yes	Yes	-
Information based				
E-mail	Yes (mainly for project management)	Yes (mainly for project management)	Yes (mainly for project management)	Yes (mainly for project management)

E-learning	Yes (failed)	Yes (failed)	-	-
Web-site	-	Yes (afterwards)	Yes (half way)	-
New manual or tools	-	Yes (afterwards)	Yes (half way)	-
Online manual	-	-	Yes (halfway)	-
Course material	Yes	Yes	-	-
Factsheets	-	-	Yes	-

In general the people-based knowledge transfer mechanisms dominated. The information based knowledge transfer mechanisms where used much less or not at all for the purpose of the product innovation knowledge transfer process. E-mail was mainly used for project management and not for knowledge transfer. Two cases (TZ and IN) attempted to incorporate e-learning through the Blackboard platform of DUT. In both cases the e-learning platform was not or very limited used (one of the problems was the speed of internet at the time of the project). The developed manuals, courses and factsheets came only available half way or afterwards the project.

People-based knowledge transfer mechanisms dominate the product innovation knowledge transfer project. ***E3***

10.8 Conclusions

As expected from the literature review, the transfer of product innovation knowledge turned out to be a dynamic and complex system in practice. Many factors, often simultaneously and inter-related, influence the process. While earlier literature often described and analysed the factors in isolation, this case study illustrated how they take place simultaneously and how they interact. From the cross case analysis it can be concluded that the conceptual framework, the list of focal points and list of expectancies, all derived from the literature review help to describe to a large extent how the product innovation knowledge transfer takes place. Based upon the empirical data both lists have been improved to get more close to the product innovation knowledge transfer process in practice. To a certain extent the current product innovation knowledge transfer process leads to successful results. However, also several mismatches can be observed between what has been offered (by the knowledge source and/or knowledge facilitator) and what was needed (by the knowledge recipient). Before discussing directions for improvement, conclusions are being made on the list of focal points, the list of expectancies, the conceptual framework, and the derived guidelines. Based upon these outcomes next steps for our study are being proposed.

List of focal points

The list of thirty-six focal points turned out to be functional to describe and analyze the cases. In the first place the list provided a range of topics to describe as well as how distinguishes within each of them can be made. This way the results of the cases can be categorized in a proper way. By using the list of focal points, the case descriptions are detailed on the basis of the same descriptors. As a consequence they can be analyzed and compared in a sound way. In addition the list of focus points facilitates in explaining the underlying theoretical principles of how the product innovation knowledge transfer takes place by referring to the existing theoretical body of knowledge in literature. Most focal points facilitated in getting a clear insight in how the knowledge transfer process takes place in practice. Six focal points (14, 15, 22, 24, 35 and 36) however, did not lead to additional insights within this case study. The description of these six focal points as well the explanations of their limited value are:

FP13: The business environment expressed in GCI is closely related to the GDP (low GDP → low GCI → low business environment).

FP14: The social development expressed in HDI is closely linked to the GDP (low GDP → low HDI → low social development).

Both focal points are related to macro environment in which the knowledge transfer takes place. The research questions and as a result the case study research as well are focussed on how the knowledge transfer is taking place within the project as well as within the participating organisations (micro-meso environment). Even though these two focal points might provide general information of the context, it does not facilitate to get more insight within the knowledge transfer within the project and organisations.

FP 22: Based upon the cultural dimensions of Geert Hofstede an indication can be made of the way of teaching and learning at local universities.

Only in two of the four cases educational institutions were actively involved. If no educational institutions are actively involved it is difficult to identify what type of pedagogic approach is used for teaching, especially to those involved in the product innovation process.

FP 23: Individualistic societies prefer explicit and independent knowledge, collectivistic societies prefer tacit and systemic knowledge.

The preference of certain societies for a particular type of knowledge is not easy to detect. Like other cultural values they are more implicit hidden within the context and within the persons. More in-depth investigations are necessary to make this clear. The data of the case descriptions are not sufficient to make any statement about this topic.

FP 34: Different professional backgrounds in the field of design can be distinguished.
FP 35:Two type of designers can be distinguished: Novice designer & Expert designer.

Both focal points are related to the characteristics of the 'individuals'. These were hard to describe and analyse because of the large amount of persons involved in all case studies (over 400) as well as the limited data available. Also in this situation counts that the four cases did not have a focus on knowledge transfer to individuals but to organisations. More in-depth search and data collection would be needed.

New focal point

In addition to the earlier identified clusters of factors influencing the product innovation knowledge transfer, a new focal point could be derived from the cross case analysis. From the case studies it is concluded that the project setting, for example the funding organizations, demonstrated to have to a large extend influence on the selection of the knowledge recipients (Who), as well as on the content of the knowledge transfer (What). Consequently, a new focal point related to the project setting has been added. The new adjusted list of focal points can be found in Appendix 2.

FP 36 The project conditions play a crucial role in selecting the knowledge transfer components.

List of expectancies

The list of expectancies derived from literature review was evaluated on its veracity in practice in the cross case analysis. To a large extent the expectancies seem to be present within the four cases. They can provide an indication of the characteristics of the knowledge recipient, what type

of product innovation knowledge fits to him or her, and what type of knowledge transfer is the most appropriate.

The following list illustrates for each of the expectancies if they could be identified in practice (√), no data were available (-) or if proved to be not valid (X) within the four cases.

	List of expectations	**TZ**	**IN**	**CA**	**CR**
	Type of knowledge				
E1	Tacit knowledge is the dominant knowledge component.	√	√	√	√
	Knowledge transfer process (How)				
E2	Primarily, socialization and externalization types of knowledge transfer take place.	√	√	√	√
E3	More 'people-based' than 'information-based' knowledge transfer mechanisms are being be used.	√	√	√	√
E4	The principal teaching approach in product innovation knowledge transfer projects is constructivism.	√	√	√	√
E5	Problem-based learning is applied intensively.	√	√	√	√
E6	Objectivism teaching approaches are dominant at the local universities.	√	X	√	√
E15	Especially small- and micro-enterprises have a low absorptive capacity.	√	-	√	√
E18	The best way for SMEs to grow is gradually, building upon the resources and capabilities available in a company.	√	-	√	√
	Product innovation knowledge (What)				
E7	For successful product innovation both domain specific (basic and design) and domain independent (process) knowledge are needed.	√	√	√	√
E20	Product innovations strategies with a lower risk are more successful for SMEs.	√	√	√	√
E21	Incremental innovations fit better to the characteristics of SMEs.	√	-	√	√
E22	Large part of the companies uses a kind of benchmark approach.	√	√	√	√
E23	Capacity companies need more and specific support compared to product companies to come to successful product innovations.	√	√	√	√
E24	There will be a stronger emphasis on people (social) aspects.	√	√	X	X
	Knowledge recipient (Who)				
E8	Food-processing and simple products (i.e. furniture) dominate the local industrial activities.	√	X	√	X
E9	The industry can be characterized as low-skill, labour intensive and not capital & knowledge intensive.	√	√	√	√
E10	The R&D support from outside as well as inside the companies is (very) limited.	√	√	√	√
E11	Public R&D institutions are poorly connected to the needs of SMEs.	√	-	√	-
E12	There are limited local industrial design capabilities and support.	√	√	√	√
E13	Comparatively more enterprises operate in the informal sector.	√	√	X	X
E14	SMEs have limited resources.	√	-	√	√
E16	A large part of the companies has low technological capabilities.	√	-	√	√
E17	A large share of the SMEs is not aware of the need to change and are not aware of what and how to change.	√	-	√	√
E19	Cultural dimensions can hamper the innovation process within a company as well as within the project team.	√	√	√	√
E25	Different design professions have different preferences for design tools and approaches.	√	√	√	√

E26	Novice and expert designers prefer different types of knowledge transfer as well as apply different approaches to solve product innovation problems.	-	-	-	-
E27	A negative attitude of the knowledge receiver can hamper the knowledge transfer process.	√	√	√	√

Almost all the expectancies were encountered within the case descriptions. A few could not be confirmed, either because no data with regard to the expectancy were available in one or more cases, or they proved to be not valid. Several expectancies are related to the characteristics of SMEs (11, 14, 15, 17, 18, 21). Since no SMEs participated in the IN case no data were available on this expectancy. In all four cases it was difficult to retrieve exact data at the individual level of the knowledge recipients. As a consequence no statement can be made on expectancy 26, if novice and expert designers prefer different types of knowledge transfer. For three expectancies the case studies proved the opposite.

According to expectancy 6, objectivism-teaching approaches are dominant at the local universities. The IN case demonstrated the opposite. The main local partner, the Industrial Design program at the Indian Institute of Technology, was already used to teach students in a constructivism and problem-based learning environment. Design schools are often progressive in teaching approaches and early adaptors of new pedagogical strategies. Consequently, one has to be careful to 'stereotype' the teaching approach of country.

Expectancy 24, predicted a stronger emphasis on people (social) aspects in the product innovation projects. This could be confirmed in the TZ and IN cases, however not in the CA and CR case. One explanation can be that the latter ones do have a relatively higher national income and as such the social aspects are of lower priority. Likewise, expectancy 13 suggests that in low income countries more companies operate in the informal sector and as such are expected part of the knowledge recipients. This could be confirmed for the lower income countries (Tanzania and India), but not for the more middle-income countries (Costa Rica & Croatia).

The cross case analysis also led to new expectancies. They provided especially insight in how product innovation takes place within SMEs in developing countries. The following four expectancies have been added to the list:

	Additional expectations	**TZ**	**IN**	**CA**	**CR**
E28	Small- and the smaller medium-sized enterprises often lack middle management. This can hamper the product innovation process.	√	√	√	-
E29	There is no structured or formalized product development process in the smaller companies.	√	-	√	√
E30	Small companies prefer simple (easy to learn and easy to communicate) checklist like tools. More complex tools have to be facilitated by external facilitators.	√	√	√	√
E31	The product development process in SMEs is inward looking, focusing on their own knowledge, production and products (i.e. no or limited focus on consumer and market research).	√	-	√	√

In section 5.1.3 Figure 5.3 illustrated how the expectancies can be clustered around the main elements of the conceptual framework. Based upon validating the expectancies within the cross case study, the figure has been updated. Figure 10.3 indicated if the expectancies could be

identified in all cases (bold), in two or three cased (normal), or if a new one was identified (bold italic).

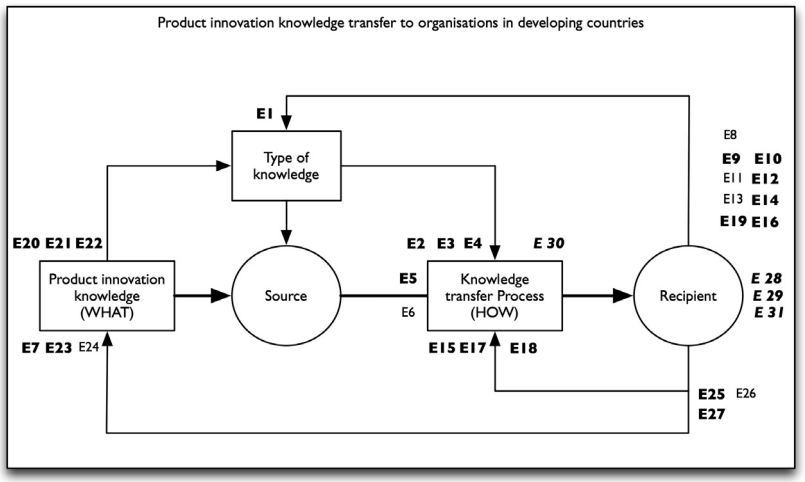


Figure 10.3: Validation of the list of expectancies (Diehl 2010).

Conceptual framework

The earlier presented conceptual framework in Chapter 5 turned out to be constructive in this situation for explaining the product innovation knowledge transfer process in practice, as well to disclose the relationships in between the knowledge recipient, the knowledge source, product innovation knowledge content, knowledge transfer process and type of knowledge. In general it became clear that three main questions should be taken into consideration in order to optimize the product innovation knowledge transfer. Who is (or should be) the knowledge recipient? What kind of knowledge content does he or she need? How can these knowledge components be transferred in an optimum way?

All 'connecting lines' within the conceptual framework except one proved to be functional in practice. Many examples appeared in the case descriptions on for example how the characteristics of the knowledge recipient have impact on the knowledge content (What) and the preferred knowledge transfer (How). The only relationship, which could not be demonstrated, was that between the knowledge recipient and his or her preference for type of knowledge). This part of the conceptual framework can only be underpinned by the outcomes of the literature review and not yet in practice (see also our earlier remarks on Focal Point 23). Alternatively, additional research on level of the individuals has to be carried out. The improved version of the conceptual framework will be discussed in Chapter 11.

Mismatch in knowledge transfer

In general there was a good match between the need and offer of knowledge. However looking in more detail, a range of mismatches can be observed in between what was offered and what was needed in practice. These mismatches can be clustered around identifying and recognizing the knowledge recipient (Who), the needed knowledge content (What) and way of knowledge transfer (How). Some examples of the mismatches are:

1. Target group (Who): Either not including or reaching the proposed target group. For example:

    a. SMEs (IN case);
    b. Facilitators as HUP and local consultants in the CR case;
    c. Not representative for the local industrial development (TZ case).
2. Knowledge content (WHAT): Knowledge recipients have different backgrounds and as such different knowledge needs. Either certain knowledge (components) were lacking or were not at a proper (innovation) level. For example:
    a. No domain specific design knowledge included (CA and CR case);
    b. No pedagogic approaches or training skills included (TZ case);
    c. Too radical innovation levels (TZ case).
3. Way of knowledge transfer (HOW):
    a. Not taking enough into consideration the absorptive capacity of the knowledge recipients;
    b. Directly introducing radical innovation approaches. Ignoring that gradually increasing the product innovation capacity fits better to SMEs;
    c. Not taking into consideration the local educational approach.

A detailed list of the observed mismatches can be found in Appendix 4.

Guidelines

From the case descriptions and the cross-case analysis success factors, or best practices' can be derived. Since all four cases did have similar type of knowledge transfer activities (i.e. TtF, demonstration projects) they could be compared and the most successful ones could be filtered out. These success factors related to the knowledge tansfer activities have been translated into guidelines, which can be used in future projects to improve the product innovation knowledge transfer. In addition to the guidelines highlighted earlier in this chapter several additional guidelines have been derived based upon the data of the case descriptions. This has led to a series of guidelines per typical knowledge transfer activity. For example the first guidelines for a Train the Facilitator (TtF) session are:

GT 1 Use within a TtF real 'problems' from the working context of the participants (for example local companies and products).

GT 2 Assess the participants prior to the TtF on their preceding product innovation experience and knowledge, and adjust the knowledge content and exercises of the TtF accordingly. Alternatively select participants that fulfil a certain specified product innovation knowledge profile.

GT 3 Provide the participants of the TtF not only with knowledge content but also with skills to transfer the gained knowledge to others.

GT 4 Use during the TtF as much as possible examples of local companies. Alternatively use examples from regions with a similar socio-economic development.

GT 5 The most (resource) efficient way to organize follow-up TtFs is to involve local (earlier trained) staff and to let the TtF take place locally.

A total list of guidelines for each knowledge transfer activity can be found in Appendix 5. Part of the guidelines will be incorporated in the needs assessment tool and design manual which will be developed in the second part of our study.

10.8.1 Answer to Research Question 1

In the first Chapter of this study Research Question 1 was raised:

How does product innovation knowledge transfer to knowledge recipients in developing countries take place, in terms of content (What) as well as didactic principles/transfer mechanisms (How)?

In order to answer this research question two types of research have been carried out: a literature review (theory) and a case study (empirical). Even though knowledge transfer can be described as a simple process of transferring knowledge from one individual or organization to another, in practice it has proven to be a complex system. A wide range of factors related to the knowledge recipient (Who), knowledge content (What), knowledge transfer mechanisms (How), knowledge source, and knowledge type influence the process of product innovation knowledge transfer. The literature review in combination with case study research has disclosed these factors and described them. Many of these factors are interrelated to each other. The original research question emphasized the What (content) and How (way of knowledge transfer). However, the knowledge recipient (Who) demonstrated in practice to be of highly influencing the process as well.

To get a good understanding of how the transfer of product innovation knowledge transfer takes place, a comprehensive overview of all factors in the system and their interrelationship is essential. To bring all these factors together, a conceptual framework has been constructed based upon the literature review (theory) and refined by the case study research (empirical). The conceptual framework has reduced the complexity and indicates how the different elements of the product innovation knowledge transfer process are interrelated (see Figure 11.1). It provides an overview for each of the knowledge transfer elements what are the alternative options that can be can be provided, as well as the characteristics of the knowledge recipient and their context to identify the need. The next challenge is to find a proper match between which knowledge elements (knowledge recipient, knowledge content and knowledge transfer mechanisms) are 'needed' and which ones can be 'offered'.

Next steps

The product innovation knowledge transfer has been described based upon the theoretical insights as well as the empirical data (case study). The first stage of our study, preliminary research, has provided sufficient insight and understanding of how the process of product innovation knowledge transfer takes place to continue with the second stage of this study: prototyping and assessment. The next challenge is to improve the product knowledge transfer process by developing a systematic approach and accompanying tools.

11 Interventions: Systematic Approach & Tools

After executing the case study research in addition to the literature review it became transparent how the transfer of product innovation knowledge takes place in practice. The picture has become more complete and less scattered: the factors that play an influential role as well as their interrelation have become clear. Based upon these progressive insights, the conceptual framework will be refined in section 11.1. Now that the knowledge transfer process has been mapped, the next step is to study how the knowledge transfer process can be improved (RQ 2). The second stage of this study, 'prototyping & assessment', will commence and its research methods will be discussed in section 11.2. As a first step, based upon the conceptual framework, a systematic approach for product innovation knowledge transfer and three propositions will be provided. This systematic approach will be made operational by a needs assessment tool (11.3) and a design manual (11.6). The earlier derived list of expectancies and list of guidelines will support this process. Both tools will be designed and developed as well tested and evaluated in practice. The chapter concludes with answers to the propositions and Research Question 2.

11.1 Conceptual framework version II

One of the goals of the 'preliminary research stage' of this study is to come to a comprehensive conceptual framework. In Chapter 5, a first version of the conceptual framework and the list of expectancies, derived from the literature review, were presented. The objective of developing the conceptual framework was primarily to map and describe how the transfer of product innovation knowledge takes place. The second goal of the framework is to function as starting point for the second part of study: how to improve the product innovation knowledge transfer to developing countries.

In addition to the literature review, this case study has led to a more complete picture of the knowledge transfer process. Consequently the conceptual framework can be refined on two aspects. In the original conceptual framework the identification and selection of the product innovation knowledge content (What) and the way to transfer the knowledge (How) were highlighted. The literature reviewed emphasised the relevance of especially these two aspects. In practice, it came to the forefront in the case studies that the selection and characteristics of the knowledge recipient (Who) are as equally or even more important. First of all, it is essential at the start of a knowledge transfer project to identify and select the proper knowledge recipients that fit to the 'requirements' and 'objectives' of the project. If not, the transfer of knowledge fails because of the wrong target group. As such part of the efforts would be wasted. Secondly, as illustrated in the case study, the specific characteristics of the knowledge recipient and (organisational) context in which he or she operates determines to a large extend the specific need for knowledge content as well as transfer mechanisms. Therefore in the refined version of the conceptual framework, the knowledge recipient (Who) has been highlighted.

This leads us directly to the second proposed refinement: the project conditions. In practice the project conditions in the case study (for example the objectives of the organisation that commissioned and/or financed the knowledge transfer project) in which the knowledge transfer

took place turned out to have a large impact on the identification and selection of the knowledge recipients and the knowledge content. In some cases the project conditions also did have a direct impact on the selection of the knowledge transfer activities. Consequently, our original framework has to include this project context surrounding all other elements of the framework. Besides, this project context will change with every new project. Not only does the 'project context' here refer to the regional socio-economic and cultural context, but also the involved network of local and international organisations and their influence on for example the financial conditions of the knowledge transfer project. Figure 11.1 illustrates the refined conceptual framework with the addition of the project context boxes and additional emphasis on the knowledge recipient (Who).

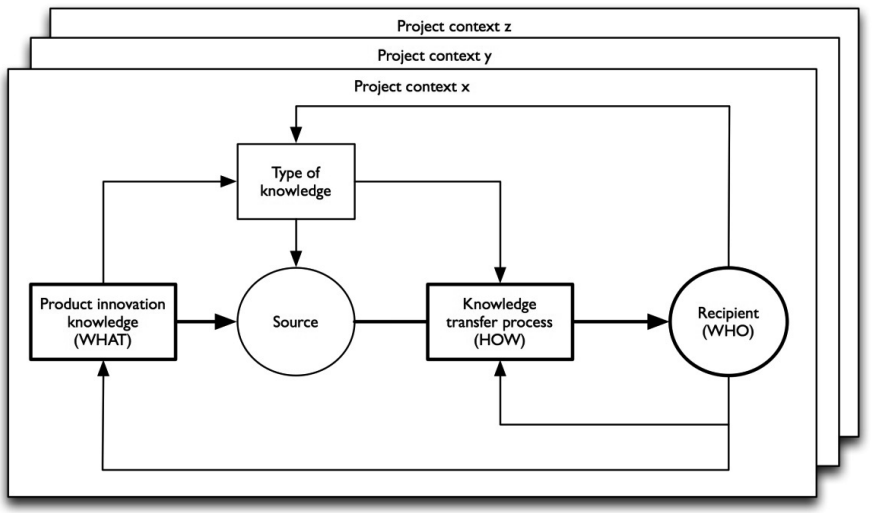


Figure 11.1: Refined conceptual framework (Diehl 2010).

11.2 Prototyping and assessment research approach

The main objective of this research, as stated in the first chapter, is to improve the transfer of product innovation knowledge to developing countries, in particular to companies at SME level and local knowledge institutions such as universities (RQ 2). The second stage of the study, prototyping and assessment, intends to answer this question.

This second stage of the study is a combination of two stages of the design-based research approach: the prototyping stage and the assessment stage, as already described in Chapter 5. Both stages are characterised by active involvement of theorists as well as practitioners and take preferably place in a real world setting (Van den Akker, Gravemeijer et al. 2006). The prototyping stage aims at designing and developing a sequence of prototypes of the proposed interventions (i.e. methods or tools) in an iterative process that will be tried out, refined and improved on the basis of formative evaluations (Van den Akker, Gravemeijer et al. 2006; Plomp 2009). The emphasis in the prototype stage is on the consistency and practicality of the proposed intervention (Plomp 2009). In this study the proposed intervention, a systematic approach and accompanying tools, will be designed and developed based upon earlier experiences reported in literature (theory) combined with the best practices of the case study research and experiences of the researcher and his colleagues at Delft University of Technology as well as from other international practitioners (practice). Outcomes of the first stage of the

study such as the conceptual framework, the list of expectancies and the guidelines will be used as inputs to design and develop the new interventions.

Next, the assessment stage will take place in order to evaluate whether the developed interventions are effective and if target users can work with the developed intervention (practicality), and are willing to apply it in their training sessions and consulting (relevance & sustainability). Potential users (practitioners) and representatives from knowledge institutions (theorists) will carry out the evaluation. The next paragraphs discuss the development of the systematic approach followed by the prototyping and assessment of the two accompanying tools.

11.2.1 How to improve the product innovation knowledge transfer?

As discussed in the previous chapter, the transfer of product innovation knowledge is a complex and dynamic process, many factors are involved and they are often interrelated. As a consequence, knowledge sources and facilitators within the product innovation knowledge transfer projects have to make many decisions with regard to the selection of knowledge recipients (Who), content (What) and transfer mechanisms (How) within a limited time span and within the boundaries of the knowledge transfer system. In addition to other factors, these decisions can lead to a mismatch between the needed and offered knowledge transfer components. For example, offering knowledge on product innovation on a too radical level (mismatch with the need for an incremental level of product innovation) or overloading the company with too much knowledge within a short period (not taking into consideration the limited absorptive capacity of SMEs). As concluded in the cross case study, these mismatches can be clustered around identifying and recognizing the knowledge recipient (Who), the needed knowledge content (What) and way of knowledge transfer (How). They decrease the efficiency and effectiveness of the product innovation knowledge transfer process.

Based on these insights acquired from the case study research, it is assumed that to a large extend these mismatches can be avoided by applying a systematic approach for indentifying and selecting the proper components (Who, What & How) of the product innovation knowledge transfer process. The systematic approach should have a strong emphasis on the characteristics of the knowledge recipients and the context in which they operate. The current conceptual framework is not sufficient within a short time frame to support all these decisions within. It is expected that a systematic approach can facilitate this decision and selection making process. Thus, the development of a systematic approach is proposed. It is assumed that such a systematic approach can contribute to an improvement of the product innovation knowledge transfer process. In this case, improvement refers to:

- Increasing the effectiveness of the knowledge transfer process: selecting the proper knowledge recipients and transfer the specific needed knowledge content
- Increasing the efficiency of the knowledge transfer process: reaching more recipients with less staff and financial resources.

11.2.2 Systematic approach

Literature suggests that systematic approaches are useful for solving complex problems (Njenga 2005). Such approaches are goal-oriented with the results of each phase being used by the next phase. Typically, each phase provides ongoing evaluation feedback to other phases in order to improve the overall system's process. A systematic approach should be objective, repeatable, transparent, systematic, comprehensive, and integrative (MacDonell, Shepperd et al. 2009).

This is typically characteristic of the systematic approaches developed for product innovation. They simplify the complex system of product innovation and facilitate designers, engineers and consultants in taking sequential and comprehensive decisions. In the context of this research, the goal is to develop a systematic approach to 'design and develop' a proper product innovation knowledge transfer process and its components. In the most generic form, the complexity of the product innovation knowledge transfer can be reduced to a linear model as presented in Figure 11.2.

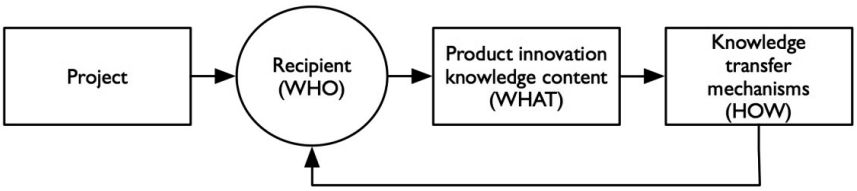


Figure 11.2: Generic linear model of the knowledge transfer process (Diehl 2010).

Based upon the project objectives, the knowledge recipient will be selected followed by the selection of the knowledge content and the knowledge transfer mechanisms. Next, the knowledge is transferred to the knowledge recipient.

However, in this way the many complex and dynamic interrelations between the boxes as indicated in the conceptual model (see Figure 11.1) are ignored and it does not represent the complexity found in practice. In addition, an over-simplified picture of the reality would provide insufficient options i.e. guiding possibilities for project developers, managers, etc. to design and manage product innovation knowledge transfer processes. Such as in product innovation models, the new systematic approach should refer, to a certain extent, to the interrelation between all the boxes as well as the iterations. From this point of view, the following systematic approach (see Figure 11.3) derived from the conceptual framework is proposed. It attempts to find a balance between reducing the complexity (simplification) and reflecting the interrelation that exists in reality.

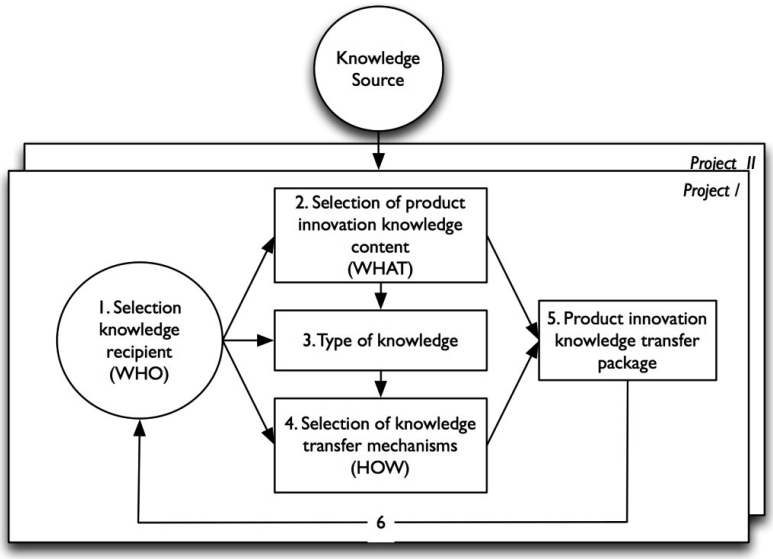


Figure 11.3: Systematic approach for product innovation knowledge transfer (Diehl 2010).

The systematic approach introduces a step-by-step sequence in order to come to a structured and proper selection of knowledge transfer components. It is built upon exactly the same elements as the conceptual framework (see Figure 11.1). In contrast to the conceptual framework, the systematic approach indicates a 'preferred' step-by-step sequence. The knowledge recipient has been positioned to the left as a starting point. These persons or organisations are the main target of the knowledge transfer process. Their characteristics and the context in which they operate influence all other elements. Stepwise the systematic approach proposes to:

1. Select the knowledge recipient (Who) based on the project objectives and the local socio-economic context.
2. Select the proper product innovation knowledge content (What) based on the project objectives in combination with the characteristics of the knowledge recipient.
3. Select the preferred type of knowledge based on the characteristics of knowledge recipient and the selected knowledge content.
4. Select the proper knowledge transfer mechanisms (How) based on the characteristics of the knowledge recipient and the outcomes of step 2 & 3.
5. Compose the product innovation knowledge transfer package (product innovation knowledge content and knowledge transfer mechanisms).
6. Transfer the product innovation knowledge transfer package to the knowledge recipient.

11.2.3 Putting the systematic approach into practice

In order to be able to use the systematic approach (derived from the conceptual framework) in practice, it has to be made operational. In the next chapter, the approach is translated into operational tools (see Figure 11.4). The specific focus of these tools is to support the transfer of product innovation knowledge to SMEs in developing economies.

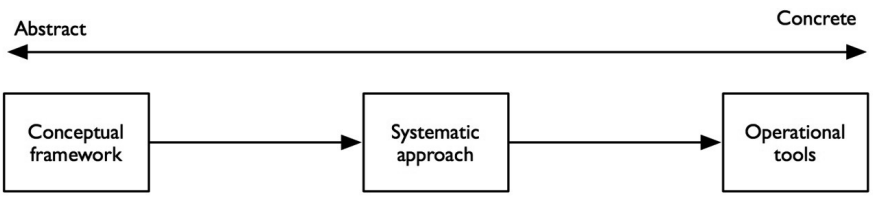


Figure 11.4: From conceptual framework to systematic approach to operational tools (Diehl 2010).

Based on the literature, cross case study and consultation with practitioners, it was decided to make the systematic approach operational by developing two types of tools: a needs assessment tool and a design manual. The needs assessment tool will be used to identify and select the knowledge recipient (Who) as well as the main requirements for the product innovation knowledge content (What). This tool represents step 1 and part of step 2 of the systematic approach. The design manual embodies in detail the specific needed product innovation knowledge content (What) for a certain target group as well as in which way it can be transferred (How) to the knowledge recipient. The manual represents steps 2, 3 and 4 of the systematic approach. The use of a combination of these two tools should result in a proper product innovation knowledge transfer package (step 5) ready for transfer to the knowledge recipient (step 6). The total process of translating the systematic approach into operational tools is visualised in Figure 11.5.

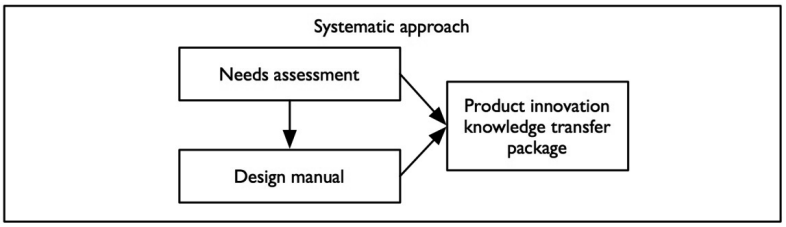


Figure 11.5: Translating the systematic approach into operational tools (Diehl 2010).

Needs assessments are generally used to answer questions such as 'who is the target group', 'what should be the content of the knowledge transfer', etc. They are deployed at the start of a knowledge transfer project in order to collect information about an expressed or implied need (Barbazette 2006). During the cross case study, it was concluded several times that an assessment of the project goals and the characteristics of the knowledge recipient could contribute to a more proper and tailor-made knowledge transfer package. From this perspective, the needs assessment approach was chosen. A needs assessment in this case helps the knowledge source and knowledge facilitator to identify the knowledge recipient and knowledge gap and as a result to specify the knowledge need. A normal needs assessment for knowledge transfer is a three-phase process: gather information (getting insight), analyze information (getting understanding), select proper knowledge recipient/content/transfer mechanism (selection) (Barbazette 2006).

For the second part of the systematic approach, it was concluded that a design manual would be a proper option. In earlier product innovation knowledge transfer projects of United Nations bodies such as UNIDO and UNEP as well the Faculty of Industrial Design Engineering of Delft University of Technology, product innovation or design manuals haven proven to be an adequate solution. Design manuals can offer simultaneously detailed knowledge content (What) and a way of knowledge transfer (How). In addition, it was observed within this study (see Chapter 10) that design manuals can function in a wide range of knowledge transfer activities. They can be used to train knowledge facilitators in train-the-facilitator sessions, in-company projects (with or without knowledge facilitators) to guide the product innovation process, in workshops to facilitate exercises, and can function in education as course materials. In other words, design manuals have demonstrated a broad usability within the process of product innovation knowledge transfer process. In addition, the development of a design manual also offers the opportunity to make the tacit knowledge of experts within the Delft University of Technology and other product innovation knowledge transfer teams explicit. As a result, it is expected that the product innovation knowledge transfer will be less dependent on specific persons (i.e. international experts), offers the opportunity to involve in a more efficient way a larger audience (i.e. through the internet) and becomes more cost-effective. From this viewpoint, it was decided to demonstrate how the second part of the systematic approach can be made operational by developing a design manual.

This second stage of the study, the prototyping and assessment stage, is described and discussed in the following sections (see Figure 11.6). At first instance the "Insight, Understanding and Selection (IUS)" need assessment tool is developed and evaluated in practice. Next, the Design for Sustainability for Developing Countries Design (D4S-DE) manual is developed and evaluated by practitioners and international knowledge institutions. The IUS needs assessment tool, if proven to be appropriate, will be incorporated in the D4S-DE Manual. For the development of both tools, the earlier findings of this study, the list of expectancies and list of guidelines, are

used to provide input into the design and development process. First, three propositions are proposed before the design, development and assessment of the two tools is discussed.

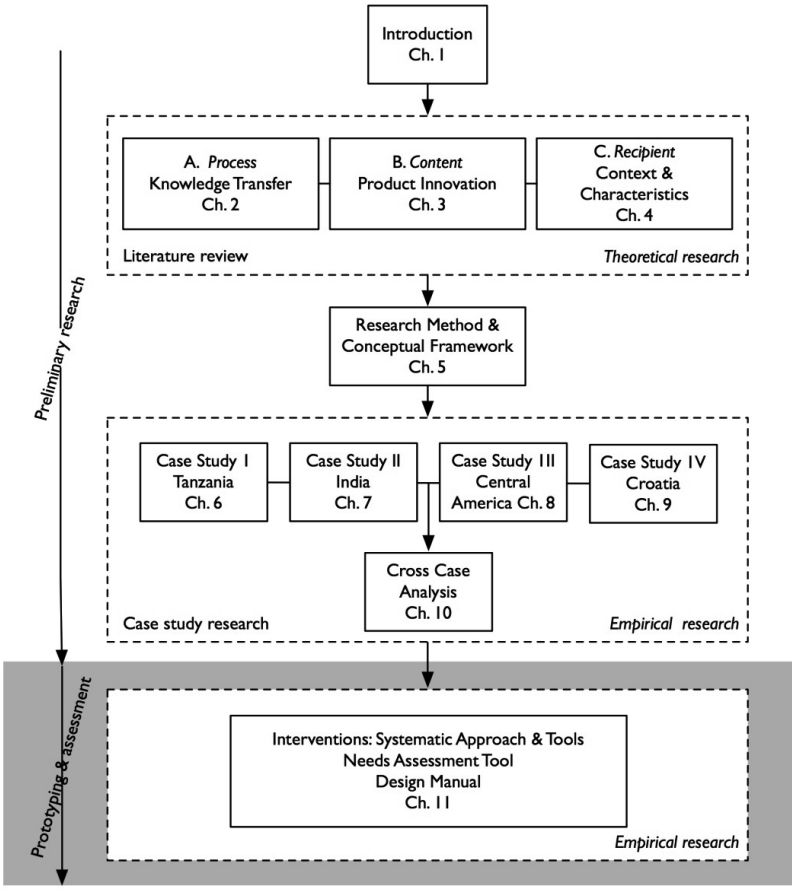


Figure 11.6: Outline of the second stage of the study, prototyping & assessment (Diehl 2010).

11.2.4 Propositions

In order to determine if the proposed systematic approach and the derived needs assessment tool and design manual are appropriate and efficient, three propositions were formulated. In this context, appropriate refers to whether the systematic approach leads to the proper selection of proper knowledge recipients, knowledge content, and transfer mechanisms, as well as whether the systematic approach can be used by the intended end-user. In order to make the propositions operational, a series of evaluation criteria to reflect upon for each proposition was created.

<u>*Proposition 1*</u>

The proposed 6-step systematic approach (see Figure 11.3) creates opportunities for an *appropriate* and relatively *efficient* knowledge transfer process with respect to product innovation between developed and less-developed economies.

Appropriate:

- Covers the main elements, essential for an effective transfer process
- Does not exclude important components, relevant for a good knowledge transfer
- Avoids the problems ("mismatches"), demonstrated in earlier case studies
- Offers a stepwise approach that is perceived as logic, practical and attractive by the users
- Facilitates and simplifies the knowledge transfer process vis-à-vis a less systematic approach.

Efficient:

- Allows for efficient communication and learning processes via the step-model's transparency
- Avoids unnecessary knowledge transfer problems in later project phases, due to the focus on needs and potentialities in the pre- and early phases of a project or program.

Proposition 2

A needs assessment is an appropriate and efficient tool to be applied for steps (1) the selection knowledge recipient; and (2) the selection of product innovation knowledge content.

Appropriate:

- Is designed in such a way that the average project manager, innovation consultant, engineer and designer involved in international knowledge transfer processes can apply the needs assessment tool as a (semi-)self-explanatory instrument
- Allows for a proper analysis of a project context, knowledge needs and source potentialities, even for mixed local and long-distance international teams of consultants, facilitators etc.
- Can be flexibly or modularly applied, depending on the project setting and the user demands.

Efficient:

- Allows for a quick but reliable assessment of the context, needs of the recipients, potentialities of the knowledge source and first selection of the knowledge content, relatively reducing time and resources spent
- Is easy to understand for all parties involved in the product innovation transfer process.

Proposition 3

A practical, product innovation oriented design manual is an appropriate and efficient tool to enable the operation of the steps (2) knowledge content, (3) type of knowledge; (4) selection of knowledge transfer mechanisms; and (5) formulating the transfer product package.

Effective:

- The design manual should give enough background, tools, guidelines and examples to stimulate product innovation approaches in environments where this is a novel philosophy and approach
- The content and language of the manual should not only be understandable and applicable for design specialists, but also be presented and formulated in such a way that other staff involved in the international transfer of product innovation knowledge can easily learn and carry out its content and application in practice
- The content of the manual represents state of the art knowledge on product innovation.

Efficient:

- The manual should be easy to disseminate and self-explanatory in order to reach a large target audience with limited investments
- It should allow quick training and learning without the facilitation of international experts.

Within the philosophy of design-based research, the proposed interventions (systematic approach and the accompanying needs assessment tool and design manual) will be tested and evaluated by practitioners (i.e. potential knowledge sources and facilitators such as teachers and consultants) as well as theorists (i.e. representatives of higher education and research institutions) and neutral non-profit organisation (i.e. the United Nations). The reflection on the propositions will be largely based on the opinion of these practitioners, theorists and representatives of non-profit and non-governmental organisations (NGOs).

Proposition 2 will be reflected upon in section 11.5 after the testing and evaluation of the developed needs assessment. Proposition 3 related to the design manual will be reflected upon in section 11.8. After designing, developing, testing and evaluation of both tools, together they cover all steps of the systematic approach, a reflection will be made on Proposition 1 in section 11.10.

11.3 Design and development of needs assessment tool: IUS Tool

As a first step to make the systematic approach operational, a needs-assessment tool will be designed, developed and tested in practice.

11.3.1 Background of the needs assessment tool

The challenge is to identify the specific need for product innovation knowledge transfer and accordingly the matching target group, the product innovation knowledge content and the proper transfer mechanisms. The characteristics of the knowledge recipient and the context in which he or she operates can play an important role in this. A six-step systematic approach has been proposed. The needs assessment tool will support the project team (knowledge source and/or knowledge facilitator) with the first two steps of the systematic approach: identifying and selecting the proper knowledge recipients (Who) and the accompanying product innovation knowledge content (What) (see Figure 11.3).

Since product innovation knowledge transfer projects do take place in different types of contexts, it can be expected that such a needs assessment tool will be used by different types of users as well as in different settings. For example, the selection process can be taken care of by either the knowledge source or knowledge facilitator independently or collaboratively in a team consisting of both of them (for example a western professor in collaboration with local consultants). In other knowledge transfer projects, the specific target group might be already known at the start of the project. In such a situation, the first step of the systematic approach, selection of target group, is not needed and can be omitted.

Based upon this background information and the evaluation criteria of the propositions as formulated in section 11.2.4, an initial set of guiding requirements was defined as input for the design and development process of the needs assessment tool. This led to the following design brief:

Develop a modular tool, which facilitates the selection of the proper knowledge recipient (Who) and the matching product innovation knowledge content (What) in an efficient and effective way. The intended users are local knowledge facilitators (i.e. consultants and universities in developing

countries) with or without collaboration with the knowledge sources (i.e. consultants and universities in developed countries).

11.3.2 Design and development of the IUS tool

In Chapter 1 (Problem context) it was stated that if the knowledge source, be it a university, a consultant or a development organisation, knows the characteristics of the knowledge recipient and the context in which the knowledge has to function, it will have better opportunities to support the necessary knowledge transfer (Jensen, Johnson et al. 2004). Similarly, in the case study research it was observed that with the support of the increased insight in and understanding of the knowledge recipient and the context gained during the projects, the knowledge transfer could be better adjusted to their specific needs. For example, in the Tanzania case the second train-the-facilitator session, the second workshop as well as the second range of demonstration projects were adjusted in terms of content to the local needs as a result of the previously gained insights in and understanding of the local knowledge recipients and context. This led to a more appropriate and efficient knowledge transfer. Based upon these and other outcomes of the literature review and the empirical study, it can be concluded that in order to make proper decisions on the selection of the knowledge recipient, one should first get a clear insight in and understanding of the context. Next, in order to select the knowledge content and transfer mechanisms, a clear picture should be provided of the characteristics of the knowledge recipient and the (organisational) context in which he or she operates.

This is similar to the process of need assessments. In this case it was suggested to provide the user insight in and understanding of the situation, followed by support to select the proper elements. In addition it was suggested to go through such a needs assessment process twice.

1. Identifying and selecting the proper knowledge recipient (Who) →Step 1 of the systematic approach
2. Identifying and selecting the proper product innovation knowledge content (What) for the selected target group → Step 2 of the systematic approach.

For this purpose the Insight, Understanding and Selection (IUS) Tool was developed. As concluded in Chapter 4 (Knowledge recipients in developing countries), the characteristics of the knowledge recipient and the context in which he or she operates can be best described and analysed on the basis of three groups of factors: national, organisational and individual level. Subsequently the IUS tool was developed based upon these three levels.

The goal and outline of the IUS tool is to provide the user first insight in and understanding of the project context at a national level (for selecting the knowledge recipient), and next at an organisational and individual level (for selection of knowledge content). The lists of focal points and expectancies from Chapter 4 have been used to support the first activity in each stage of the IUS tool: To get Insight in and Understanding of the knowledge recipient. Next, questions are asked to the user to facilitate the Selection (see Figure 11.7).

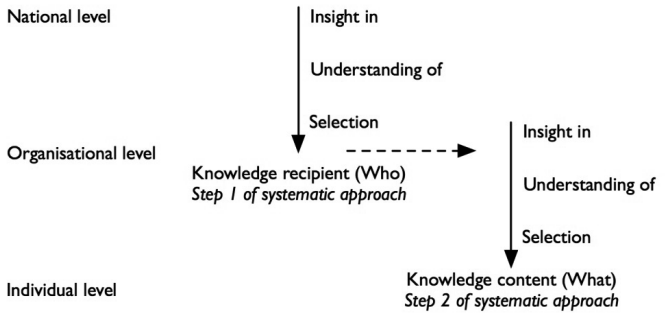


Figure 11.7: Structure of the Insight Understanding and Selection (IUS) tool (Diehl 2010).

At a national level, to a large extent, the information needed to gain insight into and understanding of the situation is quantitative (i.e. the national income per capita (GDP), such as the contribution of sectors to the GDP and expenditure on R&D and rankings (such as GCI and HDI). To facilitate the ease of use of this quantitative data, it was decided to develop the IUS needs-assessment tool as a computer-based tool in MS Excel. Excel was preferred since no specialised 'software programming' knowledge will be needed; it can provide visualizations (graphs) easily based on quantitative data as well as it is a commonly used software at different parts of the world.

A preliminary prototype of the IUS tool was developed by a team consisting of the researcher and two IDE research students taking in consideration the three levels (national, organisational and individual) as well as the three sequential stages (getting insight in, understanding of and selection) (Bos, Verburg et al. 2005). This first prototype of the IUS tool can be found in appendix 5. Two experts (Dr. H.H.C.M. Christiaans and Dr. M.R.M. Crul) who were the project coordinators of the Tanzania, Central America and Croatia cases tested the preliminary prototype of the IUS tool.

This test in an early stage of the tool development provided new valuable insights and resulted in improvements to be included in the final IUS tool. Some of the conclusions made were that the first version of the IUS tool was much like a questionnaire and not a facilitating and supportive tool; some topics questioned were not (that) relevant and some others were missing. The upcoming paragraphs will discuss in detail the outline of the improved IUS tool as well as the evaluation in practice. IUS tool
Based upon the suggestions for improvement by the experts an improved IUS tool was developed. The development process resulted in a MS Excel step-by-step IUS tool of 14-steps clustered in 4 groups. Each group is concluded with a decision moment (selection) (see Table 11.1).

Table 11.1: The 14-step approach of the IUS tool.

Step	**National Level**
1	National economical development
	Global competitivity
	Importance of SMEs and informal sector
2	Industrial sectors
	Division of GDP and labour across agriculture/industry/service
3	The impact and characteristics of import & export
4	Industrial development
5	Selection sectors (Who)

	Sector and company level
6	Product innovation strategy
7	Product innovation capacity
8	D4S drivers and environmental impact
9	Selection companies (Who) and product innovation levels (What)
	Individual and team level
10	Cultural differences and team work & education
11	Characterization of the team and preferred method & tools
12	Selection of product innovation methods, tools and content (What)
	Local support level
13	Product innovation support and R&D
14	Environmental support

The user of the IUS tool first will explore the national economical and industrial development, which leads to the selection of the most relevant sectors for their (demonstration) projects (Who). Next the characteristics of the sectors and the companies within it are explored and discussed. This leads to the selection of the proper candidate companies (Who) for the demonstration projects as well as product innovation levels (What). Subsequently the potential individuals and teams within the companies are evaluated on their characteristics in order to identify the fitting product innovation methods and tools (What). In addition, the potential support within the company as well as external (like universities, consultants and specialised institutes) is investigated. Based upon these 14 steps the user of the IUS tool is expected to be able to select the proper knowledge recipients (Who) as well as to get sufficient insight in and understanding of their knowledge need (What).

The IUS tool exists of 19 'tabs' in a MS Excel document, starting with an 'introduction' tab, followed by an 'instructions' tab, 'steps overview' tab, 'data' tab, and the 14 IUS steps. In each of the 14 steps of the IUS tool, the user is facilitated in his or her decisions in four different ways:

I. Statistical data with regard to the economical, industrial and social development (Insight);
II. Short theoretical explanations to introduce the user to the topic (Understanding);
III. Facilitating questions (Selection);
IV. Additional background information (more Understanding).

This setup will be explained in more detail in the following paragraphs.

Statistical data (Insight)

As a first step to get insight statistical data and national indicators are being used. From the literature review (Chapter 4) it became clear that economical, industrial and social characteristics of a country (national level) can be described to a large extent by indicators and statistics. Many national characteristics like the economical activities, innovation levels of SMEs and the absorptive capacity can be derived from indicators like the Gross Domestic Product (GDP) and Human Development Index (HDI) (see section 4.2). Nowadays these and other indicators can be easily retrieved from public on-line databases.

First an overview was made of the most essential indicators (based upon the literature review) and databases that could offer these data up-to-date as well as cover the world (including developing countries). An additional requirement was that the database should be online and freely accessible in order to make it accessible for any kind of user without any investments. As a result the for this purpose most reliable, up-to-date and comprehensive public databases were identified: World Bank, United Nation Development Program (UNDP) and the Central

Intelligence Agency (CIA). An example of such a database is the WorldBank 'Data & Statistics' online database (see Figure 11.8).

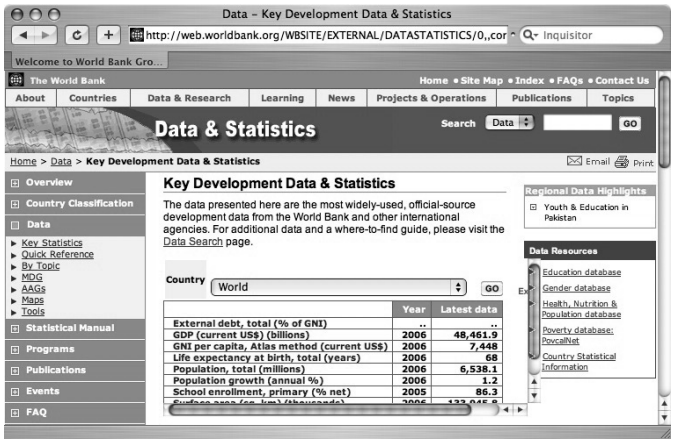


Figure 11.8: The World Bank online country data & statistics web-site.

One of the first steps in using the tool is to collect the relevant statistical data for the target country. Within the pilot version it was recommended to collect about 40 indicators from the three selected online databases. These data are gathered and entered in the 'tab' Data. From this 'tab' the data are linked to the relevant 'tabs' of the steps 1 to 14. For example data related to value added by the agriculture, industry and service sector is linked to step 2 in which the main sectors are being evaluated and selected (See Figure 11.9).

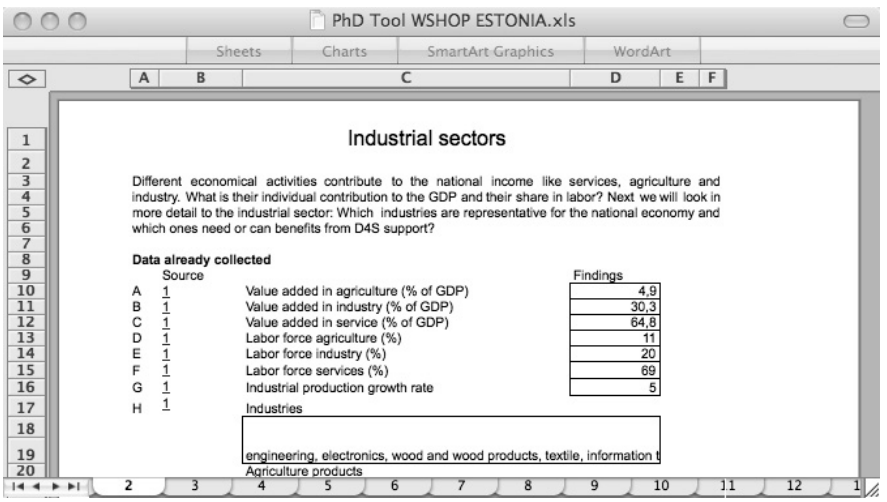


Figure 11.9: Screenshot of step 2 'Industrial sectors'. The relevant data from the databases are linked automatically to this 'tab'.

Short theoretical explanations (Understanding)

Next to the statistical data short theoretical explanations are provided to the tool user to get an understanding of the meaning of these numbers. They explain what the data and indicators mean as well as what kind of impact they can have on the selection of knowledge recipients and

knowledge content. The expected impact is derived form the list of expectancies as developed in Chapter 5. Figure 11.10 for example displays an example of a short theoretical explanation of the relation between GDP and impact of SME. Other explanations are more qualitative and describe for example the differences between 'capacity' and 'product' companies. These explanations were retrieved from the literature review (Chapter 4) as well as from the outcomes of the case studies. Together they provide an understanding of the characteristics of the knowledge recipients and the context in which they operate.

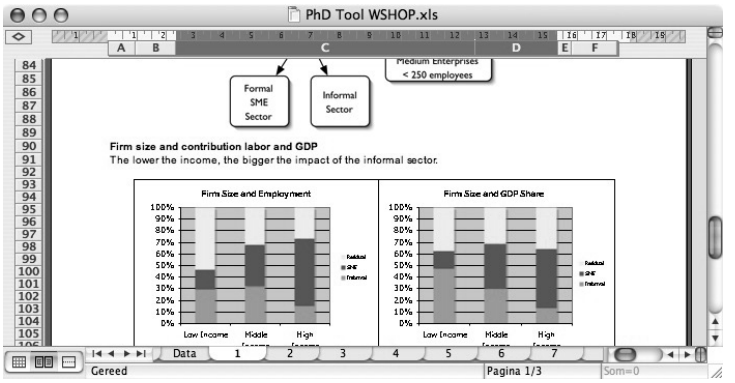


Figure 11.10: Short theoretical explanations within the tabs of the IUS tool.

Facilitating questions (Selection)

After collecting the relevant data and information (Insight), and reading the theoretical explanations (Understanding), the user is confronted with a series of facilitating questions (Selection). These questions provoke the independent user or team (of knowledge sources and/or knowledge facilitators) to think loudly what type of target group fits within the project context, and consequently what the characteristics of the knowledge recipients and the context in which they operate are and what kind of knowledge needs they have. These questions connect the earlier gathered insights and understandings and facilitate the decisions. An example of facilitating questions related to the selection of sectors is provided in Figure 11.11. The total IUS tool can be found in Appendix 7.

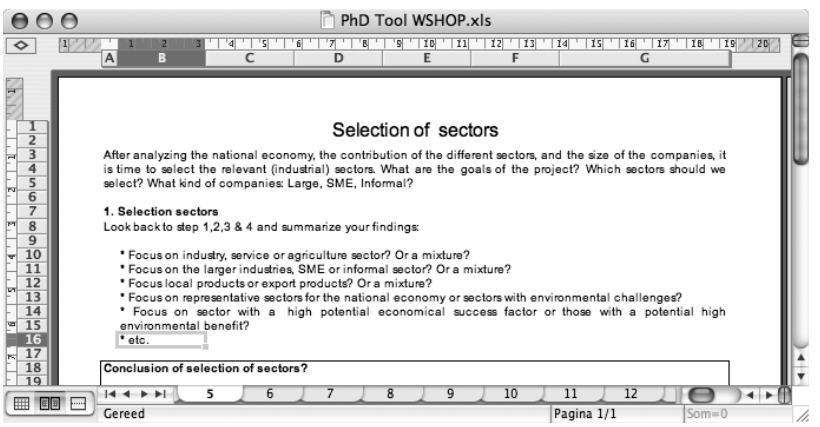


Figure 11.11: An example of facilitating questions to support the selection of sectors.

11.4 Assessment of the IUS tool

The next stage of our study, after designing and developing, is the assessment of the developed IUS tool to evaluate whether the intervention meets the pre-determined specifications. The goal of this evaluation in practice is to assess whether target users can work with the intervention (practicality), are willing to apply it in their daily professional knowledge transfer activities (relevance and sustainability) and if the developed intervention is efficient and effective (see section 11.3.1). In addition the goal is to demonstrate that the IUS approach indeed supports knowledge facilitators and knowledge sources within a product innovation knowledge transfer project in gaining more insight in and understanding of the characteristics of the knowledge recipient as well as that it supports them in identifying and selecting appropriate knowledge recipients and content. It is expected that the evaluation will lead to suggestions for improvement of the IUS tool.

In order to simulate the use of the IUS tool in practice, a evaluation was planned. From a design-based research perspective the preferred evaluation environment would be one in an actual situation (a real ongoing product innovation knowledge transfer project) and with representative participants (practitioners with the profile of future users). The EU Leonardo Da Vinci Ecodesign project was just initiated and provided a good opportunity for testing the IUS tool as an illustration of how it can function in practice.

Background of the Leonardo Da Vinci Ecodesign project

At the time of the Leonardo Da Vinci Ecodesign project (2005), SMEs in the Baltic States and the Czech Republic were facing the necessity to comply with new, usually stricter standards including larger involvement of environmental aspects into their product portfolio. In addition, because of their recent EU membership, they were encouraged to improve their competitiveness and to increase the product innovation skills and competencies of their personnel (CCPC 2004). An earlier published feasibility study (Belmane, Uselyte et al. 2003) in three of the four countries concluded that "There is a basic need to introduce Ecodesign and product innovation in the Baltic States industry, however there is no information, education or training available" (page 13).

To fill in this knowledge gap, the Leonardo Da Vinci Ecodesign project was initiated aiming at transferring knowledge in the field of Ecodesign and product innovation from The Netherlands and Portugal (knowledge sources) towards the Czech Republic, Lithuania, Latvia and Estonia (knowledge facilitators and recipients) (see Figure 11.12).

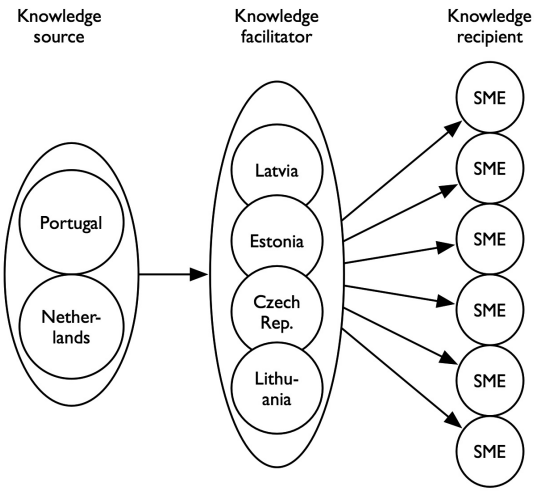


Figure 11.12: The two-step knowledge transfer approach of the Leonardo Da Vinci Ecodesign project.

The major proposed knowledge transfer activities within the project were:

1. Train the Facilitators session in Ecodesign and product innovation methodology and tools;
2. Development of training materials both general and sector specific;
3. Training of company employees;
4. In company demonstration;
5. Dissemination of developed, tested and improved materials to companies.

This EU project provided an ideal testing ground for the IUS tool. The setup of the project was similar to the analysed case studies in the empirical study. First local knowledge facilitators are being trained by the knowledge source. Next these knowledge facilitators in collaboration with the knowledge sources develop local Ecodesign training materials and facilitate in-company demonstration projects. At the time of the test of the IUS tool the companies (knowledge recipients) as well as the training materials for the companies (knowledge content) were not yet selected. Because of the identical goals, it was proposed to the Leonardo Da Vinci Ecodesign project management to use the IUS tool to facilitate this decision making process.

11.4.1 Evaluation method

Considering the time and budget constraints of this research, one test and evaluation workshop was planned. This can be seen as a limitation to generalize the findings in a later stage to other project contexts. However, because of its specific setting in a real on-going international product innovation knowledge transfer and with professional practitioners (from six different nationalities) as participants, it is expected that the test will simulate and illustrate in a representative way how the IUS tool will work in practice.

As part of the Leonardo Da Vinci Ecodesign project, a Train-the-Facilitator seminar was planned in The Netherlands from January 18th till 21st 2005. The workshop in which the IUS IUS tool was evaluated took place at Wednesday January 19th at Delft University of Technology.

Participants

In total fourteen participants joined the IUS test workshop of which 9 local consultants from the Baltic States (knowledge facilitators) and 5 international consultants from the Netherlands and Portugal (knowledge sources). All participants were young professionals (25-30 years old) with limited experience in the field of international knowledge transfer. At the beginning of the workshop, four country teams were created existing of the participants representing the knowledge receiving countries (knowledge facilitators) in combination with a know-how expert from The Netherlands or Portugal (knowledge source) (see Table 11.2).

Table 11.2: Composition of the IUS tool test teams.

Team 1	3 Czech consultants & 1 Dutch consultant
Team 2	2 Latvian consultants & 1 Dutch consultant
Team 3	3 Lithuanian consultants & 1 Portuguese consultant
Team 4	1 Estonian consultant & 2 Portuguese consultants

Prior knowledge

Some of the workshop participants had been involved in the project in different ways prior to the workshop. Three of the local consultants had been executing an in-depth feasibility study "Ecodesign in the Baltic States' Industry" (Belmane, Uselyte et al. 2003). Secondly some of the local consultants had already carried out a preliminary 'situation analysis' of the current practice in applying Ecodesign at company level in their own country. The outcomes had been discussed during a first project meeting in Riga and an initial selection of sectors was made. All the local consultants had attended this meeting. Because of this as well the fact that they live in the target countries, it is expected that at the start of the workshop they already have more insight in and understanding of the local sectors and companies.

Procedure

The IUS tool test workshop took place in a lab at the Faculty of Industrial Design Engineering at the Delft University of Technology. The relevant country specific data (statistics and indicators) were collected in advance of the workshop by the researchers. This way the time and attention could be focused on using, testing and evaluating the IUS tool.

Figure 11.13: The four country teams working with the IUS tool.

The researcher himself facilitated the workshop. At the beginning of the workshop the four teams were provided with a hard copy of the IUS tool and a digital version on a laptop (see Figure 11.13 and 11.14). The workshop existed of four sessions of one-hour each (see Table 11.3), in which the teams applied each time a part of the IUS tool. After each session the results were shortly presented in order to share the insights gained with the other country teams.

Table 11.3: Outline of the IUS tool test workshop.

Session I	Level 1 (step 1-5): National level (selection of sectors)
Session II	Level 2 (step 6-9): Sector and company level (selection of companies and product innovation levels)
Session III	Level 3 (step 10-12): Individual and team level (selection of methods and tools)
Session IV	Level 4 (step 13-14): Local support

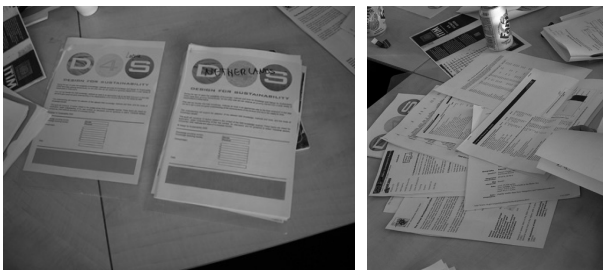


Figure 11.14: The hardcopy version of the IUS tool before and during the workshop.

Instruments

To capture the learning process and experiences of the participants, three types of instruments were used:

1. Quantitative: *Prior and end measurement* indicating the participants insight in and understanding of a topic at the beginning and at the end of the workshop;
2. Qualitative: *Learning experiences* written down with regard to what the participants have learned and to what extend they expect that they can apply this within their own projects.
3. Observations: Made by the researcher during the workshop.

Prior and end measurement

In order to get a quantitative picture of the increase of insight in and understanding of the knowledge recipient and his or her context, each participant was asked to indicate on a line for eight topics to what extent they did (not) have already a clear picture. These eight topics are related to the characteristics of the knowledge recipient (Sector, Companies and People), four of them are related to the knowledge content (Approach, Need, Content and Tools), and one related to the overall project objectives (Project).

Project:	Do you already have a clear picture of what the objectives of the project are?
Sector:	Do you already have a clear picture of the for the project relevant sectors?
Companies:	Do you already have a clear idea of what kind of companies will fit within the project?
Strategy:	Do you already have a clear view of what type of product innovation levels will be appropriate for the participating companies?
Individual:	Do you already have a clear view of what kind of people will receive the training?
Need:	Do you already have a clear view of the knowledge needs of the knowledge recipients of the training?
Content:	Do you already have a clear idea on the content of training materials?
Tools:	Do you already have a clear idea what kind of product innovation methods and tools should be used in the training materials?

The participants were confronted with an A4 with these eight questions and associated lines. Prior to the workshop the participants were asked individually to indicate with a cross 'X' their current insight in and understanding of each of these eight topics. Similarly they indicated at the end of the workshop with a circle 'O' their opinion (see Figure 11.15).

Do you already have a clear picture of what the aims are of the project?

Not Clear ←----------**X**----------**O**----------→ Clear

X indicating at the start of the workshop
O indicating at the end of the day

Figure 11.15: Example of one of the eight questions and associated lines.

The results of this questionnaire have been translated into numbers on a scale of 1 to 100. A 'zero' would refer to the extreme left side of the line (not clear), and a 'hundred' would represent a marking on the total right side (clear). This way the increase in insight and understanding of the participants by using the IUS tool during the workshop could be measured. These resulting numbers have been processed and analysed in SPSS in order to calculate the means and standard deviations and to identify if any of the results are significant.

Learning experiences

In addition to the measurement at the beginning and at the end, the participants were asked to write a short retrospective report, a so called 'learner report', at the end of the workshop. This qualitative method implies that the participant writes his or her learning experiences over the preceding period (Groot 1974; Christiaans 1992; Eyk 1992). This measurement tool can be used to get a more qualitative insight in the knowledge gained. An important condition for eliciting valid reports is that the report is made directly after finishing the problem solving task (Christiaans 1992). It is recommendable to provide short starting sentences like "I have learned that….." or "I have realized that…" (Eyk 1992). As a result one can expect as an output of the learner report:

- Evaluating remarks;
- Objective descriptions of the learning result;
- Remarks regarding follow up activities.

To stimulate this 'learning experiences' process the participants were asked to write down their learning experiences on two levels:

- Learning: "I have learned…."
- How they will transfer the new learning into practice; "I will use the new ideas for……"

The participants were requested to reflect on their learning experiences related to each of the 4 workshop sessions: I) the national context, II) the sectors and companies, III) team and individuals and IV) local support. In addition the participants were asked to write their comments and suggestions for improvement of the IUS tool.

11.4.2 Results prior and end measurements

Three specific situations have been analysed, the perception of the participants at the beginning, at the end, and the increase of insight in and understanding of the knowledge recipient and context by using the IUS tool. The results will be discussed in the next paragraphs. The main discriminating variable is if the participant is a local consultant (knowledge facilitator) and living in

one of target countries or an international consultant (knowledge source) from outside the target country.

Insight and understanding at start

The measurements at the beginning of the workshop provide an indication of how much insight and understanding the participants had at that moment (according to themselves) into the eight topics. Underneath see Figure 12.8 illustrates the averages of the international consultants and the local consultants. A high score refers to a clear insight in and understanding of the topic.

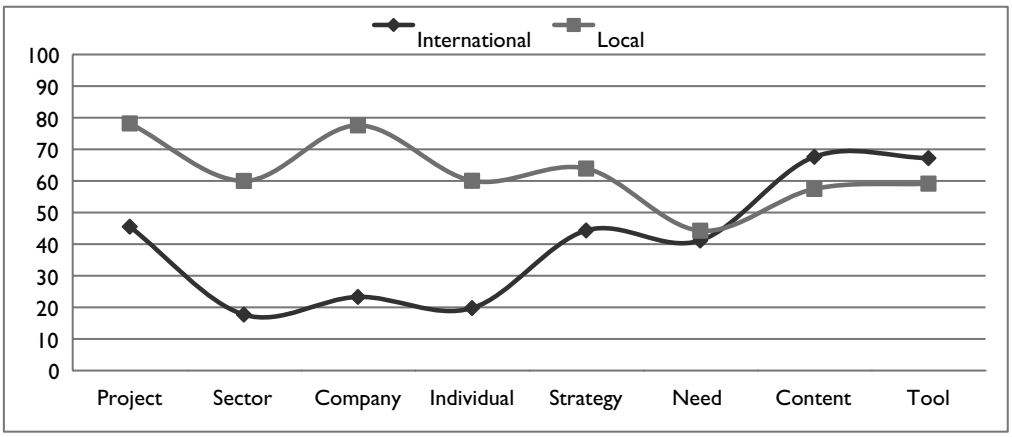


Figure 11.16: Outcomes of the measurements at the start of the workshop.

From the results in see Figure 11.16, it can be concluded that the local consultants do have a better insight in and understanding of the goals of the project, the potential sectors and companies, what kind of people will participate and appropriate product innovation strategies. The better understanding of the goals of the project can be clarified by the fact that they are the problem owners and in addition have been attending more previous project meetings (see section 11.4.1). The better understanding of the sectors, companies and people can be clarified by the fact that they live in these countries and have more knowledge and experience with the local context as well as conducted in an earlier stage feasibility studies (see section 11.4.1). This in contrast to the (relatively young) international consultants, who do not posses that much knowledge of this (for them) new context, and do not have yet a good insight in and understanding of the knowledge recipients yet.

The international consultants on the other hand do have a slightly better understanding of the needed content and tools for the to be developed training materials. Since they are the experts in Ecodesign they are expected to be more certain about the content and tools of the knowledge transfer package.

The differences between the local and foreign consultants are significant for the topics project, sector, company and individuals. These are exactly the topics related to the characteristics of the knowledge recipients and the context in which he or she operates.

Insight and understanding increase

In a next stage the outcomes of the measurements at the beginning and at the end of the workshop were processed and compared in a similar way. Figure 11.17 and 11.18 illustrate the start and end measurements of the international and national consultants.

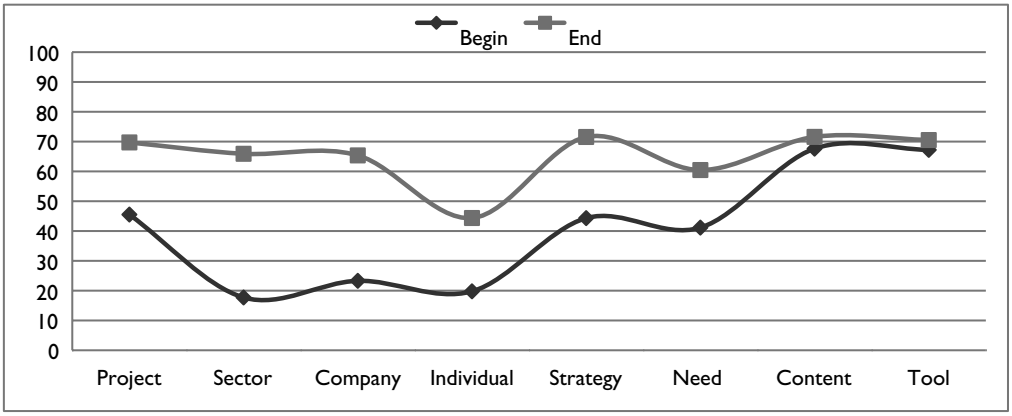


Figure 11.17: Outcomes of the measurements of the international consultants at the beginning and at the end of the workshop.

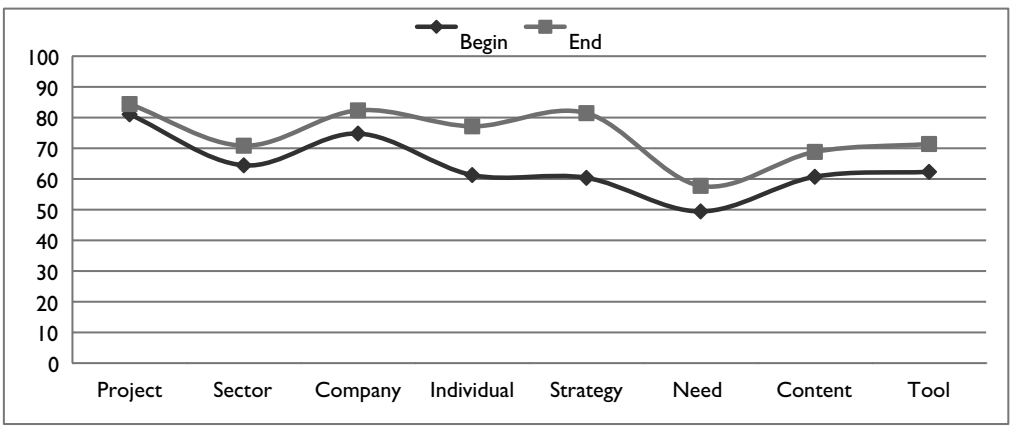


Figure 11.18: Outcomes of the measurements of the local consultants at the beginning and at the end of the workshop.

In both cases it is obvious that the insight and understanding of the participants has been increased. However there are clear differences in how much their insight and understanding increased in general as well as per topic. To make the comparison of learning of the local and international consultants more clear, the difference between the score at the start of the workshop and at the end of the workshop after using the IUS tool were calculated. The results are illustrated Figure 11.19. A higher score indicates a larger increase in insight and understanding by the participant.

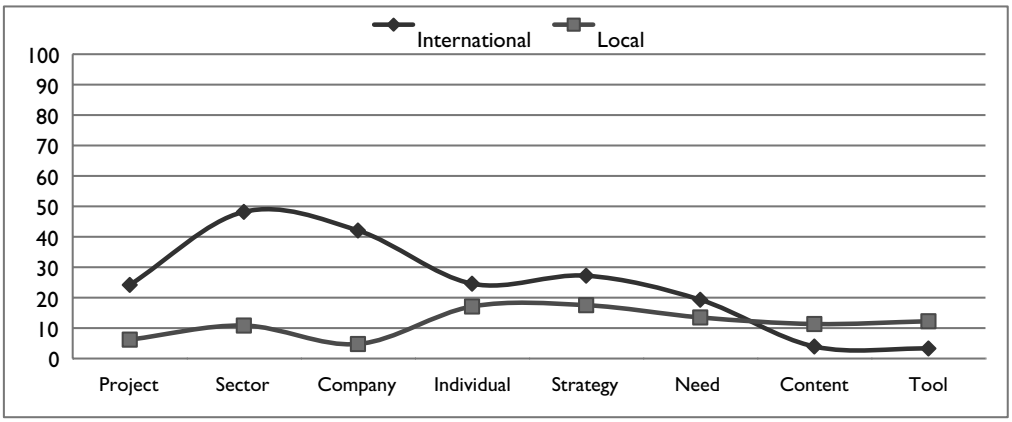


Figure 11.19: Increase of insight in and understanding of the international and local consultants.

Figure 11.19 demonstrates clearly that the insight in and understanding of the international consultants has been increased the most. Some of the scores went up by 40 to 50 points. Compared to the local consultants they have gained especially more insight in and understanding of the project goals, sectors and companies. On the individual, product innovation strategy and need level the increase in insight and understanding by both groups was more equal. In the last two categories, content and tools, the local consultants gained more than the international consultants. The international consultants gained almost no new knowledge on these two topics. The differences are only statistically significant for the topics project, sector and company.

On average the local consultants gained less than the international consultants. This might be logic since they come from this context. The local consultants learn only more, compared to the international consultants, about the potential content and tools of the training materials. This can be explained by the fact that the international consultants are already 'experts' in product innovation and ecodesign and as a result will gain less new insights and understanding on these topics.

Insight and understanding at the end

The results of the analyses of the scores of all participants at the end of the workshop can be found in see Figure 11.20. It is remarkable that at the end of the workshop the insight in and understanding of the two groups (local and international consultants) have become close to each other. After applying the IUS tool there is not anymore a big difference in understanding of the context between the local and foreign consultants. This provides a good start for the product innovation knowledge transfer project since both teams are on an equal level. Using the IUS tool as a team created a kind of shared vision for the product innovation knowledge transfer project. The only serious gap is the understanding in the 'individuals' (significantly). It seems that the IUS tool cannot yet support the teams in that perspective (especially not the international experts).

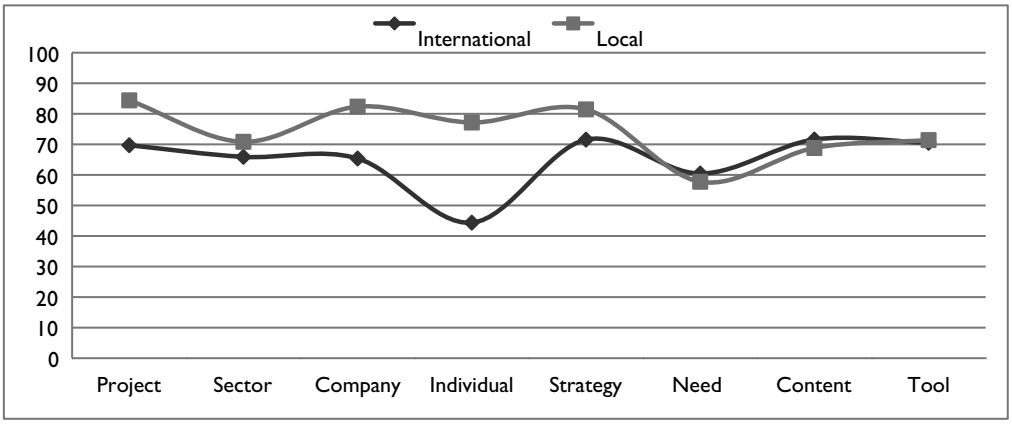


Figure 11.20: The outcomes at the end of the workshop.

11.4.3 Results learning experiences

The learning experiences resulted in 160 statements made by the IUS workshop participants. In a next step these statements were clustered in order to identify some general findings in relation to the use of the IUS tool. The most relevant findings are summarised in the next paragraphs. In some cases either the local or international consultants specifically made certain statements, in that case the source will be mentioned. Otherwise the expressions are presented mixed.

Session 1: National Level

As an outcome of the reflection on the first session, the local consultants concluded that the IUS tool facilitated them to bring the 'pieces' of the project together, to confirm some of their preliminary ideas as well as to identify the weaknesses:

> "The set of questions helped me to extend my view of the total problem".
> "... and uncovered the weak areas which are a lack of information about the target group".
> "Reconfirmation and justification of some of our ideas".

For the international consultants the main conclusion was that they gained insight in and understanding of the context. These outsiders mentioned more about the knowledge gained of the context than the local consultants and were surprised how fast they could achieve this goal:

> "I have learned about the country, it was new to me, so all information is useful for the continuation of this project".
> "I did not know that much of the economical context and the industries. I was surprised how fast and relatively easy you can achieve this goal".
> "I learned to have an overview of a wide range of parameters before starting working".

According to the users, the IUS tool facilitates in identifying the proper innovation levels:

> "It seems to me that this putting-into-context will help me in the process of deciding what is realistic to do in the project and what not".
> "I have learned that the Ecodesign project in the projects in my country will focus more on Eco-Redesign (product innovation level 2) rather than on more innovative approaches (product innovation level 3 & 4)".

As an outcome of the use of the IUS tool the participants proposed direct actions for their project:

"This information is very important for the continuation of the project, mainly with regard to the content of the training kit".
"We need to collect information with regard to the level of research and innovation activities in SMEs".
"The subjects we have identified during the exercise will be used in my work of preparation of the manual taking in consideration the specific context of the country".

Session II: Sector and company level

The results of the second session are related to the sectors and companies. It provided similar kind of learning experiences as the first session. The use of the IUS tool made the participants aware that a good understanding of the sectors is needed before you can select them as well as to develop proper training materials for them:

"The selection and understanding of the sectors will help me structuring and find the right information/methods/tools for the manual".
"I have realised that we still have to find information about our selected sectors".
"More attention should be paid to every sector separately".
"Understanding of the sector is basic for development of trainings materials and manuals. The learning helped me to uncover the weak areas".

In addition the use of the IUS tool provided more insight into the characteristics and needs of the companies:

"More understanding of the needs and drivers of the companies was good".
"A new way of characterizing the companies was new and useful".
"The exercise helps to think about which companies should be taken on board".
"This material will help me to evaluate companies needs and capacity".

The increased insight in and understanding of the sectors and companies led to a new notion related to the proper innovation levels for the training materials and demonstration projects:

"I have learned that different sectors as well as companies can have a different approach to Ecodesign (different product innovation level). Some can be more innovative, some prefer to work just with redesign".
"Defining the Ecodesign approach according to the sectors needs was very useful".
"Within a country companies operating within the same sector can have each different strategies because of different owners, drivers and financial situation".
"I will use these insights to identify better the tools for different companies".
"Decisions related to Ecodesign strategies/tools should be made considering the needs of the company".
"Got me into deeper and more realistic views. Practically it was a shift from 'what we would like to do' to 'what is possible to do'".

The newly gained knowledge by the participants will not only be used within this project, but they also intend to use it in follow up projects:

"I will use the new learning experiences during this project and afterwards".
"I will use the new ideas in other projects with different sectors and companies".

Session III: Team and individual level

The learning experiences of the participants during the third session were mainly related to the characteristics of the team composition and team members within the planned demonstration projects. First of all they learned to take into consideration the background and characteristics of the individual team members:

"Importance of taking into account different / people / organisational forms".
"It is needed to consider conditions in each company training. The design of the training modules needs to reflect the company environment".
"The background (education, designer, engineer etc.) really determines your view of the reality".
"To define how to work in another country it is necessary to know how individuals are in each country".
"It is a good practice broadening the analysis to the actors of the process itself".
"I realised: Still too many people in companies are engineers and focus on logic and rationality. They are usually focused on step-by-step improvement and not font of uncertainty".
"It was useful to rethink the training methods taking into account cultural differences".
"The topic brought new skills and uncovered new areas, which I did not take into consideration earlier".
"To become aware of potential problems/barriers/issues that might arise".

In addition to the individual team members, the participants also became more aware about the team composition:

"The teams and the work of the individual within a team must be organised in balance".
"When the project team will be compiled we will choose the way to work".
"How to get the right people in my team".
"I will pay more attention in the phase of establishing the working team".

These new insights in the potential characteristics of the individuals as well as the team composition during the proposed pilot project resulted in new actions like:

"I will use the new ideas and approaches in doing the projects in the company".
"We should learn more about the product innovation process in the demonstration companies".

Session IV: Local support

The last session was dedicated to the potential local product innovation expertise, which could support the demonstration projects. This resulted in the following insights:

"There is a gap between the research at academic level and its application".
"We don't have a real support for product innovation: no infrastructure, no consultants".
"It reconfirms the ideas I had before with regards to the local support in product innovation".
"Local support in product innovation is important (policies, legislation, education databases etc.) but is missing in many of these areas".
"I have learned that it is better to involve other institutions to prepare the training materials. Their role could be as expert in product development to make the manual of better quality".
"There is a need to communicate with educational institutions for supporting the product innovation knowledge transfer".

Finally some general remarks of the participants:

"Everything I learned today is interesting and will be useful".
"Useful idea to me was to compare or to learn from the other participants about their imagination how could look the training material".

> "Challenge: get the training materials on the level of their needs within the time and money within the project"

11.4.4 Observations on the use of the IUS tool

During the workshop the researcher made some additional observations on the use of the IUS tool. At the end of each session the teams presented their results to each other. In this way they also became informed about data, results and decisions of the other country teams. Especially on national and sector level, the teams (of knowledge sources and knowledge facilitators) were eager to compare the outcomes with the other teams to get a better understanding of their own results. The teams were working independently and did not need any additional support from the workshop facilitator (the researcher).

The IUS tool was developed as a 'computer tool' and each team was provided with both a digital version on a laptop and a print out. During the workshop, however, the teams did almost not use the laptops. Instead, they preferred to work on the version.

The pilot IUS tool requested the user to collect 40 socio-economic indicators from online databases. In practice during the workshop the participants only used about twenty of them.

11.5 Conclusion and discussion needs assessment tool

First we will provide a reflection to proposition 2, followed by further discussion on the developed and evaluated needs assessment tool.

Reflection to proposition 2

Reflecting on Proposition 2 "A needs assessment, in this case operationalized in terms of a Insight Understanding and Selection Tool (IUS), is an appropriate and efficient tool to be applied for steps (1) the selection knowledge recipient; and (2) selection of product innovation knowledge content." *We conclude that proposition 2 can be maintained. In practice the IUS needs assessment tool indicated that the user can apply it independent of external support (self-explanatory) and results in a proper analysis of the project context and knowledge needs leading to well-considered identification and selection of knowledgde recipients and knowledge components. It demonstrated to be quick and efficient in use (reduced staff time) as well as flexible depending on the user and project setting.*

The IUS tool was developed with the intention to support the knowledge transfer team (knowledge facilitators and/or knowledge sources) in identifying and selecting the proper knowledge recipient (Who) and knowledge content (What). In practice the use of the IUS tool led to the intended result. From the answers on the questionnaires and the learning experiences of the participants of the workshop it can be concluded that it facilitates both the knowledge source and the knowledge facilitators in getting more insight in and understanding of the context of the knowledge recipient as well as to select the proper knowledge recipient and knowledge content. By using the IUS tool the international consultants (knowledge source) gained especially more insight in and understanding of the characteristics of the knowledge recipient and the context in which he or she operates (Who). The local consultants (knowledge facilitators) gained insight in and understanding of particularly the knowledge content needed such as proper innovation levels, methods and tools (What). The use of the IUS tool made the participants aware that a proper analysis of the project context such as the sectors and companies is needed before they can make decisions on the selection of the knowledge recipients and the by them needed knowledge content.

The IUS tool provided an increased insight and understanding to the users for all topics (project, sector, company, strategy, need, content and tools) except one. The IUS tool proved to be not successful in providing a clear picture of the knowledge recipient at the individual level. In spite of this it raises awareness and questions, which the participants will bring into practice during the project itself. They became aware about the potential characteristics as well as the importance of the team composition. The IUS tool stimulates the team in case of missing data to gather it themselves during the early stages of the knowledge transfer project.

The IUS tool proved to be efficient in use. Several users mentioned that they were surprised how fast they could get insight in and understanding of the national, sectoral and organisational context. With limited financial resources and time (less than a day), the local and international consultants could obtain a higher level of understanding of the knowledge recipient (Who) and the matching knowledge content (What). The IUS tool demonstrated to be flexible in use as well as self-explanatory. Users could start using the tool at different entry levels as well as could apply it without external support.

However it should be remarked that this conclusion is based on one specific assessment and with participants from middle-income developing countries. Therefore, we suggest further testing with participants of low-income developing countries as well. The developed needs assessment will be incorporated in the design manual which will be introduced in the next sections. As part of the test of this design manual, 16 practitioners from low-income developing countries will test the improved IUS tool.

Discussion

By applying the IUS tool in a team setting, the team members were getting a 'shared and congruent vision' of the goals, knowledge recipients, knowledge content of the project. Moreover, by discussing all these elements within a short time span all team members gained a comprehensive view of all the pieces of the knowledge transfer project. The IUS tool also in some cases facilitated the teams to uncover weak reasoning as well as to reconsider earlier made decisions. In practice the IUS tool fulfilled other functions as well. The use of the IUS tool in a team setting of knowledge facilitators and knowledge sources facilitated the exchange of (implicit) knowledge in between them. Next, after applying the IUS tool, the knowledge sources and knowledge facilitators reached an equal level of insight in and understanding of the proper knowledge recipients and knowledge content. This leads to a good condition at the start of a product innovation knowledge transfer project for making conscious decisions collaboratively at a team level.

It is expected that the IUS tool functions most efficiently in the early stages of a product innovation knowledge transfer project. In that stage both the local and the international consultants have still limited information of the project and context and as such the IUS tool can provide a leapfrog start for both of them. Most of the elements of the knowledge transfer process are still unclear and have to be determined.

The test in practice also led to suggestions for improvement. During the workshop the participants used not all 40 socio-economic indicators. Consequently it is expected that the amount can be reduced. The participants mentioned that by seeing the indicators of other countries during their presentations, it was easier to position their own country as well as to understand the values. As such it is recommended to build in a 'benchmark' option in which the user can compare the socio-economic indicators with other (neighbouring or competitive) countries. During the workshop the participants used most of the time the print out hardcopy of

the IUS tool instead of digital version on the laptops. For future application a well worked out paper version will be needed as well.

These suggestions for improvement will be incorporated in the final version of the needs assessment tool, which will be incorporated in the design manual.

11.6 Design and development of a design manual: The D4S-DE Manual

Next, the second part of the systematic approach (step 2, 3 and 4) will be translated into an operational tool, a design manual. The design manual will offer in detail the product innovation knowledge content as well as a way to facilitate the transfer of the knowledge to the recipient. This design manual will work out in more detail the content of the knowledge transfer (What) as well as how to transfer it (How). Combined, the IUS needs assessment tool and the design manual result into a knowledge transfer package (step 5) ready for transfer (step 6).

11.6.1 Background of the design manual

Different options have been explored of how to translate the second part of the systematic approach into an operational tool. It was concluded that a design manual would be a proper option to do so. Design manuals can offer simultaneously detailed knowledge content (What) and a way of knowledge transfer (How) and can function in a wide range of knowledge transfer activities. In addition, the development of a design manual also offers the opportunity to make the tacit knowledge of experts within the Delft University of Technology and other product innovation knowledge transfer teams and institutions explicit. This way it is expected that the product innovation knowledge transfer will be less dependent on specific persons (i.e. international experts), offers the opportunity to reach out to a larger audience (i.e. through the internet) and become more cost-effective.
Based upon this background information and the evaluation criteria of proposition 3 as formulated in section 11.2.4, an initial set of guiding requirements was defined as input for the design and development process of the design manual. As a starting point for the development a design brief was formulated:

Develop a practical product innovation manual, which fits to the needs and characteristics of knowledge recipients in developing countries. The manual will be used by knowledge recipients independent as well as with support of knowledge facilitators and/or knowledge sources.

11.6.2 Design and development of manual

The application of the IUS needs assessment tool results in the identification of a specific target group and accordingly the main topics for the knowledge content for the product innovation knowledge transfer. The next step, to develop a matching design manual (content wise as well as educational approach) depends a lot on the in the first stage selected specific target group. From this perspective it was decided to develop a design manual for a particular target group to demonstrate how a design manual could function in practice to facilitate the transfer of product innovation knowledge. As such the research team was looking for a real setting, in order to develop a product innovation manual that could be designed, developed (prototyping), used, tested and evaluated (assessment) in practice.

In 2004 the United Nations Environment Program (UNEP) approached the Design for Sustainability (DfS) research program of the Delft University of Technology with the request to develop a design for sustainability manual for SMEs in developing economies. Earlier in 1996 the same research group developed in assignment of UNEP a design for sustainability manual (Brezet and Hemel 1997) with a focus on developed economies. The goal of the new manual was to

combine product innovation with sustainability (likewise in the India and Central America case). This provided an ideal setting for developing, testing and evaluating a design manual for a specific target group: SMEs in developing countries with a focus on product innovation and sustainability.

In consultation with UNEP a manual development team was composed existing of Dr. Marcel Crul (project coordinator of the Central America Case) and the researcher of this thesis. Both researchers did have comprehensive experience in introducing product innovation in developing countries. Taking in consideration the specific setting of the design manual (product innovation in combination with sustainability) and the specific target group (SMEs) the original design brief was reformulated into:

Develop a practical Design for Sustainability (D4S) manual, which fits to the needs and characteristics of SMEs in developing countries. The manual will be used by SMEs (knowledge recipients) independent as well as with support of knowledge facilitators and knowledge sources (i.e. consultants, universities and national cleaner production centers).

One of the goals of the design manual development was to incorporate as much as possible the earlier findings of this PhD research (i.e. literature review, empirical study, list of focal points and expectancies). At the start of the development of the design manual, the team made an overview of the earlier findings and highlighted the most essential ones. The following main suggestions were derived to support the development of the new design manual:

What (content-wise):

1. *Introduce the basic elements and methods of product innovation*: Knowledge recipients as well as knowledge facilitators in developing economies often lack domain specific design knowledge;
2. *Focus on incremental product innovation levels 1&2*: Incremental product innovation approaches fit the best to the characteristics and needs of SMEs in developing economies;
3. *Introduce profit, planet (ecological) and people (social) aspects simultaneously*; The social part of product innovation plays in developing countries an equal important role as the profit and planet aspects.

How (way of knowledge transfer):

4. *Be appropriate for use independent by SMEs as well as with support from knowledge facilitators:* Medium-sized enterprises are capable to apply the new methods themselves; Small-sized enterprises do need external support.
5. *Contain simple pragmatic tools and detailed instructions for exercises;* SMEs in developing economies prefer simple, step-by-step and checklist type of tools.
6. *Flexible in such a way that different users in various settings can use the design manual.* It is expected that the design manual will be used in for example workshops, T-t-F sessions, demonstration projects, courses and other knowledge transfer activities.

The preceding, for UNEP developed, Design for Sustainability manual for the western world (Brezet and Hemel 1997) was used as a starting point for the development of the new manual. All elements of this manual were evaluated upon their appropriateness for the new target group. Strong elements were kept and weak parts were either eliminated or improved and adjusted to the needs of SMEs in developing countries. The main structure stayed identical, the manual consists of two parts:

1) A theoretical part for reading;
2) A practical part existing of worksheets for exercises.

In order to make the use of the manual flexible, both parts are composed of modules. The outline of the initial version of the UNEP Design for Sustainable for Developing Economies (D4S-DE) manual is depicted in see Figure 11.21.

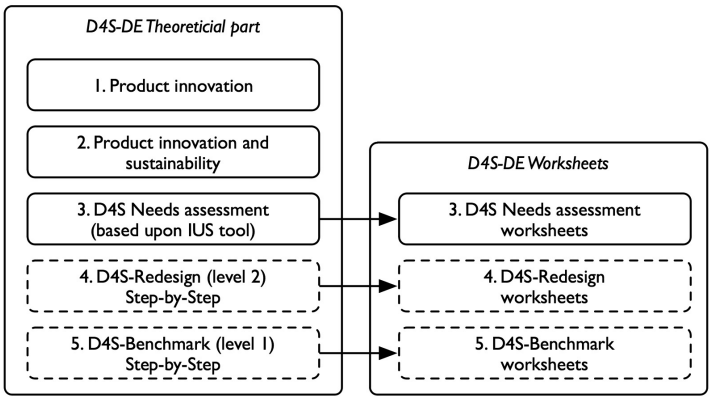


Figure 11.21: Outline of the initial UNEP D4S-DE manual (all modules are of interest for the knowledge facilitators, modules indicated by '-----' are of interest for the knowledge recipients (SMEs)) (Diehl 2010).

The theoretical part exists of five modules. Module I introduces the reader to the basic principles and methods of product innovation, Module II creates a link between product innovation and sustainability. Modules I & II are more theoretical of its kind, do not have exercises and are meant to support Module III and IV. Module III is a D4S needs assessment tool based upon the improved version of the IUS tool developed in the previous section. Module IV introduces two D4S approaches on an incremental product innovation level: D4S Redesign and D4S Benchmarking. These last two modules are written more action oriented and closely connected with the exercises in the connecting worksheets (see Figure 11.21).

This way a modular setup for the manual is provided in which depending on the target group and setting, specific modules can be selected and used for training or other product innovation knowledge transfer activities. All text modules and worksheets are relevant for the knowledge facilitators. The boxes with a 'dotted' contour line are of specific interest for the knowledge recipients. Based upon this new outline a working version of the D4S-DE manual and worksheets were developed. A full version can be found in Appendix 8.

11.7 Assessment of the D4S-DE Manual

In consultation with UNEP it was decided to test, evaluate and improve the D4S-DE Manual in two sequential stages with two different types of stakeholders. In a first stage, potential future knowledge facilitators (practitioners) from developing countries applied the D4S-DE manual in practice during a 3-day workshop in Berlin. Goal of this test was to evaluate if the content and approach of the D4S-DE Manual were appropriate for their daily work circumstances and if it would fit to the needs of local SMEs. Based upon the evaluation and feedback of the practitioners on the D4S-DE manual, a list of improvement options was made and incorporated in a second improved version of the D4S-DE design manual.

In a second stage of the evaluation procedure, the improved version was submitted to an external review board existing of international academic experts and United Nations representatives (theorists). The goal of this second evaluation was to judge the validity of the content. Once again suggestions for improvements were made and were incorporated in the final improved D4S-DE manual. The outline of the two-stage assessment trajectory is illustrated in see Figure 11.22.

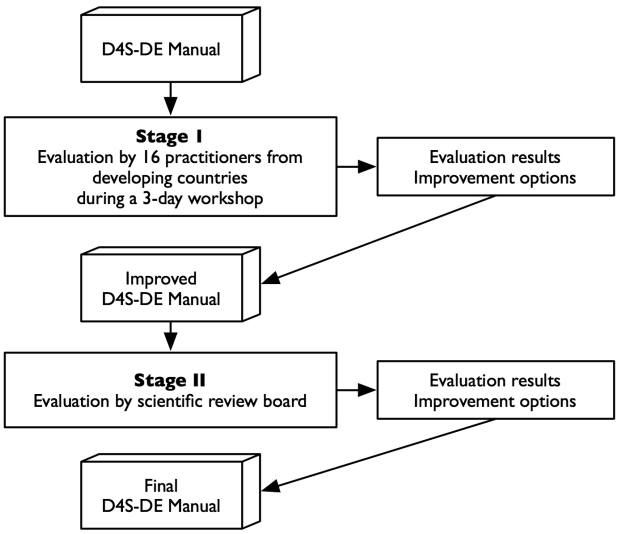


Figure 11.22: The two-stage evaluation procedure of the D4S-DE Manual (Diehl 2010).

11.7.1 Evaluation method

For stage I, a three-day evaluation workshop with practitioners was organised in collaboration with UNEP in October 2005 at the InWent office in Berlin, Germany. InWent, a German non-profit organisation dedicated to human resource development, was one of financial contributors to the UNEP D4S-DE Manual design and development.

Participants

In advance sixteen participants were selected and invited by UNEP. The focus target group were potential future D4S-DE knowledge facilitators, mainly recruited from National Cleaner Production Centers (NCPCs) and universities. In order to get a world-wide opinion with regard to the usability and relevance of the content of the developed D4S-DE manual, the participants were selected out of ten countries from different continents: Ethiopia, Uganda, Mozambique, Morocco, Colombia, Guatemala, Costa Rica, Vietnam, Sri Lanka and China.

Procedure

One week before the workshop a digital version of the D4S-DE manual was sent to the participants. They were requested to read the manual prior to the workshop. In addition the participants were requested to bring products, brochures and information from companies they work with in their home country. They received the following briefing:

- *Bring one product from a local company you know. Gather information on the company like economical, organisational, environmental and management data (this product and information will be used for applying the D4S Redesign Module).*
- *Bring several processed and packed food products produced in your own country like i.e. packaged coffee, tea or dried fruits (these products will be used for applying the D4S Benchmark Module).*

By doing so the participants could apply the D4S-DE methods during the test workshop directly on products and companies from their own context, similar to their daily professional practice. This way the future use and application of the D4S-DE manual was simulated as much as possible. Examples of products brought for the D4S Redesign session were leather shoes (Morocco), a wooden bottle opener (Uganda), a low-cost shaver (China) and a galvanised stationary holder (Vietnam) (see Figure 11.23).

Figure 11.23: Products brought by the workshop participants from their home country for the D4S Redesign session (left) and the D4S Benchmark session (right).

During three days, the participants applied to a large extend the D4S-DE manual in two workshop spaces. The participants worked in teams of two persons. In case of more than one participant per country, national teams were formed. Alternatively participants from the same region were combined. The workshop program was split up in three parts, each focussing on a specific module of the manual:

Day 1: Module III → D4S Needs Assessment; Identifying relevant sectors and companies in their own economy. Selecting the proper innovation levels, tools and methods for the local knowledge recipients. This is a second test of the needs assessment tool, this time as part of the integral solution as well as to test it with practitioners from low-income developing countries.

Day 2: Module IV → D4S Redesign; Redesigning products from their own origin focussing on the company goals & drivers, impact assessment and design strategies.

Day 3: Module V → D4S Benchmark: Dismantling and comparing electronic products and benchmark improvement sessions on local products. Making a D4S action plan.

The workshop sessions were introduced and facilitated by the two developers of the D4S-DE manual. After the introduction of each session the national teams started working on the exercises as described in the D4S-DE manual and worksheets.

Figure 11.24: Participants working on the D4S-Benchmark method.

At the end of each session every team was requested to present their outcomes (see Figure 11.25) followed by a group discussion on the outcomes as well as to evaluate the applied methods.

Figure 11.25: Participants presenting the outcomes of the exercises.

Instruments

In order to capture the experiences and opinions of the participants with regard to the usability of the D4S-DE manual and the appropriateness of its content two instruments were used:

1. A 'module questionnaire' to evaluate the content (consistence) and usability (practicality) of each module specific;
2. An 'appropriateness questionnaire' to evaluate if the proposed content and approach will fit to the local industry;

Both questionnaires were conducted on day three of the test workshop during the evaluation session.

Module questionnaire

The module questionnaire asked the participants to review the complete D4S-DE manual, each of the 5 modules separate and the worksheets. For each module specifically they were asked if it should be kept, adjusted or removed. In addition they could indicate what kind of content should be added in order to further improve the knowledge transfer package for the target group.

Appropriateness questionnaire

The appropriateness questionnaire existed of 6 open questions. The first four of them were related to the content of the manual and if the content is appropriate for knowledge facilitators

and knowledge recipients in their own country. The last two questions discussed the potential future implementation and use in the daily work of the participants.

Based upon the outcomes of the evaluation by the practitioners from the developing countries an improved version of the D4S-DE manual was developed. The improved version of the D4S-DE manual can be found in Appendix 8

Scientific review board

Next to the practitioners, a scientific review board was composed with members representing the academic world as well as the United Nation bodies. The task of the board was to judge the face validity and the content validity of the developed manual. The eight members of the scientific review board were selected on their expertness in sustainable product development related to developing countries. In addition the members were selected from the different continents in order to get a worldwide feedback.

A digital version of the improved D4S-DE manual was sent to the members of the scientific review board for review. Each member was requested to judge the face and content validity of the D4S-DE manual and was contacted personally for his or her judgement as well as suggestions for further improvement.

11.7.2 Results practitioners

First the results of evaluation stage I, the workshop in Berlin with future potential practitioners will be discussed followed by the outcomes of stage II (review by the scientific review board).

Module questionnaires

All participants evaluated the D4S-DE manual as a good and appropriate approach to train SMEs in their own local context. The practical method of step-by-step, learning by doing approach, by using the worksheets as well as applying it on local products was valued very positive. All participants proposed to keep all current modules and suggested only minor changes. Table 11.4 provides an overview of the judgements of the workshop participants (K=keep, A=adjust and R=remove). The most relevant suggestions and remarks for each module are summarized in the right column of the table.

Table 11.4: Judgements on the D4S-DE modules (K=keep, A=adjust and R=remove) and suggestions for improvement by the workshop participants.

Question	**K**	**A**	**R**	**Remarks**
Opinion about the D4S-DE package	16	0	0	A good and generic approach; Applicable to SMEs as well as academic and research institutions; Will need further details to support the knowledge facilitators; The worksheets are well organized, learning by doing; Some additional information on the worksheets would make the work complete; More case studies should be included; A part on creativity techniques would be useful; Sector or product specific manual could be helpful.
Overall structure training package	16	0	0	Well structured; The structure is for consultants supporting SMEs; Create more compatibility between content and worksheets; Provide examples of filled in exercises; Add boxes with examples;

				Include more case studies; Provide example for an 'artificial company'; Add links to other sources and further reading.
Module I: Product Innovation	7	9	0	Especially for consultants of SMEs; Add more and simple examples, especially at critical points to improve clarity; Write a bit simpler, less academic; Add didactics.
Module II: D4S	14	2	0	Make planet and people aspects more clear with examples; Add some more (simple) examples.
Module III: D4S Needs Assessment	11	5	0	Important for consultants; Nice subject; Good idea to select sectors; For consultants macro information is important for funding; Add some more (simple) examples.
Worksheets D4S Needs Assessment	8	8	0	Add how to define national sustainability; If you already have selected companies, make it possible to skip certain sections; Make for each worksheet clear the purpose and expected results; Need more simple instructions; Add some simple and guiding examples.
Module IV: D4S Redesign	9	7	0	Elaborate more on the evaluation and implementation; Pay more attention to marketing; Good MET-matrix including social (people) aspects; How to get conclusions (priorities) out of the MET matrix; Include examples on real results.
Module V: D4S Benchmark	8	8	0	Good and important; Good light version of D4S Benchmark; How to evaluate the priority of the criteria listed; Add example with solution; Make sector specific.
Worksheets D4S Redesign & D4S Benchmarking	9	7	0	Should be prepared for specific sectors; Add consumer / market point of view; Add some simple and guiding examples.

Results 'appropriateness questionnaire'

The 'appropriateness questionnaire resulted in 170 statements made by the 16 participants. In a next stage these statements were sorted and clustered. The main (clustered) findings are summarized underneath:

1. *Does the D4S-DE Manual helps you to get a better understanding of what D4S can mean for your local context and local companies?*

All participants agreed. The interaction between the manual and the worksheets, which made it learning by doing, was highly appreciated. It does make it more clearly for them how to apply it in their own country and companies. They gained a better understanding of D4S and its application in practice. It became for them clear what the differences are between benchmarking, redesign, and the more radical product innovation levels. In a short time they were being introduced to a whole range of new concepts. The macro- and meso-socio-economic data derived from the D4S Needs Assessment module (the former IUS tool) facilitated them to get a better understanding of the context in which they operate.

Questions 2 & 3 resulted in similar kind of answers. For this reason they are summarized together.

2. *This manual has been developed for SMEs in developing economies. Do you think this package and approach is appropriate for SMEs in developing economies taking into consideration their characteristics, context, competences etc. ?*
3. *If you would make the manual more specific for your own country: what kind of topics, information, examples and approaches would you add for the local target groups?*

The participants suggested including more case studies and examples of projects in developing economies especially in SMEs in the agricultural, food, packaging and tourism sector. If possible these case studies should not only be described qualitative but also quantitative (for example how much reduction in environmental impact and costs has been achieved). In addition lessons learned (success and failures) in earlier projects would be appreciated. According to some of the participants the tested D4S-DE approach might still be too complex for small- and micro-enterprises to use on their own. The small-enterprises will need the support of consultants (knowledge facilitators). The micro-enterprises might need a different approach. As such a special module related to the informal sector would be of use. For localised national manuals it was suggested to add information on the importance of innovation in the local economies and to identify and include local stakeholders that must be part of the (product) innovation strategy.

4. *D4S is about sustainability and product innovation. In the current approach do we pay enough attention to both topics? Or should the manual provide for example more basic knowledge on the product innovation process and strategic product innovation?*

The new module on product innovation proved of use for the sustainability experts. According to the participants the two aspects sustainability and product innovation should be introduced simultaneously in the case of a UNEP Design for Sustainability Manual. It should balance both, but depending on the skills of the user it could be adjusted accordingly. Since most SMEs in developing countries have limited experience with product innovation, it was recommend adding more knowledge and examples on product innovation, especially on the strategic aspects (marketing, consumer research, intellectual property).

5. *How are you going to use the D4S-DE Manual in your own organization?*

The participants proposed a wide variety of activities of how they would start using the D4S-DE manual within their own organisation like awareness raising, capacity building, training sessions with industrials and or NCPC staff, starting up a new programme on D4S, increase collaboration with the university.

6. *What are your plans to multiply the use of the D4S-DE Manual in your country?*

Similar kind of answers came out of question 6. The participants proposed to start D4S programmes for enterprises (in a particular sector), to integrate D4S into the university curriculum, to request funding for projects, cooperate with stakeholders, organize training workshop, and to design a D4S-DE training.

11.8 Conclusion and discussion design manual

11.8.1 Conclusion and discussion practitioners

Conclusions practitioners
From the outcomes of both questionnaires it becomes clear that all participants are positive about the D4S-DE Manual. None of the modules should be removed. It is a good and generic approach for SMEs in developing economies. The participants appreciated positively the main structure, the content, the learning by doing interaction between the manual and the worksheets as well as the newly developed D4S Needs Assessment, Product Innovation and D4S Benchmark modules. According to them the manual provides in a short time a clear insight in the different D4S approaches as well as makes it clear what and how to apply D4S in their own context.

The participants mentioned that the manual is especially of interest for consultants (knowledge facilitators) working with SMEs. Some of the medium-sized enterprises are expected to be capable to apply the D4S-DE manual on their own, the smaller-sized enterprises will need external support. The approach might not fit micro enterprises in the informal sector. According to the participants all modules are of interest for the knowledge facilitators, module IV and V (D4S Redesign and D4S Benchmarking) are of particular interest of the knowledge recipients. The D4S-DE approach is suitable for a range of knowledge transfer activities like awareness rising as well as capacity building and demonstration projects. The conclusions of the workshop participants are in line with the initial guiding principles at the start of the development of the design manual (11.6.1).

Discussion practitioners
The evaluation of the design manual by practitioners also led to a range of proposed improvement options. Most suggestions were related to the worksheets (more compatibility between manual and worksheets, and additional information), the product innovation module (more information, especially on the strategic aspects), case studies (more and sector specific), detailed instructions (to support the facilitators), tools (more simplified), more support in decision-making (setting priorities) and a less academic writing style. In addition it was suggested to add a module on creativity techniques as well as references for further reading.

11.8.2 Results and conclusions of scientific review board

Based upon this list of suggested improvements a second improved version of the D4S-DE Manual was developed. A digital version of the improved D4S-DE manual was sent to the members of the review board with the request to analyse and judge it in detail on: A) face and content validity, B) if the content of the manual reflects the 'state-of-the-art' knowledge in this field.

All reviewers approved that the manual as scientific valuable and that the content was valid. In addition the members of the scientific review board provided several suggestions for incremental improvements:

General:

- Make clear in the beginning that D4S Benchmark and D4S Redesign (product innovation levels 1& 2) are the central approaches of the manual;
- Start with 'Design for Sustainability' instead of with 'Basics of Product Innovation' (UNEP, the commissioner of the project has as a main goal to stimulate environmental reduction);

- More illustrations of cases and better distributed over the continents;

Module I: Product Innovation

- Simplify the module 'Basics of product innovation", write it less academic, and make it more practical for the target group;
- Pay more attention on defining the mission and the vision of the company;

Module III: D4S Needs Assessment

- The D4S Needs Assessment has to become more simple and practical;
- Make more clear that the D4S Needs Assessment is only for knowledge facilitators. SMEs (knowledge recipients) can start directly with the D4S Redesign or D4S Benchmark module;
- Provide more detailed criteria for the company selection;

Module IV: D4S Redesign and D4S Benchmark

- Make the 'step names' in the D4S Redesign and D4S Benchmark modules more action oriented;
- Build in more priority setting and decision making steps into the worksheets;
- Provide more examples of the use of the tools.

As can be concluded, the feedback of the scientific review board was mainly related to how to increase the user friendliness of the D4S-DE approach, and to a lesser extent to the content. They suggested providing a clear introduction mentioning the main approach as well to indicate directly which modules are of interest for the knowledge facilitator and which ones for the knowledge recipient (more guidance). In addition, it was advised to make the writing style even more practical and action oriented, as well as to build in more priority setting.

11.9 Final D4S-DE Manual

Based upon the feedback of the scientific review board the D4S-DE manual was improved for a second round. This resulted in the final version of the D4S-DE manual. The final version of D4S-DE manual is built up out of three main parts (see Figure 11.26). The final version of the D4S-DE manual can be found in online at www.d4s-de.org.

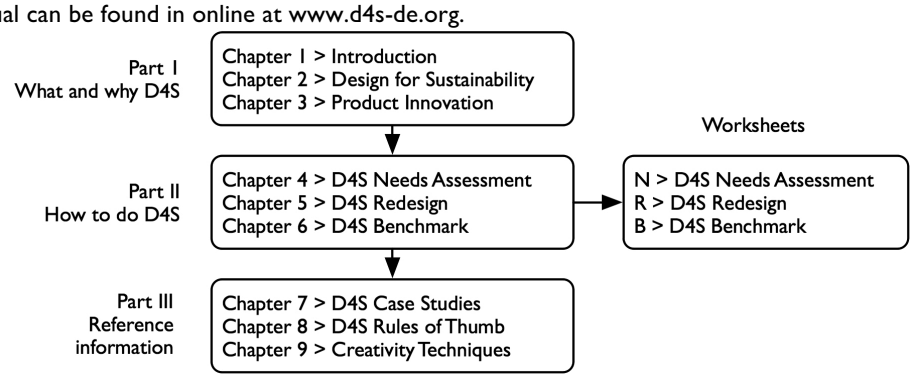


Figure 11.26: Overview of the structure of the final D4S-DE Manual (Crul and Diehl 2006).

The first part, What is D4S and why do it? (Chapters 1 to 3) introduces the reader to the main concepts. Chapter 1 explains what the D4S-DE manual is about, what the target audience is and how to use it. Chapter 2 describes the D4S concept in more detail and what might motivate companies in developing economies to adopt it. Chapter 3 concludes the first part by elaborating on what product innovation is and why companies should do it. The second part, How to do D4S in practice (Chapters 4 to 6) is the backbone of the manual. It explains the three practical,

step-by-step approaches to execute a D4S project in a company. Chapter 4, the D4S Needs Assessment shows how to evaluate the economic position of a country and how to prioritize industry sectors in order to target the selection of demonstration project companies as well as to select the proper product innovation strategies and knowledge transfer content. Chapter 5 outlines the step-by-step approach to carry out a D4S Redesign project, aimed at the sustainability-driven, incremental improvement of an existing product. In Chapter 6, the D4S Benchmark approach is presented. For each of the three practical approaches of Part II, a set of accompanying worksheets is available. In Part III, Reference information on D4S, additional information is provided that can support the execution of a D4S project. Chapter 7 provides the reader with D4S case studies from developing economies. Chapter 8 presents 'rules of thumb' for carrying out a D4S project. Chapter 9 gives an overview of creativity techniques that can be applied by a D4S team during a project to come up with creative and novel solutions for product innovation issues (Crul and Diehl 2006).

Since both main partners, UNEP and DUT, are non-profit oriented as well as wanted to share the new developed D4S-DE manual with as much as possible interested knowledge facilitators and recipients in developing economies it was decided to make the manual available on-line (see Figure 11.27). The online version offers the opportunity for dissemination to a worldwide audience without any investments in distribution as well as to make it accessible for a large target group. In addition the end-user can select, download and print only those modules, which are relevant for the situation, the D4S knowledge transfer is needed. Both aspects contribute to an increased accessibility and affordability for the end-user.

Figure 11.27: The final version of the D4S-DE Manual and D4S-DE web-site.

11.10 Discussion

This chapter discussed how the second part of the systematic approach has been made operational by means of developing a design manual for a specific target group: SME's in developing economies. As a starting point for the development the in 1997 published UNEP Design for Sustainability Manual for developed countries was taken. Based upon the earlier learnings in this PhD study (the literature review and empirical study), a first version the UNEP Design for Sustainability for Developing Economies (D4S-DE) was developed. This manual has been tested and evaluated by potential future practitioners (knowledge facilitators as well as a scientific review board). Based upon their feedback the D4S-DE manual has been improved in two rounds resulting in the final UNEP D4S-DE Manual.

As a result the outline, content, tools, method and approach of the UNEP D4S-DE manual differs considerably compared to the UNEP manual for developed countries. In order to make the manual appropriate for the needs and characteristics of the knowledge recipient in developing countries, in total more than 50 essential changes have been implemented in the new manual. Some examples are provided in Figure 11.28.

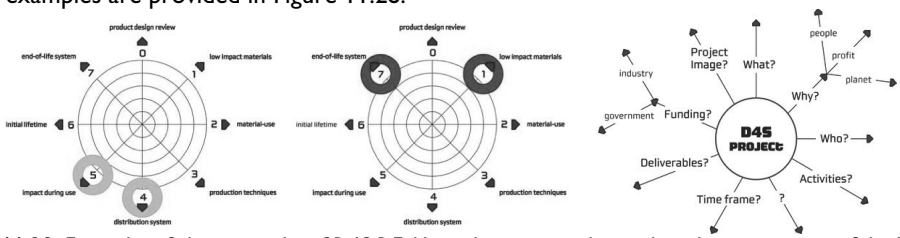


Figure 11.28: Examples of changes in the of D4S-DE Manual: strategy selection based upon priorities of the D4S Matrix and the D4S Drivers (left & middle picture) and facilitating making an action plan (right picture) (Diehl 2010).

A list of all changes can be found in Appendix 9. This way the content and approach has become much more proper for knowledge recipients in developing countries. However, one should take into account that not all SMEs in developing economies do have the same characteristics and the same need for product innovation knowledge transfer. As earlier suggested, tailor made design manuals with a more regional and/or sector focus are expected to fit better to the local needs. Subsequently, after the publication of the D4S-DE manual in 2006, in several regions of the world D4S demonstration and capacity building projects have been initiated with as starting point the D4S-DE approach. The D4S projects in Costa Rica, Vietnam, Lao and Cambodia have led to new D4S-DE manuals in their local language with (slightly) adjusted structure and with local examples (see Figure 11.29). All localised versions of the D4S-DE manual can be downloaded from the D4S-DE web portal www.d4s-de.org. The local use of the D4S-DE manual demonstrated successful examples like for example in the packaging, food and handicraft sector in Vietnam (Clark, Kosoris et al. 2009).

Figure 11.29: The Spanish and Vietnamese version of the D4S Manual.

At the time of writing of this thesis more than 40.000 visitors were registered on the D4S-DE web-site. The online publication of the D4S-DE Manual not only gained interest from knowledge facilitators in the field but also from academics and teachers in both developing and developed economies. Several academic papers have been published about the experiences with application of the D4S-DE approach in practice in amongst others the Fiji Islands, Brasil, Singapore, The United States and Vietnam (Sampaio, Muraro et al. 2007; Mathieux, Evrard et al. 2008; Santos,

Sampaio et al. 2008; HOYOS 2009; Puzzuoli and Barakat 2009). A range of schools and universities have incorporated (parts of) the D4S-DE manual into to their curriculum and course materials.

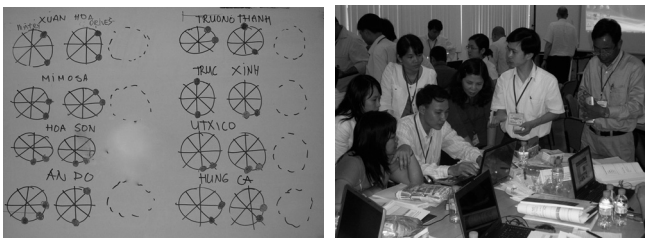


Figure 11.30: D4S-DE workshop in Vietnam with 8 SMEs.

11.10.1 Propositions and research question 2

At the end of the second stage of our study (prototyping & assessment) proposition 2 and 3 as well as Research Question 2 will be answered.

Reflection on proposition 3

Reflecting on proposition 3: *A practical, product innovation oriented design manual, in the case the D4S-DE Manual is an appropriate and efficient tool to operationalize the steps (2) knowledge content, (3) type of knowledge; (4) selection of knowledge transfer mechanisms; and (5) formulating the transfer product package* we can conclude that proposition 3 can be maintained. The evaluation of the design manual by 16 practitioners from developing countries and the acdamic review board existing of representatives from the UN and the academic has indicated that it can make the transfer of, in this case, 'sustainable product' innovation transfer to and within developing countries more appropriate and efficient.

Reflection on proposition 1

Reflecting on proposition 1: The proposed 6-step systematic approach creates opportunities for an *effective* and rather *efficient* knowledge transfer process with respect to product innovation between developed and less-developed economies. We can conclude that proposition 1 can be maintained. To a large extent the answer to proposition 1 is covered by proposition 2 and 3. As earlier concluded, the combination of a needs assessment tool and a design manual can result into a proper product innovation knowledge transfer package for SMEs in developing countries. The six-step systematic approach facilitates in a systematic and well-considered way the selection and elaboration of the product innovation knowledge transfer components. As illustrated in practice the systematic approach can lead into a knowledge transfer package containing all the main essential elements for a successful product innovation knowledge transfer.

Reflection on proposition 3

Reflecting on proposition 3: *A practical, product innovation oriented design manual, in the case the D4S-DE Manual is an appropriate and efficient tool to operationalize the steps (2) knowledge content, (3) type of knowledge; (4) selection of knowledge transfer mechanisms; and (5) formulating the transfer product package* we can conclude that proposition 3 can be maintained. The design manual has demonstrated that it can make the transfer of, in this case 'sustainable product' innovation transfer to and within developing countries more effective and efficient. This was not only illustrated by the outcomes of the workshop with 16 practitioners from developing countries and a review board existing of representatives from the UN and the academic world, but also by

the successful use in product innovation knowledge transfer projects in Vietnam, Cambodia, Lao, Moroco and Costa Rica (real practice).

Reflection on proposition 1

Reflecting on proposition 1: The proposed 6-step systematic approach creates opportunities for an *appropriate* and relative *efficient* knowledge transfer process with respect to product innovation between developed and less-developed economies we can conclude that proposition 1 can be maintained. To a large extent the answer to proposition 1 is covered by proposition 2 and 3. As earlier concluded, the combination of a needs assessment tool and a design manual can result into a proper product innovation knowledge transfer package for SMEs in developing countries. The six-step systematic approach facilitates in a systematic and well-considered way the selection and elaboration of the product innovation knowledge transfer components. As illustrated in practice the systematic approach can lead into a knowledge transfer package containing all the main essential elements for a successful product innovation knowledge transfer.

Research Question 2

As defined in Chapter 1, the second research question is "How can the product innovation knowledge transfer to knowledge recipients in developing countries be improved?"

In order to answer this main question of this thesis, first the preliminary research stage was carried out to provide an answer to research question 1. It was concluded that the transfer of product innovation knowledge is a complex process, which is influenced by many (interrelated factors). In practice this means that within a product innovation knowledge transfer project many decisions within a limited time span have to be made to identify and select the proper target group (Who), knowledge content (What) and transfer mechanisms (How). In practice, in the empirical case study it was observed that because of a lack of insight and understanding as well as the limited time, mismatches between offered and needed product innovation knowledge elements occur. As a consequence the transfer of product innovation knowledge transfer becomes less efficient and less effective.

To improve the transfer of product innovation knowledge to developing countries a systematic approach, derived from the conceptual framework has been proposed, and has been made operational. The developed systematic approach and accompanying needs assessment tool and design manual have illustrated in practice how the transfer of product innovation knowledge to developing countries can be improved.

The third and last stage of our study is called reflection, a retrospective analysis of the study (conclusions and recommendations) and specification of design principles (see Figure 11.31).

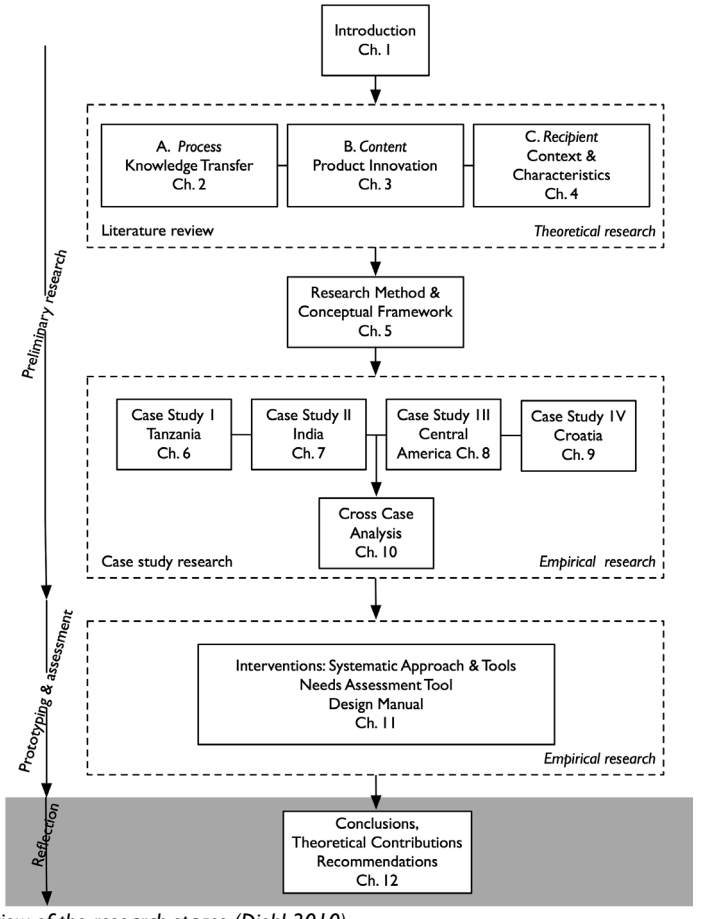


Figure 11.31: Overview of the research stages (Diehl 2010).

12 Reflection

The last stage of the study, reflection, is discussed in this chapter, which concludes this thesis: a retrospective analysis of the study resulting in main research findings, theoretical contributions scope and limitations and recommendations. The first section, 12.1, presents the main research findings including the answers to the research questions and propositions. The scientific contribution of this research, and thus the thesis, is discussed in section 12.2. The generalization, scope and limitation are debated in section 12.3. Finally section 12.4 discusses additional findings which were made and recommendations are provided in section 12.5.

12.1 Main research findings

There are different paths for developing countries to increase their economic and social development. One way is to stimulate and increase local capacity and performance in product innovation. Product innovation is expected to be one of the key drivers to economic and social development, income and job generation, and consequently self-sufficiency. In order to achieve this local increase in product innovation capacity, knowledge and skills have to be transferred to local knowledge institutions and enterprises. This transfer can be a part of international aid projects as well as local initiatives. In both situations, the transfer of production knowledge depends to a large extent on the acquisition of knowledge from outside the country. Currently a major part of product innovation knowledge is created in developed countries. Until sufficient local product innovation capacity is created and new local product innovation knowledge is generated, knowledge transfer from developed to developing countries will play a crucial role. Although it has been acknowledged that knowledge transfer on product innovation can be a positive incentive for social and economic development, there is still a general lack of systematic interest from knowledge institutions and international organisations in how the current product innovation knowledge transfer takes place and how it can be improved. This thesis focused on this underexplored research area of how the transfer of knowledge on product innovation to developing countries takes place and how it can be improved.

The primary research objective of this study was to improve product innovation knowledge transfer (RQ 2). In order to do so, the researcher first aimed to understand and carefully describe how the current transfer of product innovation knowledge to developing countries takes place (RQ 1). To be able to answer the two research questions, a three stage design-based research was carried out. The first stage provided an answer to Research Question 1, and subsequently the second stage of the research answered Research Question 2.

At first glance, the current way of how product innovation knowledge transfer to developing countries takes place and how it can be improved was studied. The research methods in the first part of this study were literature reviews and case study research. For the case study research, four cases in different regions and with different levels of national income were selected. Based upon the outcome of the first part of the research in combination with the earlier experiences of the researcher and his colleagues in practice, a systematic approach and accompanying tools were developed in a series of iterative cycles. The results provide a first illustration of how a systematic approach, which is made operational by means of a needs assessment tool and a design manual, can improve the process of transferring product innovation to developing countries.

12.1.1 How does the product innovation knowledge transfer to knowledge recipients in developing countries take place?

The current literature on the transfer of knowledge of product innovation to developing countries often describes the process in a rather theoretical manner, and discusses its distinct elements in isolation. In this way, detailed and in-depth analyses of specific parts of the process are provided. Nevertheless, in practice a coherent and consistent overview of all elements (and their interrelationships) is needed in order to understand the current process as well as to be able to improve it (Pérez-Nordtvedt, Kedia et al. 2008). Based upon the literature review, a preliminary conceptual framework was developed to bring the several elements of the product innovation knowledge transfer together. The case study research provided the opportunity to observe these elements simultaneously as well how they interact in practice. Consequently, the conceptual framework was refined for its coherence and consistency.

Based on the first part of the study, the conclusion is that the transfer of knowledge can be described as a simple process of transferring knowledge from one individual or organization to another. In practice however, it proved to be a dynamic and complex system. A wide range of factors related to the knowledge recipient (Who), knowledge content (What), knowledge transfer mechanisms (How), knowledge source, and knowledge type influence the process of product innovation knowledge transfer. This is in line with the earlier work of scholars such as Szulanski (2000), Inkpen (1998) and Cummings (2003). The literature review in combination with the case study research disclosed these factors and described them. Many of these factors are interrelated. The original research question emphasized the What (content) and How (way of knowledge transfer). However, the case study research demonstrated that in practice the knowledge recipient (Who) and the project conditions are highly influential as well. As expected in its current practice, the knowledge transfer of product innovation is dominated by tacit knowledge components and people-based knowledge transfer mechanisms (Venselaar and Christiaans 1990; Poelman 2005).

To bring all of these factors together, a conceptual framework was constructed based on the literature review (theory) and refined by the case study research (empirical study) (see Figure 12.1).

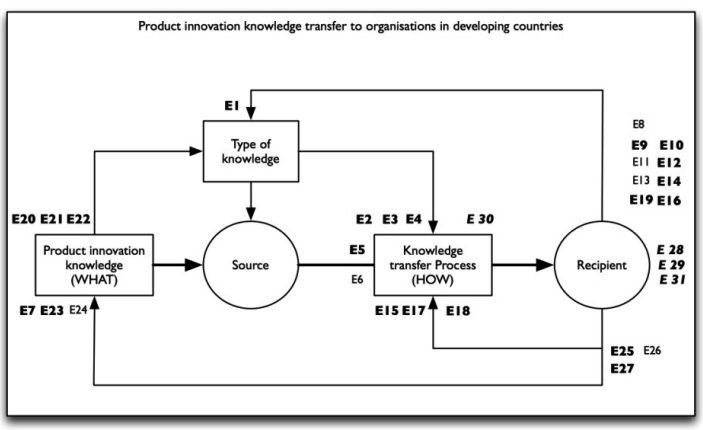


Figure 12.1: Conceptual framework and the expectancies (Diehl 2010).

All 'connecting lines' within the conceptual framework except one proved to be functional in practice. The only relationship which could not be demonstrated clearly in the empirical study, was that between the knowledge recipient and his or her preference for the type of knowledge.

In addition to the conceptual framework, a list of focal points and expectancies was made. The focal points facilitate by describing how the transfer of product innovation takes place, while the list of expectancies makes an expectation of the characteristics of the knowledge recipients and their specific need for knowledge content and transfer mechanisms. Both lists were at first instance derived from the literature review and then validated on their relevance in the empirical study. From the list of thirty-five focal points, twenty-nine proved to be functional in describing and analysing the cases. In addition, the empirical study resulted in one new focal point. With regard to the list of expectancies (see Figure 12.1), almost all were encountered in practice. Several (six) could not or only partially be confirmed either because no data regarding the expectancy was available within the cases, or they proved to not be valid. The case study research led to four new expectancies, especially related to the process of product innovation within SMEs in developing countries.

The conceptual framework and both lists reduced the complexity and indicated how the different elements of the product innovation knowledge transfer process are interrelated, and how they influence the process. It provided an overview for each of the knowledge transfer elements, and which alternative options can be delivered. Together with the list of focal points and the list of expectancies, the conceptual framework provides an answer to Research Question 1.

12.1.2 How can the product innovation knowledge transfer to knowledge recipients in developing countries be improved?

The objective of the second and leading research question of this study was to improve the process of product innovation knowledge transfer to developing countries. In order to be able to answer this research question, the second stage of the study, prototyping and assessment, was carried out in two parts: the design and development of a systematic approach and accompanying tools, followed by an evaluation by practitioners and an academic review board.

As a consequence of the complexity and the many (interrelated) factors involved in the knowledge transfer process, knowledge sources and facilitators have to make many decisions with regard to the selection of the knowledge recipients (Who), knowledge content (What) and transfer mechanisms (How) within a limited time span. Due to that complexity and other factors, as observed in the case studies, several mismatches between what was offered and what was needed in practice within a knowledge transfer project can take place. These mismatches decrease the efficiency and appropriateness of the knowledge transfer.

Even though the developed conceptual framework provides a detailed overview of how the transfer of product innovation knowledge transfer takes place, it does not yet enable the stakeholders to develop an efficient and appropriate product innovation knowledge transfer process. To improve the transfer of product innovation knowledge to developing countries, a systematic approach derived from the conceptual framework was proposed and made operational. The systematic approach (see Figure 12.2) introduces a step-by-step sequence in order to come to a structured and systematic identification and proper selection of the knowledge transfer components. It has a strong focus on the characteristics of the knowledge recipients (individuals and organisations) and their context because of their crucial impact on the selection of the different elements of the knowledge transfer process. In order to make the

systematic approach operational, two tools were developed which were combined together into the United Nations Design for Sustainability for Developing Economies (D4S-DE) manual.

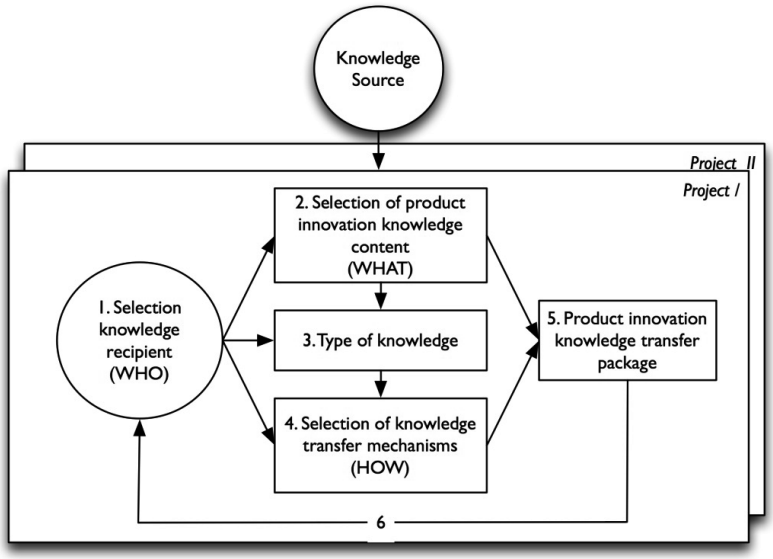


Figure 12.2: The systematic approach.

Three propositions were formulated in order to determine whether the systematic approach, and derived needs assessment tool and design manual, are appropriate and efficient in transferring product innovation knowledge to developing countries:

Proposition 1: "*The proposed six-step systematic approach creates opportunities for an appropriate and relative efficient knowledge transfer process with respect to product innovation between developed and less-developed economies*".

Proposition 2: *"A needs assessment, in this case operationalized in terms of an Insight Understanding and Selection Tool (IUS), is an appropriate and efficient tool to be applied for (1) the selection knowledge recipient; and (2) selection of product innovation knowledge content of the systematic approach".*

Proposition 3: *"A practical, product innovation oriented design manual, in this case the D4S-DE Manual is an appropriate and efficient tool to operationalize the steps (2) knowledge content, (3) type of knowledge; (4) selection of knowledge transfer mechanisms; and (5) formulating the transfer product package".*

At first instance the IUS needs assessment tool was developed in order to make the first part of the systematic approach operational. The IUS tool was tested by practitioners in an on-going European Union project on the transfer of (sustainable) product innovation knowledge from West Europe to the Baltic States. In real practice the IUS needs assessment tool demonstrated that the user can apply it independently of external support (self-explanatory) and it resulted in a proper analysis of the project context and knowledge needs. It also demonstrated to be quick and efficient in use. From the assessment by the practitioners, it can be concluded that it facilitates both the knowledge source and knowledge facilitator in gaining more insight in and understanding of the context and knowledge recipient as well as to select the proper knowledge

recipient and knowledge content. It can be stated that the IUS tool demonstrated to be efficient (reduced time), appropriate (leading to well considered identification and selection), and flexible in use.

As a second step in making the systematic approach operational, the D4S-DE manual for the United Nations Environment Program was developed. Sixteen practitioners from developing countries tested the D4S-DE manual in first instance during a three-day workshop, in which they applied the tools on products and companies from their own context. In addition, an academic review board evaluated the face validity of the content of the manual. The design manual demonstrated that it can make the transfer of, in this case 'sustainable' product innovation, to and within developing countries more appropriate and efficient. The manual quickly provided clear insight into the different D4S approaches and also made it clear how to apply D4S in the local context of developing countries.

Both tools were tested in a 'real setting': these tests were part of on-going product innovation knowledge transfer projects to developing countries and were executed by practitioners who applied the tools on products and companies from their local context. As such it can be stated that the conditions in which the test took place simulated as much as possible the real life conditions. Consequently, the outcomes can be qualified as ecologically valid and it was concluded that all three propositions could be maintained. Nevertheless it is advised to test the systematic approach on a larger scale to evaluate its applicability to other situations as well.

In conclusion, the combination of a needs assessment tool and a design manual resulted in a proper product innovation knowledge transfer package for SMEs in developing countries. The six-step systematic approach facilitated in a systematic and comprehensive way the selection and elaboration of the product innovation knowledge transfer components.

Together, the three propositions provided an answer to Research Question 2: "How can the product innovation knowledge transfer to knowledge recipients in developing countries be improved?" A systematic approach, which is made operational by means of a combination of a needs assessment tool and a design manual, illustrated that the transfer of product innovation knowledge can be improved (in the sense of efficiency and appropriateness).

12.2 Theoretical contributions

In this section the theoretical contributions deriving from this research are further reviewed.

This thesis covers research in the field of transfer of product innovation knowledge with a special focus on knowledge recipients in developing countries. One of the focuses is the development of a systematic approach to improve the process of product innovation knowledge transfer to this target group. In this thesis, this was carried out through design-based research by first using literature review (theory) and empirical research (case studies) to explore and describe how the transfer of product innovation knowledge takes place. This was followed by an iterative design and development process with built-in evaluation steps to come to a systematic approach and accompanying tools. In this way, the research contributes to describing and explaining how the current product innovation knowledge transfer takes place as well as how it can be improved.

Firstly, the research systematically explored how the current product innovation knowledge transfer to developing countries takes place based upon a literature review as well as four case studies in different regions of the world with different developments. Even though much is

known about how to transfer in a systematic and structured way knowledge in the field of for example healthcare and agriculture to developing countries, not much is known about the transfer of product innovation knowledge. In addition earlier literature often describes and analyses the factors that influence the transfer of product innovation knowledge to developing countries in isolation. The case study in this research illustrated how they take place simultaneously and how they interact. Together the literature review and the empirical study resulted in a conceptual framework that provides a comprehensive view of how the knowledge transfer takes place and how the factors interact together in the system. The conceptual framework and relationships between the different elements of the product innovation knowledge transfer to developing countries are proposed for theory building. The case study research not only disclosed how the knowledge transfer takes place but also highlighted that there are often mismatches between the knowledge elements offered (by the knowledge source and knowledge facilitator) and those needed by the knowledge recipient.

The second contribution of this research is in the field of design research methodology. As very little was known about how to develop a systematic approach to improve the process of transfer of product innovation knowledge to developing countries, this was an explorative study on how to do so. Based upon a three staged design-based research approach in a 'systematic way', a 'systematic approach' was designed and developed to improve the process of product innovation knowledge transfer to developing countries. By looking at literature (theory), a conceptual framework and and lists of focal points and expectancies were constructed as a base for improvements. Next, the conceptual framework and lists were applied and validated in the empirical study. The combination of theoretical and empirical data allowed new relationships to emerge (new focal points and new expectancies) as well as strengthening and validating both contributions. In addition, the empirical research resulted in a list of guidelines for each typical knowledge transfer activity (i.e. workshop, demonstration project, and Train the Facilitator sessions) and how they can be facilitated and improved. Based upon these outcomes, interventions were created in an iterative design process in order to improve the knowledge transfer process as the second stage of the research. The earlier findings from theory and practice could be combined and contributed to the development of the new interventions. This was done in two stages by first developing a systematic approach and second by making it operational through the development of tools, which can be used in practice in developing countries. Not only solutions and interventions were suggested based on the outcomes of the research, but they were also tested by practitioners in practice and evaluated by representatives of international independent organisations such as UNEP, UNIDO and different bodies from the academic world. In this way not only does this research study 'look back' but also provides ways to 'look forward' and improve the current practice as well as combined theorists and practitioners perspectives (Plomp 2009).

12.3 Generalizing, scope and limitation

This section reflects on the scope and limitations of this research and to what extent the findings can be generalized to other fields of product innovation knowledge transfer as well as on its scope and limitations.

As part of the contribution to the body of knowledge on the transfer product innovation knowledge to developing countries, the possibility of replicating the interventions made in this research for other product innovation knowledge transfer settings is substantiated as well. The research model used in this study had to be extensive. It included a range of topics connected to knowledge transfer, product innovation and the characteristics of the knowledge recipient and the context in which he or she operates in developing countries. This broad field of attention

was considered to be necessary, because many factors are involved and a holistic and comprehensive view is needed (not in isolation like in previous literature). However, some restrictions were made in order to prevent the research field from becoming too large to manage. The focus was on the transfer of product innovation knowledge to SMEs and knowledge intermediates such as universities, consultants and NCPCs, instead of large industries and government bodies for example. In practice, SMEs are the backbone of economic growth with limited in-house product innovation capacity and as such depend to a large extent on external facilitation by external consultants and universities. On the other hand, large industries are expected to execute product innovation themselves or to be able to invest and contract external facilitation. The focus on knowledge transfer to knowledge facilitators (intermediates) and SMEs made the study manageable and more transparent in its setup, analysis and development of interventions. Inevitably, the conclusions drawn are also limited to this domain. However, the outcomes can have implications for other contexts as well.

Another limitation of this research was the case studies. Due to a lack of proper existing case studies on product innovation knowledge transfer to developing countries, four cases were selected in which Delft University of Technology was one of the main partners. This might be seen as a limitation. However, in each case a wide range of other international and national stakeholders (i.e. consultants, universities, enterprises, chambers of industry, and local research institutions) were involved and as such these projects do not only reflect the perspective of Delft University of Technology. In addition, it should be noted that the case studies are a representation of the time span of this study (1998-2004). Taking into consideration the fast economic growth of some developing countries within a range of 5-15% per year, some of the presented data might be outdated. Nevertheless, one should also take into consideration that an increase in economic growth will not directly change all of the characteristics and needs for product innovation knowledge of SMEs and universities in these countries (Aubert 2004). It is a gradual process.

The case studies observed and described the knowledge transfer from knowledge source to knowledge facilitator and finally to knowledge recipient, as well as the impact in practice within those companies (i.e. knowledge capacity building and success of product innovation); i.e. the entire knowledge transfer process. For the second part of the study, the developed interventions (systematic approach, needs assessment tool and design manual) and the testing was limited to the transfer from the knowledge source to the knowledge facilitator. The use of the newly developed tools by the final knowledge recipient (SMEs in developing countries) was not part of this study and has to be the topic for further research. The final impact (increased capacity in product innovation as well as successful product innovation projects) may only become evident in a later stage. However, taking into consideration that the final outcomes, the needs assessment tool and design manual, were commissioned and approved by the United Nations (a neutral body) and evaluated by 16 practitioners from 10 different developing countries as well as by an independent international academic review board, it is expected that the systematic approach and tools will also have their intended impact for the knowledge recipient. In addition, after finishing this study, the design manual and needs assessment tool were successfully applied in other international product innovation knowledge transfer projects such as the CP4BP project (Vietnam, Cambodia and Lao PDR) and projects in Fiji, Costa Rica, Mexico, India and Morocco. These projects demonstrated that the use of the D4S-DE approach can lead to successful outcomes within local SMEs (knowledge recipients). Meanwhile, the D4S-DE manual itself was downloaded 40.000 times from the Internet at the time of finishing this thesis and is also being used as course material at universities in Mexico, India, USA, Brazil, the Netherlands, Belgium,

Thailand, South Africa, and Costa Rica among others. As such it has proved its value for training and education at universities as well.

Yin (1994) comments that a common criticism of case studies is the difficulty of generalizing from one case to another, no matter how large the set of cases is or how profound the research itself was. In this situation, it can expected that the developed outcomes such as the systematic approach and the design manual could be generalised and used in other settings as well. The focus of this study was on its application in developing countries, but can also have its value and implication in the developed economies. Recent research projects at Delft University of Technology such as the Ecomind project (The Netherlands, United Kingdom and France) raised similar questions and needs for support. In the Ecomind project the focus is on support in the field of sustainable product innovation to start-up enterprises in Europe. The same questions and reasoning are valuable. Who is the target group, what type of knowledge need they have and what is the most preferred way to transfer it to them taking into consideration their specific characteristics? Many other examples are available to illustrate the need for a systematic approach for identifying the essential knowledge elements of a product innovation knowledge transfer process, not only in developing countries but also in developed countries. The systematic approach for the intervention developed in the form of a needs assessment tool and design manual makes it feasible to replicate and refine the intervention based on a similar format. As such it is expected that the lessons learnt as well as the outcomes of this study will be applicable for other regions (developed countries and countries in transition) and other stakeholders (i.e. government bodies, knowledge institutions such as TNO, intermediates such as Syntens, and NGOs).

Because of the broad set of topics and the multidisciplinary approach, this study did not entail a detailed analysis on a number of topics. On a national and organisational level, sufficient data could be collected and analysed. However getting detailed data and consequently detailed insight in and understanding of the knowledge recipient at an individual level was more challenging. The wide diversity of people as well as the number of participants (over 1000) made it difficult to reach detailed conclusions at this level. However, it is expected that the systematic approach and the developed needs assessment tool can guide the knowledge transfer team sufficiently in indentifying the characteristics and needs at an individual level.

The choice to perform this study by a design-based research approach (Van den Akker 1999; Plomp 2009) proved to be a proper one. The design-based research approach allowed the researcher to execute an in-depth and rich analysis of how the current product innovation knowledge transfer takes place based on literature review and empirical studies. It also offered the opportunity to design, develop and test a systematic approach and tools to improve this process in practice. In this way, the research not only resulted in an insight and understanding of the current process, but also opened ways to improve it in practice. The combination of literature review (theory) and empirical studies (practice) in the first stage of the research study led to a constructive base and conceptual framework to build on for the second stage. The second stage of the research was characterised by an evaluation by practitioners and academics that led to multidisciplinary validation and confirmation of the outcomes of the study.

As a consequence of the chosen design-based research approach, the researcher was actively involved in the empirical research (case studies) as well as in the development of the interventions in the second stage of the study. This position of the researcher had its advantages and disadvantages. The positive aspect was that the researcher had the opportunity to gain a comprehensive overview, deep insight, as well as provided directions for solutions based on early

findings within the research. A disadvantage might have been that the researcher was getting too involved and as such could not always have a broader view of the situation. However as discussed earlier, the involvement of many other stakeholders in this research project as well as the external evaluation and validation of the outcomes of this research made them representative and not influenced by subjective opinions of the researcher.

12.4 Discussion

In addition to the answers to the two research questions, several other findings and observations were made which will be discussed briefly in this section.

Firstly, the application of a needs assessment tool not only led to a more proper and efficient selection of the needed knowledge transfer components, but also contributed to a shared vision and common understanding of the different partners involved within the knowledge transfer projects. Product innovation knowledge transfer projects are complex and many stakeholders are involved. In order to achieve a proper and successful result, all partners should have the same mindset and understanding of the knowledge transfer objectives of the projects. In this case, the needs assessment was successful in facilitating this process. In addition, by facilitating this discussion it demonstrated the ability in making the existing knowledge within a team more explicit.

Within this research the focus was on the transfer of product innovation knowledge from developed countries to developing economies. This focus was chosen because a large part of the product innovation knowledge is still generated in developed countries. In practice there were also many learning experiences in the opposite direction, providing new knowledge on product innovation to the partners in Europe. The manner in which product innovation takes place in developing countries provided inspiration and new ways of thinking. Especially in the field of design for sustainability, the partners in developing countries showcased interesting and relevant cases of how to find a balance between social and ecological aspects in combination with economical growth and increased competitiveness. This thesis also delivered, by means of the case studies, insight into the local needs in the consumer markets of developing countries. As van Eijk (2007) mentioned in his inaugural speech, knowledge from emerging economies on how product innovation takes place and how culture plays a role in this is essential for Dutch enterprises to understand the local needs in emerging economies. Similar trends in product innovation and lessons from emerging economies can be observed for example in the research of the University of Botswana (Kumar, Christiaans et al. 2009).

Literature review and empirical studies can provide a good insight in and understanding of the local need for knowledge and characteristics of the knowledge recipient. However, care should be taken in not stereotyping organisations and individuals. The provided systematic approach and tools are there to facilitate the process of identifying and selecting the proper knowledge transfer components, but cannot guarantee a successful result based only on data from a database and earlier experiences. The logic, discussion and reflection within the knowledge transfer team are still crucial in order to reach a successful result. The human part cannot be ignored.

This point raises another issue: how far should the research go in making the transfer of product innovation knowledge tailor-made. The outcomes of this research demonstrated that if the elements of the product innovation knowledge transfer are adjusted to the characteristics and needs of the knowledge recipient, the expected results of the knowledge transfer project are more successful. The downside of customisation is the required amount of resources needed to

analyse the local need for knowledge and to adjust the knowledge transfer package accordingly. An appropriate and efficient balance should be found between global and local customised product innovation knowledge transfer projects.

12.5 Recommendations for further research

This thesis identified a substantial potential for improvement of the transfer of knowledge on product innovation to developing countries. However, it is expected that more improvements can be achieved which did not fall within the scope of this study. This paragraph will give recommendations to several stakeholders for further improvement.

First, it is recommended to further develop and improve the developed systematic approach and tools by testing them in practice in other situations. Not only by working with knowledge facilitators but also by monitoring the impact on the end-user: the knowledge recipients. The current systematic approach is developed for knowledge facilitators and SMEs in developing countries. It would be of interest to test the approach within an even less industrialised context, such as communities of craftsmen and the informal sector, in order to learn how it could be adapted to the needs and characteristics of this target group.

In general, it would be recommended in the future to involve more the knowledge recipients themselves in the selection of the product innovation knowledge transfer components. Still too much is decided by the knowledge source and knowledge facilitator, and not by the knowledge recipient himself, of what is relevant and how it should be transferred to them. More involvement of local stakeholders could lead to an even better insight in and understanding of the real need for product innovation knowledge in SMEs and universities in developing countries. This could be similar to the participatory approaches as being applied in Base of the Pyramid (BoP) projects (Kandachar, Jongh et al. 2009).

Effect studies with an emphasis on upscaling the intervention to a wider context, and in doing so reaching a wider audience, will be important. It should be researched if the proposed target group in developing countries is prepared for information based (internet) types of interventions. The current ongoing SPIN project on the dissemination of sustainable product innovation to SMEs in South East Asia and managed by Delft University of Technology in collaboration with UNEP is a good opportunity for this (Crul and Twickler 2009).

This study illustrated how the knowledge recipients in developing countries can be supported in general product innovation knowledge and specific knowledge on design for sustainability. In addition, it is expected that SMEs and universities in developing countries also need knowledge support in other related product innovation fields such as market research, emerging trends, quality control, etc. The United Nations (UNEP and UNIDO) could be the proper platform for making this knowledge available. It could take the lead and identify the best knowledge sources in the world and facilitate in order to make this best practice knowledge available in a proper way for knowledge recipients in developing countries.

References

Abdul Ali, M. U. Kalwani, et al. (1992). "Selecting Product Development Projects: Pioneering versus Incremental Innovation Strategies." Management Science 39(3): 255-274.

Abou-Zeid, E.-S. (2005). "A culturally aware model of inter-organizational knoweldge transfer." Knowledge Management Research & Practice(3): 146-155.

Abramowitz, M. (1989). Thinking about Growth. Cambridge, Cambridge University Press.

Adams, R. S., J. Turns, et al. (2003). "Educating effective engineering designers: the role of reflective practice." Design Studies 24: 275-294.

Adeboye, T. (1997). "Models of Innovation and Sub-Saharan Africa's Development Tragedy." Technology Analysis & Strategic Management 9(2): 213-235.

Adenikinju, A. F. (2005). Productivity performance in developing countries: Country case studies:. Vienna, Unido.

Al-Ghailani, H. H. and W. C. Moor (1995). "Technology transfer to developing countries." International Journal of Technology Management 10(7/8): 687-703.

Althuis, P., H. H. C. M. Christiaans, et al. (2004). Final report of MHO/UDSM/DUT/IDE Development of Industrial Design Engineering. Delft, CICAT, Delft University of Technology.

Amiel, T. and T. C. Reeves (2008). "Design-Based Research and Eductaional Technology: Rethinking Technology and the Research Agenda." Educational Technology & Society 11(4): 29-40.

Ansoff, H. I. (1968). Corporate Strategy. Harmondsworth, Penguin.

APQC (1999). White paper for senior management based on the internationally acclaimed study organizing and managing benchmarking, APQC (American Productivity and Quality Center).

Archer, B. L. (1974). Design awareness and planned creativity in industry. Ottowa, Department of Industry, Office of Design, Trade an Commerce.

Archibugi, D., R. Evangelista, et al. (1994). On the Definition and Measurement of Product and Process Innovation. Innovation in Technology Industries and Institutions. Studies in Schumpeterian Perspectives. Y. Hionoya and M. Perlman. Michigan, USA, University of Michigan Press.

Arnold, E., R. Allinson, et al. (2005). Make Technological Knowledge Work: A Study of teh Absorptive Capacity of Irish SMEs. Forfas. Dublin, Farfas.

Arnold, E. and M. Bell (2001). Some New Ideas About Research for Development. Partnership at the Leading Edge: A Danish Vision for Knowledge, Research and Development. Copenhagen, Danish Ministry of Foreign Affairs.

Ashton, P. Social networks and the transmission and embedding of design knowledge and innovation. 4th Proximity Economics Congress.

Ashton, P. (2004). "Social networks and the transmission and embedding of design knowledge and innovation." International Journal of Knowledge, Culture and Change Management 4.

Astill, J. (2006). Sustainable Product Design & Development: Exploring the applicability of European Experience. Tauranga, Locus Research.

Athie, M., D. Beardsley, et al. (1995). High-level advisory services to the government of Costa Rica for ecologically sustainable industrial development. Vienna, UNIDO.

Aubert, J. E. (2004). Promoting innovation in developing countries: A conceptual framework, World Bank Institute.

Ayyagari, M., T. Beck, et al. (2003). Small and Medium Enterprises across the Globe. World Bank Policy Research Working Paper 3127. W. Bank. Washington DC, World Bank.

Baas, L. (1998). Checklist 'unpacking eco-design process': Panel-ex. San Jose, CEGESTI.

Badke-Schaub, P. (2004). "Strategies of experts in engineering design: between innovation and routine behaviour." Journal of Design Research 4(2).

Bakker, C. (1995). Environmental Information for Designers. Delft, Delft University of Technology.

Bakotic, D. (2005). medium Sized Enterprises in Croatia and their Growth Strategies. Faculty of Economics. Ljubljana, University of Ljubljana. Master.

Bangens, L. (2004). Clusters of competence: forming succesfull alliances between university and industry in East Africa. Regional conference on innovation systems and innovation clusters in Africa. Bagamoyo, Tanzania.

Barab, S. and K. Squire (2004). "Design-based research: putting a stake in the ground. ." Journal of the Learning Sciences 13(1): 1-14.

Barbazette, J. (2006). Training Needs Assessment: Methods, Tools, and Techniques, Wiley.

Barrows, H. and Tamblyn (1980).

Bassani, A. and S. Scarpetta (2001). Links between Policy and Growth: Evidence from OECD Countries. OECD Economics Department Working Papers. Paris, OECD.

Bastic, M. (2004). "Succes factors in transition countries." European Journal of Innovation Management 7(1): 65-79.

Bates, D. J. and O. F. Pedgley (1998). An Industrial design team's approach to engineering design. IMC-15: Proceedings of the Fifteenth Conference of the Irish Manufacturing Committee, Jordanstown.

Baumann, H., F. Boons, et al. (2002). "Mapping the green product development field: engineering, policy and buisness perspectives." Journal of Cleaner Production 10: 409-425.

Bejakovic, P. and J. Lowther (2004). Croatian Human Resources Competitiveness Study. Zagreb, Institute of Public Finance.

Bell, M. and E. Giuliani (2007). " Catching up in the Global Wine Industry: Innovation Systems, Cluster Knowledge Networks and Firm-level Capabilities in Italy and Chile." 3(2/3): 1997-1223.

Belmane, I., R. Uselyte, et al. (2003). Eco-Design in the Baltic States' Industry. Lund, IIIEE.

Berchicci, L. (2005). The Green Entrpeneur's Challenge: The Influence of Environmental Ambition in New Product Development Industrial Design Engineering. Delft, Delft University of Technology. PhD.

Bertola, P. and J. C. Teixtera (2003). "Design as a knowledge agent. How design as a knowledge process is embedded into organisations to foster innovations." Design Studies 24: 181-194.

Bhagat, R. S., B. L. Kedia, et al. (2002). "Cultural variations in the cross border transfer of organizational knowledge: an integrative framework." Academy of Management Review 27(2): 204-221.

Biggs, T. (2002). Is Small Beautiful and Worthy of Subsidy? Literature Review. Washington, international Finance Corporation.

Biggs, T., M. Shah, et al. (1996). Technological Capability and Learning in African Firms. Technical Paper. Washington, World Bank.

Bijma, A. and J. C. Diehl (2004). Building capacity for innovation in the Tanzanian manufacturing industry. Vienna, UNIDO.

Birkinshaw, J. (2001). "Why is knowledge management so difficult?" Business Strategy Review 12(1): 11-18

Blackmore. (1996). "Pedagogy: Learning styles." Telecomunnications for remote work and learning, from http://cyg.net/~jblackmo/diglib/styl-a.html.

Blanke, J., F. Paua, et al. (2005). The Growth Competitiveness Index: Analyzing Key Underpinings of Sustained economic Growth, World Economic Forum.

Boks, C. and J. C. Diehl (2004). Integrating sustainability in business cases for Industrial Design Engineering students: A 5-year learning curve. Engineering Education in Sustainable Development EESD 2004, Barcelona.

Boks, C. and A. Stevels (2003). "Theory and Practice of Environmental Benchmarking for Consumer Electronics." Benchmarking - An International Journal 10(2): 120-135.

Bos, M., J. Verburg, et al. (2005). Ecodesign Context Manual: Identifying relevant Ecodesign context information for a specific country. Delft, Delft Univeristy of Technology.

Boschloo, R. (2005). Out of context. International implementation of innovative product development - three case studies in Croatian context. Industrial Design Engineering. Delft Delft University of Technology. M.Sc.

Breunlin, J. (Unknown). The effects of hypermedia-aided anchored instruction upon the achievement and retention of polygonal area concept in geometry.

Brezet, J. C. (1997). "Dynamics in Ecodesign Practice." UNEP Industry and Environment 20(1-2): 21-24.

Brezet, J. C. and C. G. v. Hemel (1997). Ecodesign: A promising approach to sustainable production and consumption. Paris, UNEP.

Brezet, J. C., T. v. d. Horst, et al. (1994). PROMISE Handleiding voor milieugerichte productontwikkeling. Den Haag, NOTA/SDU.

Brooks, J. G. and M. G. Brooks (1993). In Search of Understanding: The Case for Constructivist Classrooms Alexandria, Association for the Supervision and Curriculum Development.

Brouwer, E. and A. Kleinknecht (1996). "Firm size, small business presence and sales of innovative products: A micro-economic analysis." Small Business Economics 8(3): 189-201.

Brundtland, G. H. (1987). Our Common Future World. Oxford, Oxford Univeristy Press.

Bucciarelli, L. L. (2002). "Between thought and object in engineering design." Design Studies 23: 219-231.

Buckley, L. C. Starting with Culture. Sacramento, California, California State Univeristy.

Budworth, D. (1996). Finance and Innovation, International Thomson Business Press.

Buijs, J. (2003). "Modeling Product Innovation process, from Linear Logic to Circular Chaos." Creativity and innovation management 12(2).

Buijs, J. and R. Valkenburg (2000). Integrale Productontwikkeling. Utrecht, Lemma.

Camelo, C., F. Martin, et al. (1999). Explenatory factors of product innovation: the Spanish context.

Candy, L. and E. Edmonds (2003). Collaborative expertise for Creative Technology Design. Design Thinking Research Symposium 6: Expertise in Design, Sydney.

CBI (2008). Understanding modern manufacturing. C. o. B. Industry. London, Department of Business Enterprise and Regulatory Reform.

CCPC (2004). Transfer of knowledge in the field of Ecodesign. Proposal for Leonardo da Vinci Programme. Prague, Czech Cleaner Production Center.

Chaminade, C. and J. Vang (2006). Innovation Policy for Small and Medium Size SMEs in Asia: an Innovation Systems Perspective Handbook of Research on Asian Business. H. Yeung, Edward Elgar.

Charter, M. and A. Chick (1997). "Welcome to the first issue of The Journal of Sustainable Product Design." Journal of Sustainable Product Design 1(1): 5-6.

Chen, D. H. C. and C. J. Dahlman (2004). Knowledge and Development: A Cross-Section Approach. World Bank Policy Working Paper 3366, World Bank.

Chen, N.-C. (2008). "An Educational Approach to Problem-based Learning." The Kaohsiung Journal of Medical Sciences 24(3): 23-30.

Christiaans, H. H. C. M. Reader Ontwerpdidactiek. Delft, Delft University of Technology.

Christiaans, H. H. C. M. (1992). Creativity in design: the role of domain knowledge in designing. Utrecht, Lemma.

Christiaans, H. H. C. M. (2003). Porject Proposal Product Benchmark Project. Delft, Delft University of Technology.

Christiaans, H. H. C. M. (2004). Product Innovation: A Technical Benchmarking Project. Delft, Delft University of Technology.

Christiaans, H. H. C. M. (2005). Mission report February 2005 Product Benchmark Project. Delft, Delft University of Technology.

Christiaans, H. H. C. M. (2005). Mission report July 2004 Product Benchmark Project. Delft, Delft University of Technology.

Christiaans, H. H. C. M. and J. C. Diehl (2002). The Introduction of Industrial Design Engineering in Developing Countries. Designing Designers 2002, 3rd Intervention on University Courses in Industrial Design, Milan.

Christiaans, H. H. C. M. and J. C. Diehl (2003). Knowledge transfer from univeristy to industry. International Conference on Industrial Design Engineering. Dar es Salaam, UDSM.

Christiaans, H. H. C. M., J. C. Diehl, et al. (2006). The Challenge for Product Innovation in Medium Sized Enterprises in Croatia. Design 2006 Conference, Dubrovnik.

Christiaans, H. H. C. M., J. C. Diehl, et al. (2006). The Challenge for Product Innovation in Medium Sized Enterprises in Croatia. 9th International Design Conference Design 2006, Dubrovnik, Design Society.

Christiaans, H. H. C. M., J. C. Diehl, et al. (2006). NPD in Croatia: A Case Study. Design 2006 Conference, Dubrovnik.

Christiaans, H. H. C. M. and K. Dorst (1992). Cognitive models in industrial design engineering: a protocol study. DTM92 Design Theory and Methodology, New York, USA.

Christiaans, H. H. C. M. and K. Venselaar (2005). "Creativity in Design Engineering and the Role of Knowledge: Modelling the Expert." International Journal of Technology and Design Education 15: 217-236

Chung, K.-W. (2004). Korean Design Strategy and the Role of Design Education Played to Build Korea into an Industrial Giant. Design Education Forum of South Africa, Pretoria, South Africa.

Chung, K.-W. (2004). Strategic Advancement in Korean Design Promotion: How Korea has transferred itself from an Imitator to a Pioneer in Design Promotion. Expert Exchange Conference, Pretoria, South Africa.

Chute, A. (1989). Designing for intercultural teletraining, ERIC Document: ED313017.

CICAT (1997). Project proposal EU-India Economic Cross Cultural Programme. Delft, Delft University of Technology.

CII (2004). Emerging Challenges and Opportunities. Indian Global Summit on SMEs. New Delhi, CII.

Clark (2002). Proposal for a School of Design at the University of California. Irvine, California, University of California.

Clark, G., J. Kosoris, et al. (2009). "Design for Sustainability: Current trends in sustainable product design and development." Sustainability 1: 409-424.

Cohen, W. and D. Levinthal (1990). "Absorptive capacity: A new perspective of learning and innovation." Administrative Science Quarterly 35.

Conceicao, P. and M. V. Heitor (2002). Sustainable Societal Learning: A discussion of the role of the university. London, Quorum Books.

Coombs, R., P. Saviotti, et al. (1987). Economics and Technical Change, Macmillan Education Limited.

Cooper, R. G. (1979). "The dimensions of indystrial new product success and failure." Journal of marketing 43: 93-103.

Cortazzi, M. (1990). Cultural and Educational Expectations in the Language Classroom. ELT Documents 132: 54-65.
Cortazzi, M. and L. Jin (1997). Coomunicating for Learning Across Cultures. Overseas Students in Higher Education. D. McNamara and R. Harris. London, Routledge: 76-90.
Cowan, R. and D. Foray (1997). "The Economics of Codification and the Diffusion of Knowledge." Industrial and Corporate Change 67(4): 595-622.
Cross, N. (1984). Developments in design methodology. Chicester, Wiley & Sons.
Cross, N. (1990). "The nature and nurture of design ability." Design Studies 11(3).
Cross, N. (2004). "Expertise in design: an overview." Design Studies 25: 427-441.
Crul, M. (2003). Ecodesign in Central America. Design for Sustainability research program. Delft, Delft University of Technology.
Crul, M. and J. C. Diehl (1999). Transfer of European Ecodesign experiences to Central America and back. ERCP '99. Budapest.
Crul, M. and J. C. Diehl (2006). Design for Sustainability: A Practical Approach for Developing Economies Paris, United Nations Environment Program (UNEP).
Crul, M. R. M. (2002). External Evaluation of the Indian European Ecodesign Programme (IEEP). Nijmegen, Aries Environmental Consultancies.
Crul, M. R. M. and J. C. Diehl (1999). Ecodiseño: manual para la implementacion de Ecodiseño en Centroamerica. San Jose, Costa Rica, CEGESTI/DUT.
Crul, M. R. M. and J. C. Diehl (2002). Technical Report: Product Innovation for Cleaner Production. UNIDO. Vienna, UNIDO.
Crul, M. R. M. and T. Twickler (2009). SPIN: Sustainable Product Innovation in Vietnam, Cambodia and Laos. Delft, Delft University of Technology.
Cummings, J. (2003). Knowledge Sharing: A review of the Literature. Washington, The World Bank Operations Evaluation Department.
Daghfous, A. (2004). "Knowledge management as an organisational innovation: an absorptive capapcity perspective and a case study." International Journal Innovation and Learning 1(4): 409-422.
Dahl, S. (2004). Intercultural Research: The Current State of Knowledge Middlesex, Middlese University.
Dahlman, C. and R. Nelson (1995). Social absoprtion capability, national innovation systems and economic development. Social Capability and Long Term Growth. D. H. Perkins and B. h. Koo. Basingstoke, Macmillan Press.
Davenport, T. H. and L. Prusak (1998). Working knowledge: how organisations manage what they know. Boston, Harvard Business School Press.
Dewar, R. D. and J. E. Dutton (1986). "The Adoption of Radical and Incremental Innovations: An Empirical Analysis." Management Science 32(11): 1422-1433.
Dewberry, E. and P. Goggin (1996). "Spaceship Ecodesign." Co-Design: the interdisciplenary journal of design and contextual studies 5(6): 12-17.
Dicken, P. (2003). Global Shift: Reshaping the global economic map in the 21st century. London, Sage Publications.
Diehl, J. C. (2010). Product Innovation Knowledge for Developing Countries. Industrial Design Engineering. Delft, Delft University of Technology. PhD.
Diehl, J. C. and J. C. Brezet (2003). Ecodesign Methodology, tools and knowledge transfer. 1st International Meeting of Science and Technology of Design Senses and Sensibility: Linking tradition to innovation through design., Lisbon, ESD/IADE & UNIDCOM/IADE.
Diehl, J. C. and J. C. Brezet (2004). International Ecodesign Education: Development, Transfer and Local Implementation. International Conference on Engineering Education in Sustainable Development EESD 2004, Barcelona.

Diehl, J. C. and H. H. C. M. Christiaans (2003). Comparative study on the implementation of IDE in African Countries. 14th International Conference on Engineering Design ICED 03, Stockholm, Design Society.

Diehl, J. C. and H. H. C. M. Christiaans (2003). Product Innovation for Cleaner Production (Eco-Design) in Africa. International Conference on Industrial Design Engineering. Dar es Salaam, UDSM.

Diehl, J. C., H. H. C. M. Christiaans, et al. (2001). The introduction of the industrial engineering concept in Tanzania. International Conference on Engineering Design, ICED 01, Glasgow.

Diehl, J. C., M. R. M. Crul, et al. (2001). "Ecodesign in Central America, Ecodesign methodology: Product Improvement Tool (PIT)." The Journal of Sustainable Product Design 1(2): 197-205.

Diehl, J. C. and A. Mestre (2002). Indian European Ecodesign Program: Methodology and network development in India. European Roundtable of Cleaner Production. Cork, Ireland.

Diehl, J. C. and A. Mestre (2003). "Go to Sustainable Design: a new sustainable design knowledge network & forum." Journal of the Asian Design International Conference 1.

Diehl, J. C., G. V. Soumitri, et al. (2001). Ecodesign Methodology Development within the Indian European Ecodesign Program. EcoDesign 01, Tokyo, Japan.

Diehl, J. C., G. V. Soumitri, et al. (2002). Ecodesign Methodology Development within the Indian European Ecodesign Program. Ecodesign in Education: Fifth Ecodesign Workshop, Ahmadabad, IIT Delhi.

Diyamett, B. D. (2004). The concept of technological innovation: Theoretical overview and some practical implications for Africa. Regional conference on innovation systems and innovation clusters in Africa. Bagamoyo, Tanzania.

Diyamett, B. D. (2004). Innovativeness and institutional linkages in the Tanzanian manufacturing sector with reference to metal and engineering sub sector Globelics 2004, Lisbon.

Dorst, K. (1997). Describing Design: A comparion of paradigms. Industrial Design Engineering. Delft, Delft University of Technology.

Dorst, K. (2003). Exploring the structure of design problems. International Conference on Engineering Design ICED 03, Stockholm.

Drucker, P. F. (1992). "The New Society of Organizations." Harvard Business Review 70(5): 95-104.

DZDesign (1996). Diseno industrial: Beneficio para las empresas. Bilbao, DZDesign.

Ehrenfeld, J. and M. Lennox (1997). "The development and implementation of DfE programmes." Journal of Sustainable Product Design 1(1).

Eijk, D. v. (2007). Cultural diversity & design. Delft, Delft University of Technology.

Eisenhardt, K. M. (1989). "Building Theories from Case Study Research." The Academy of Management Review 14(4): 532-550.

Elias, E. (2004). Innovation identification of opportunities for product development. Industrial Design Engineering Workshop. Dar es Salaam.

Elias, E. and B. A. Majaja (2004). Industrial Design Engineering Workshop. Dar es Salaam UDSM.

Elias, E. and B. A. Majaja (2005). Interview UDSM Summer 2005. D. J.C. Dar es Salaam.

Elias, E. and N. G. Nalitolela (2003). Introduction of Industrial Design Engineering (IDE) concepts to SMEs in Tanzania: Difficulties and possibile approaches. International Conference on Industrial Design Engineering. Dar es Salaam, UDSM.

Elkington, J. (1998). Cannibals with Forks: the Tripple Bottom Line of 21st Century Business, New Society Publishers.

Eneroth, C. (2000). E-Learning for Enviornment: Improving e-Learning as a tool for Cleaner Production Education. IIIEE. Lund, Lund University.

Er, O. (1997). Nature of Design Consultancy Work for Newly Industrialised Country Clients. Ankara, Turkey, Department of Industrial Design, Middle East Technical University.
Er, O. and A. O. Ergin (2003). What makes Smes in Newly Industrialized countries innovate?: A case study of a menium-sized manufacturing company from Turkey. 5th European Academy of Design Conference, Spain.
EU (2009). Design as driver of user-centred innovation. C. o. t. E. Communities. Brussels, Commission of the European Communities.
Evers, V. (1997). Human-computer interfaces: Designing for culture. Faculty of Mathematics, Informatics, Physics and Astronomy. Amsterdam, University of Amsterdam.
Eyk, G. H. A. v. (1992). Leren van ongestructureerde ervaringen. Een instructie over het formuleren van leerervaringen, een techniek voor ervaringsleren en self-learning, Delft University of Technology, Industrial Design Engineering.
Faludi, J. (2006). "Praveen Nahar on Ecodeisgn and Development in India." from http://www.worldchanging.com/archives/004852.html.
Flick, U. (2002). An Introduction to Qualitative Research, Sage.
Forfas (2005). Making Technological Knowledge Work: A study of the Absorptive Capacity of Irish SMEs. Dublin, Forfas.
Foster, J. and I. Parker (1995). Carrying out investigations in psychology: methods and statistics, Wiley-Blackwell.
Freeman, C. (1982). The Economics of Industrial Innovation. London, Frances Pinter.
Gaillard, J. (2000). Science in Africa at the dawn of the 21st century: Tanzania. Brussels, European Commission DG XII.
Garud, R. and P. R. Nayar (1994). "Transformative capacity: Continual structuring by intertemporal technology transfer." Strategic Management Journal(15): 365-385.
Geerlings, T. and T. v. d. Veen (1980). Lesgeven en zelfstandig leren. Assen, Van Gorcum.
Geidt, J. (1996). "Distance education into group areas won't go." Open Learning 11(1): 12-21.
Goedhuys, M. (2007). "Learning, product innovation, and firm heterogenity in developing countries, evidence from Tanzania." Industrial and Corporate Change 16(2): 269-292.
Granger, D. (1995). "Supporting students at distance." Adult Learning V7 1: 22-23.
Groot, A. D. d. (1974). To what purpose, to what effect? Some problems of method and theory in the evaluation of higher education. . Methodological problems in research and higher education. Rotterdam.
Haghirian, P. (2003). Does Culture Really Matter? Cultural Influences on the Knowledge Transfer Process within Multinational Corporations. Eleventh European Conference on Information Systems, Naples, Italy.
Hall, E. T. (1966). The Hidden Dimension. New York, Doubleday and Company.
Hall, E. T. (1973). The Silent Language. New York, Doubleday.
Hall, E. T. (1977). Beyond Culture. Garden City, New York, Anchor Press/Doubleday.
Hampden-Turner, C. and F. Trompenaars (1993). The Seven Cultures of Capitalism. London, Piatkus.
Hemel, C. G. v. (1998). EcoDesign empirically explored: Design for Environment in Dutch small and medium sized enterprises. Design for Sustainability Programme. Delft, Delft University of Technology.
Herrington, A., J. Herrington, et al. (2009). Design principles for mobile learning. New technologies: new pedagogies: mobile learning in higher education. A. Herrington, J. Herrington and J. Mantei. Wollonong, University of Wollongong.
Heskett, J. (1980). Industrial Design. London, Thames and Hudson Ltd.
Hofstede, G. (1980). Culture's Consequences. Beverly Hills, Sage.
Hofstede, G. (1986). "Cultural differences in teaching and learning." International Journal of Intercultural Relation 10(3): 301-320.

Hofstede, G. (1991). Cultures and Organisations: Software of the Mind. London, McGraw-Hill.
Hofstede, G. (2002). "A summary of my ideas about national cultural differences." Retrieved 1-4, 2003, from http://www.geerthofstede.com.
Hoof, B. v. (2001). Cleaner Production Education in Colombia through Internet. European Roundtable of Cleaner Production, Lund.
Hoornstra, P. (1998). Checklist 'unpacking eco-design process': Waiman. San Jose.
HOYOS, C. A. M. (2009). SOLVING SMALL PROBLEMS INSIDE THE UNIVERSITY. National University of Singapore.
Huberman, A. M. and M. B. Miles (2002). The qualitative researcher's companion. London, Sage Publications.
ICSID (2005). Definition of Design.
IDSA (2005). ID Defined.
IMF (2008). World Economic Outlook Database.
INCAE/CLACDS and Harvard-HHID (1999). Central America in the 21st Centrury: An agenda for competitiveness and sustainable development. San Jose, Costa Rica, INCAE/CLACDS.
Inkpen, A. C. and A. Dinur (1998). The transfer and management of knowledge in the multinational corporation: considering context, Carnegie Bosch Institute of Applied Studies in International Management.
Jansen, M. (1995). Influences Upon Sustainable Product Development in the Developing World. Amsterdam, UNEP-WG-SPD.
Jensen, M. B., B. Johnson, et al. (2004). Absorptive Capacity, Forms of Knowledge and Economic Development. Working paper 2004-2, G.R.E.D.E.G., Universite de Nice.
Johnson, B. and B. A. Lundvall (2001). Why all this fuss about codified and tacit knowledge? DRUID Winter Conference Aalborg.
Jones-Evans, D. (1998). SMEs and Technology Transfer Networks - Project Summary. Pontypridd, Welsh Enterprise Institute, University of of Glamorgan.
Kacker, S. (2005). Overcoming barriers to innovation for Indian SMEs. New Delhi, Ministry Small Scale Industries.
Kandachar, P., I. d. Jongh, et al. (2009). Designing for emerging markets: Design of product and services. Delft, Delft University of Technology.
Karskarel, M. (2005). IDE in Croatia: Product Development for Adriacink. Design of an Innovative Boat Cradle for the Croation Market. Industrial Design Engineering. Delft, Delft University of Technology. M.Sc.
Kenny, C. (2004). "Why are we worried about income? Nearly everything that matters is converging." World Development 33(1): 1-19.
Kibira, D., J. B. Turyagyenda, et al. (2005). The second regional conference on innovation systems and innovative clusters in Africa. Makarere, Makarere University.
Kirschner, P., P. v. Vilsteren, et al. (1997). "The Design of a Study Environment for Acquiring Academic and Professional Competence." Studies in Higher Education 22: 151-171.
Kogut, B. (2003). Designing global strategies: comparative and competitive value-added chains. Smart Globalization. A. K. Gupta and D. E. Westney. San Francisco, Jossey-Bass.
Kostova, T. (1999). "Transnational Transfer of Strategic Organizational Practices: A Contextual Perspective. ." The Academy of Management Review 24: 308-324.
Kostova, T. (1999). "Transnational transfer of strategic organizational practices: A contextual practice." Academy of Management Review 24(2): 308-324.
Kotelnikov, V. (2005). Innovation Strategies.
Kumar, K., H. Christiaans, et al. (2009). New trends in design research: The case of designing a culturally appropriate coffin for Botswana. IASDR. Hong Kong.

Labone, R. (2003). Succes by Design: A Report and Strategic Plan. New Zealand, New Zealand Institute of Economic Research (NZIER).

Lagerstedtt, J. (2003). Functional and environmental factors in early phases of product development - Eco Functional Matrix. Department of Machine Design. Stockholm, Royal Institute of Technology.

Lall, S. (1992). "Technological capabilities and industrialization." World Development and Change 20(2): 165-186.

Lall, S. (2000). Strengthening SMEs for International Competitiveness. Oxford, University of Oxford.

Lane, P. and M. Lubatkin (1998). "Relative absorptive capacity and interorganizational learning." Strategic Management Journal 19(461–477).

Lane, P. J. and M. Lubatkin (1998). "Relative Absorptive Capacity and Interorganizational Learning. " Strategic Management Journal 19: 461-477.

Laughlin, M., B. Salome, et al. (1990). Skills training for the informal sector: analysing the success and imitations of support programmes. The informal sector revisited. Paris, OECD.

Lawson, B. (1980). How Designers Think. London, The Architectural Press.

Lederman, D. (2007). Product Innovation by Incumbent Firms in Developing Countries: The Roles of Research and Development Expenditures, Trade Policy, and the Investment Climate. Policy Research Working Paper. Washinghton, WorldBank.

Leifer, R., C. M. McDermott, et al. (2000). Radical Innovation: How Mature Companies Can Outsmart Upstarts. Cambridge, Harvard Business School Press.

Lentz, R. and D. T. Mortensen (2005). An Empirical Model of Growth Through Product Innovation. NBER Working Paper. Cambridge, MA, USA, National Bureau of Economical Research.

Lieshout, P. v. (2010). Aid for development can be better. The Broker. 19.

Liet, S. (2004). Needs Analyses Study for Industrial Design Engineering in Uganda. Delft, Delft University of Technology.

Lind, S. (2007). Adaptation of eco-design methods for SMEs in India. Environmental Sciences. Norrkoping, Linkopings Universitet. MSc. .

Lofthouse, V. A. (2004). "Investigation into the role of core industrial designers in ecodesign." Design Studies 25(2): 215-227.

Lofthouse, V. A. and T. A. Bhamra (2000). Ecodesign Integration - Part 1: Putting Co into Ecodesign. CoDesign 2000, Derby.

Lopez-Mesa, B., G. Thompson, et al. (2002). Managing uncertainty in the design and development process by appropriate methods selection. International Deisgn Conference - Design 2002, Dubrovnik.

Lundvall, B. A. and B. Johnson (1994). "The learning economy." Journal of Industrial Studies 1(23-42).

MacDonell, S., M. Shepperd, et al. (2009). "How Reliable Are Systematic Reviews in Empirical Software Engineering?".

Magnusson, T. (2001). "State-of-the-Art: A review of Ecodesign Research." Retrieved 31-7, 2003, from http://www.vinova.se/innsysfosk/F%F6rstudier/Chr%20Berggren.

Mahemba, C. M. and E. J. d. Bruijn (2003). "Innovation activities by small and medium-sized manufacturing enterprises in Tanzania." Creativity and innovation management 12(3): 162-173.

Majaja, B. A., E. Elias, et al. (2003). Un-ergonomic Practices in the Society - What is the solution? International Conference on Industrial Design Engineering. Dar es Salaam, UDSM.

Makundi, D. (2003). Flawed approach to design engineering in Tanzania. International conference on industrial design engineering, Dar es Salaam.

Marcus, A. and E. Gould (2001). Cultural Dimensions and Global Web Design: What? So What? Now What? Emeryville, CA, USA, Aaron Marcus and Associates.

Maresch, S. (1997). IEEP EU-India Cros Cultural Programme Proposal. Delft, CICAT.

Markiewicz, K. R. (2004). Firm capabilities ad absorptive capacity: Implications for Exploitationof public science and the pace of knowledge exploitation. Berkely, UC Berkely.

Marshall, C. and G. Rossman (1995). Designing Qualitative Research. London, Sage Publications.

Masera, D., M. R. M. Crul, et al. (2004). D4S for Micro and Small Enterprises. D4S-Design for Sustainability. J. C. Diehl. Delft, DUP.

Mathieux, F., D. Evrard, et al. (2008). Sustainability and adapted product ecodesign in Small Island Developing States of the South Pacific.

Maxwell, J. A. (1996). Qualitative Research Design: An Interactive Approach. Thousand Oaks, Sage Publications.

McDonough, J. and C. Shaw (1993). Materials and Methods in ELT: A Teacher's Guide. Oxford, Blackwell.

McGilly, K. (1994). Classroom lessons: Integrating cognitive theory and classroom practices. Cambridge, MIT Press.

McKenney, S., N. Nieveen, et al. (2006). Design research from a curriculum perspective. . Educational design research. London: Routledge, 62-90. J. Van den Akker, K. Gravemeijer, S. McKenney and N. Nieveen. London, Routledge: 62-90.

McIsaac, M. and C. Gunawardena. (1997). "Distance Education." from http://seamonkey.ed.asu.edu/~mscisaac/dechapter/history1.htm.

Meacham, D. and A. Zubair (1992). Models of Distance Education for Developing Island States, ERIC: ED355452.

Merriam, S. B. (1998). Qualitative research and case study applications in education. San Francisco, Jossey-Bass Publishers.

Meyers, M. (2000). "Qualitative Research and the Generalizability Question: Standing Firm with Proteus. ." The Qualitative Report 4(3/4).

MICIT and CEGESTI (1995). Needs assessment for the introduction of cleaner technologies in Costa Rica. The Hague, Dutch Ministry VROM.

Miles, M. B. and M. A. Huberman (1994). Qualitative Data Analysis: An expended Sourcebook. Thousand Oaks, California, Sage Publications.

Ministry (2002). Small and and Medium Enterprises Developemnt Policy. Dar es Salaam, Ministry of Industry and Trade.

Moffet, S., R. McAdam, et al. (2002). "Developing a model for technical and cultural factors in knowledge management: A facto analysis." Knowledge and Process Management 9(4): 237-255.

Mont, O. (2004). Product Sevice Systems: Panacea or myth? IIIEE. Lund, Lund University. PhD.

Montobbio, F. and F. Rampa (2005). "The impact of technology and structural change on export performance in nine developing countries." World Development 33(4): 527-547.

Morris, M. H., P. Jones, et al. (1997). The Informal Sector, Entrepreneurship and Economic Development.

Mosha, S. P. (2003). Needs of industry: Synergy in Industrial Design and Mechanical Engineering. International conference on industrial design engineering, Dar es Salaam.

Most, S. v. d. (2005). Qb234: Product Development in a Croatian Context. Industrial Design Engineering. Delft, Delft University of Technology. M.Sc.

Mrak, M. (2000). Globalization: Trends, Challenges and Opportunities for Countries in Transition. Vienna, UNIDO.

Mshoro, I. B. (2000). Industrial Design Engineering in Tanzania. UDSM-TU Delft Workshop on Industrial Design Engineering. Dar es Salaam, UDSM.

Mshoro, I. B. (2004). Industrial Design Engineering at the University of Dar es Salaam. Industrial Design Engineering Workshop. Dar es Salaam.
Murray, T. (2004). A conceptual examination of product design, Rua Design.
Mutlu, B. and A. Er (2003). Design Innovation: Historical and Theoretical Perspectives on Product Innovation by Design. 5th European Academy of Design Conference, Barcelona.
Mwamilla, B. L. M. (2005). Towards an innovations systems and cluster programme for Eastern Africa (ISCP-EA). The second regional conference on innovation systems and innovative clusters in Africa, Jinja-Uganda, Makarere University.
Mytelka, L. K. and F. Farinelli (2003). From local clusters to innovation systems. Systems of innovation and development, Evidence from Brasil. J. E. Cassiolato and H. M. Lastres. Cheltenham, Edward Elgar.
Nabeth, T., A. Angehrn, et al. (2002). Towards Personalized, Socially Aware and Active Knowledge Management Systems. E-2002 e-Business and e-Work Annual Conference, Prague, Czech Republic.
Nalitolela, N. G. (2002). Comments with respect to Jonathan Stranders's report. J. C. Diehl and H. H. C. M. Christiaans. Dar es Salaam.
Nalitolela, N. G. (2003). Development of Industrial Design Engineering at the University of Dar es Salaam. International conference on industrial design engineering, Dar es Salaam.
Nalitolela, N. G. (2004). Progress report MHO IDE UDSM 2004. Dar es Salaam, UDSM.
Nalitolela, N. G., E. Elias, et al. (2000). Company visits for the IDE project. Dar es Salaam UDSM & DUT.
Nickols, F. (2003). The knowledge in knowledge management, Distance Consulting.
Nieveen, N. (1999). Prototyping to reach product quality. Design approaches and tools in education and training. J. Van den Akker, R. M. Branch, K. Gustafson, N. Nieveen and T. Plomp. Boston, Kluwer academic: 125-136.
Nieveen, N. (2009). Formative evaluation in educational design research. An introduction to educational design research. T. Plomp and N. Nieveen. Enschede, SLO.
Njenga, J. K. (2005). Instructional design process in a web-based learning management system. Department of Information Systems. Cape Town, University of the Western Cape. MSc.
Nonaka, I. and H. Takeuchi (1995). The knowledge creating company: how Japanese companies create the dynamics of innovation. New York, Oxford University Press.
NRC. "Design for environment guide." 2004.
NTNU. (2000). "Ecodesign: a promising approach to sustainable production and consumption."
OECD (2004). Creativity, Innovation and Econiomic Growth in the 21st Century: An Affirmative Case for Intellectual Property Rights. Paris, France, OECD.
OECD (2004). Promoting entrepreneurship and innovative SMEs in a global economy: Towards a more responsible and inclusive globalisation, OECD.
OECD (2004). Promoting entrepreneurship and innovative SMEs in a global economy: Towards a more responsible and inclusive globalistaion, OECD.
Olofsson, D. (2003). Radical Product Innovations: A multidimensional model for identifying radical product innovations, Malardalnes Hogskola.
Oyeyinka, B. (2004). Building innovative clusters - The role of learning and local capabilities. Regional conference on innovation systems and innovation clusters in Africa. Bagamoyo, Tanzania.
Patton, M. Q. (1990). Qualitative evaluation and research methods. Newbury Park, Sage Publications.
Pérez-Nordtvedt, L., B. L. Kedia, et al. (2008). "Effectiveness and Efficiency of Cross-Border Knowledge Transfer: An Empirical Examination." Journal of Management Studies 45(4): 714-744.

Petersen, B., T. Pedersen, et al. (2001). The role of knowledge in firms' Internationalization process. Copenhagen Business School working papers. Copenhagen, Copenhagen Business School.

Pieters, J. M. (2004). "Designing artefacts for inquiry and collaboration when learners take the lead." European Educational Research Journal 3(1): 77-100.

Plomp, T. (2009). Educational Design Research: an Introduction. An introduction to educational design research. T. Plomp and N. Nieveen. Enschede, SLO.

Poelman, W. (2005). Technology Diffusion in Product Design: Towards an Integration of Technology Diffusion in Design Process. Design for Sustainability. Delft, Delft Univeristy of Technology.

Polak, M. (2001). "Power distance' dimension and methodology. Birmingham, University of Birmingham.

Polanyi, M. (1958). Personal Knowledge. Chigaco, University of Chigaco.

Polanyi, M. (1967). The Tacit Dimension. London, Routledge & Kegan Paul Ltd.

Popovic, V. (2003). General Strategic Knowledeg Models Connections and Expertise Development in Product Design. Expertise in Design: Design Thinking Research Symposium 6.

Porter, M. E. (1980). Competitive strategy. New York, The Free Press.

Punch, K. F. (1998). Introduction to social research: Quantitative and Qualitative Approaches. London, Sage Publications.

Puzzuoli, A. and N. Barakat (2009). Sustainability in Product Design and Manufacturing. Engineering Education for Betterment of Society. Grand Valley State University.

Quintana, I., A. Rebate, et al. (2000). Manual practico de ecodiseno. Bilbao, IHOBE.

Racic, D. (2004). Croatian Innovation Policy and its Effects. Zagreb Ekonomski Institut Zagreb.

Reeves, T. C. (2006). Design research from a technology perspective. Educational design research. J. Van den Akker, K. Gravemeijer, S. McKenney and N. Nieveen. London, Routledge: 52-66.

Richy, R. C. and J. D. Klein (2005). "Developmental Research Methods: Creating Knowledge form Instructional Design an Development Practice." Journal of Computing in Higher Education 16(2): 23-38.

Rodrigues, J., C. Thompson, et al. (2007). Multistakeholder approach for people centered solutions: Welcome to East Africa. Include 2007: Designing with People. Royal College of Art, London.

Romijn, H. A. (1996). Acquisition of technological capability in small firms in developing countries. Center for Economic Research. Tilburg, Tilburg University.

Roozenburg, N. F. M. (1977). De basis ontwerpcyclus. Collegedictaat Ontwerpmethodologie. Delft, Delft University of Technology, Industrial Design Engineering.

Roozenburg, N. F. M. and J. Eekels (1995). Product Design, Fundamentals and Methods. Chicester, Wiley & Sons.

Roozenburg, N. F. M. and J. Eekels (1998). Productontwerpen, structuur en methoden. Utrecht, Lemma.

Rosenberg, N. (1982). Inside the Black Box: Technology and Economics. Cambridge, University Press.

Rutkowski, J. (2003). Does Strict Employment Protection Discourage Job Creation? Evidence from Croatia. Washington, World Bank.

Sabano, R. (2004). Innovation systems and the policy environment: An overview of Uganda's industrial and support policy systems. Regional conference on innovation systems and innovation clusters in Africa. Bagamoyo, Tanzania.

Sagafi-Nejad, T. (1990). International technology transfer literature: Advances in theory, emperical research, and policy. The international communication of technology: A book of readings. R. D. Robinson. New York, Taylor & Francis.

Sampaio, C. P. d., G. Muraro, et al. (2007). Appliability of D4S methodology for development of sustainable services – sustainable

coffe shop. International Symposium on Sustainable Design. Curitiba.

Santos, A. d., C. d. Sampaio, et al. (2008). Analise da Metodologia D4S no Levantamento de Neccidades para o Projeto de um Produto. International Symposium on Sustainable Design, Curitiba.

Schnaars, S. P. (1994). Managining imitation strategies: how later entrants seizee markets from pioneers. New York, The Free Press.

Schneider, F. and D. Enste (2000). "Shadow Economies: Size Causes and Consequences." Journmal of Economic Literature 38: 80.

Schön, D. A. (1983). The reflective practicioner: howprofessionals think in action. New York, Basic Books.

Schön, D. A. (1988). Education the Reflective Practitioner. San Francisco, Jossey-Bass.

Schumpeter, J. A. (1934). The theory of Economic Development. Cambridge, Harvard University Press.

Schumpeter, J. A. (1934). The theory of economic development. Cambridge, Mass.,, Harvard University Press.

Schumpeter, J. A. (1942). Capitalism, Socialism, and democracy. New York, Harper & Brothers.

SER (2010). SER 2010 Ontwerpadvies "Meer werken aan duurzame groei. The Hague, Commissie Duurzame Ontwikkeling, Sociaal-Economische Raad.

Sherwin, C. and S. Evans (2000). Ecodesign Innovation: Is 'early' always 'best'?

Shrestha, G. (1997). A Perspective on Cultural and Linguistic Problems Associated with Distance Education in Developing Countries, Info 21 / Information and Communications Technologies for Development, UNDP.

Simbakalia, J. L. (1999). The manufacturing industry in Tanzania. Seminar on Engineers as a Resource for Sustainable National Development. Arusha.

Simonin, B. (1999). "Ambiguity and the process of knowledge transfer in strategic alliances." Strategic Management Journal 20: 595-623.

Simonin, B. L. (1999). "Ambiguity and the process of knowledge transfer in strategic alliances." Strategic Management Journal 20(7): 595-623.

Smith, A., L. Dunckley, et al. (2004). "A process model for developing usable cross-cultural web-sites." Interacting with computers 16.

Smith, H. A. and J. D. McKeen (2005). "KM Tools and Technologies: What Works and What Doesn't." KM Forum 5(3).

Smulders, B. (1999). Ecodesign possibilities in Tanzania. Dar es Salaam, CPCT & DUT.

Smulders, F. E. H. M., M. H. Kiers, et al. (1998). Handboek voor commerciele technici, Samson BedrijfsInformatie.

Soumitri, G. V. and S. Chaudhuri (2001). Starting and ecodesign movement in the Delhi region. (Eco) Design for Profit: Achieving Commercial Success, Sheffield, UK.

Soumitri, G. V., S. Chaudhuri, et al. (2003). Final Technical Report Indian European Ecodesign Programme. Delft, Delft University of Technology & IIT Delhi.

Soumitri, G. V. and J. C. Diehl (2001). The development of the Ecodesign course for Industrial Design students and professionals in India. EcoDesign 01. Tokyo, Japan.

Soumitri, G. V., J. C. Diehl, et al. (2002). Creating an Ecodesign Network in Delhi, India. Greening of Industry.

Sowden, P., S. McKibbin, et al. (2004). Skills for Innovation: Ensuring the competitive future of companies, Technopolis.

Spender, J. (1994). "Organizational Knowledge, Collective Practice and Penrose Rents." International Business Review 3(4): 353-367.

Srinivasa, S. and J. Sutz (2008). "Developing Countries and Innovation:Searching for a New Analytical Approach." Technology in Society(30): 129-140.

Stranders, J. (2002). The Need for Industrial Design Engineering in Tanzania: Evaluation of demonstration projects. Dar es Salaam, Industrial Design Engineering, Delft University of Technology.

Strauss, A. and J. Corbin (1990). Basics of qualitative research: Grounded theory procedures and techniques. Newbury Park, CA, CA: Sage Publications, Inc.

Svaljek, S. (2005). Innovations Development in Croatia. Business Hr, Zagreb.

Sz_cs, D. A. (2001). Higher Education Open and Distance Learning Knowledge Base for Decission Makers. Budapest, European Distance Education Network.

Szogs, A., C. Chaminade, et al. (2008). Building absorptive capacity in less developed countries: The case of Tanzania. CIRCLE Electronic Working Papers. R. a. C. i. t. L. E. Center for Innovation. Lund, Center for Innovation, Research and Competence in the Learning Economy.

Szulanski, G. (1996). "Exploring internal stickiness: Impediments to the transfer of best practice within the firm." Strategic Management Journal 17: 27-43.

Szulanski, G. (1999). The process of knowledge transfer: A diachronic analysis of stickiness. Strategic Management Journal, Wharton School, University of Pennsylvania. 17.

Szulanski, G. (2000). "The process of knowledge transfer: A diachronic analysis of stickiness." Organizational Behavior and Human Decission Process 82(1): 9-27.

Teece, D. (2000). "Strategies for managing knowledge assets: the role of firm structure and industrial context." Long Range Planning 33: 35-54.

Tennyson, R. D. (1991). Advancements in instructional design theory. Annual Conference of the American Educational Research Association.

Timbrell, G. T., N. M. Andrews, et al. (2001). Impediments to Inter-firm Transfer of Best Practices in an enterprise systems context. 7th Americas Conference on Information Systems. Boston: 1084-1090.

Tischner, U., E. Schminck, et al. (2000). How to do Ecodesign: A guide for environmentally and economically sound design. Berlin, Verlag Form GmbH.

Trompenaars, F. and C. Hampden-Turner (1997). Riding the waves of culture: Understanding cultural in business. London, Nicholas Brealy Publishing.

Tylee, J. Cultural issues and the online environment. Australia, Charles Sturt University.

Tynjala, P. (1998). "Traditional Studying for Examination Versus Constructivistic Learning Tasks Do Learning Outcoe Differ?" Studies in Higher Education 23: 173-189.

UN (2009). Millenium Development Goals Indicators.

UN (2009). United Nations Statistics Division.

UNCTAD (1999). Growing Micro and Small Enterprises in LDCs: The 'missing middle' in LDCs: Why micro and small enterprises are not growing. Geneva, UNCTAD.

UNIDO (2001). Tanzania: Sustainable Industrial Development and Competitiveness. Vienna, UNIDO.

UNIDO (2003). Industrial Development Report 2002/2003: Competing through Innovation and Learning, Vienna: UNIDO.

Uygur, U. (2003). Choice of knowledge transfer mechansims and difficulty of knowledge transfer within teh firm: and inquiry to teh characteristics of of knowledge. Doctoral Consortium 2003 Papers. Ontario, Queens School of Business.

Van den Akker, J. (1999). Principles and Methods of Development Research. Design approaches and tools in education and training. J. Van den Akker, R. M. Branch, K. Gustafson, N. Nieveen and T. Plomp. Boston, Kluwer academic: 1-14.

Van den Akker, J., K. Gravemeijer, et al. (2006). Educational design research London, Routledge.
Veen, W. (2001). Flexibel onderwijs voor nieuwe generaties studerenden: Inaugural Speech. Delft, Delft University of Technology.
Veenselaar, K. and H. H. C. M. Christiaans Kennis bij het oplossen van ontwerpproblemen.
Venselaar, K. and H. H. C. M. Christiaans (1990). Kennis bij het oplossen van ontwerpproblemen.
Venselaar, K., W. G. v. d. Hoop, et al. (1987). The Knowledge Base of the Designer. Regulation of learning. P. R. J. Simons and G. Beukhof. The Hague, SVO: 121-135.
Vergragt, P., J. C. Diehl, et al. (2000). Creating an Ecodesign Network in Delhi, India. Greening of Industry Asia. Bangkok.
Viljoen, A. (1997). Design education and training for devloping countries. ICSID News.
Villela, A. (2004). Chilean Experience: Collaboration between Academia and Industry in favor of the Chilean Economy: A contribution to National Competitiveness in the Latin American Market. Santiago, School of Design DuocUC.
Voeten, J., J. d. Haan, et al. (2009). Is that Innovation? Assessing Examples of Revitalized Economic Dynamics among Clusters of Small Producers in Northern Vietnam. U. MERIT. Maastricht, UNU-MERIT.
Wang, F. and M. J. Hannafin (2005). "Design-based research and technology-enhanced learning environments." Educational Technology Research and Development 53(4): 5-23.
Wangwe, S. M. and B. D. Diyamett (1998). Cooperation Between R&D Institutions and Enterprises: The Case of URT. XI Bulletin, Approaches to Science and Technology Cooperation and Capacity Building. New York, UNCTAD.
Watson, G. (1993). Strategic Benchmarking: How to rate your company's performance against the world's best. New York, Wiley.
WBI (2004). Technical Briefing to the Board: Knowledge for Development Program WBIKD. Washington, Technical Briefing to the Board: Knowledge for Development Program WBIKD.
WBSCD and UNDIO (2002). Developing Countries and Technology Cooporation: An industrial capacity-building perspective. Vienna, WBSCD/UNIDO.
Weenen, H. v. (1995). "Towards sustainable product development." Journal of Cleaner Production 3(1-2): 95-100.
Weggeman, M. (2000). Kennismanagement: de praktijk. Schiedam, Scriptum.
Weir, J., W. Lewis, et al. (2003). Solving skills for solving complex design problems. International Conference on Engineering Design ICED 03, Stockholm.
Wignaraja, G. (2003). Promoting SME exports from developing countries. Regional workshop on trade capacity building and private sector development in Asia, Pnom Penh, OECD.
Wijnans, D. (1998). Management systems and Ecodesign in Central America. San Jose, CEGESTI.
World-Bank (1999). Knowledge for Development. Oxford, University Press.
World-Bank (2000). Higher Education in Developing Countries : Peril and Promise. Washinghton, WorldBank, THE TASK FORCE ON HIGHER EDUCATION AND SOCIETY.
Worldbank (2002). Kroea: How firms use knowledge, Part A Firm Level Innovation in the Korean Economy. Washington, World Bank.
WWR (2010). Minder pretentie, meer ambitie : ontwikkelingshulp die verschil maakt. WRR, WRR. 84.
Yin, R. K. (1984). Case Study Research: Design and Methods. Newbury Park, Sage.
Yin, R. K. (1989). Case study research: Design and methods (Revised edition). Newbury Park, CA, Sage Publishing.
Yin, R. K. (1994). Case Study Research: Design and Methods (2nd edition). Beverly Hills, CA, Sage Publishing.

Zahedi, F., W. V. v. Pelt, et al. (2001). "A Conceptual Framework for International Webdesign." IEEE Transactions on professional communications 44(2).

Zahra, S. A. and G. George (2002). "Absorptive capacity: a review, reconceptualisation, and extension." Academy of Management Review 27(2): 185-203.

Zaky, A. and M. El-Faham (1998). The University-Industry Gap and Its Effects on Research and Development in Developing Countries. FIE Conference. A. A. f. S. a. Technology. Alexandria.

13 Samenvatting

De Wereld Bank, de OECD en andere financiële onderzoeksinstituten verwachten dat het overdragen van kennis op het gebied van productinnovatie aan ontwikkelingslanden één van de belangrijkste drijfveren zal zijn voor het stimuleren van concurrerende en economische groei, alsook onderdeel van de oplossing voor milieu en sociale vraagstukken. Op het ogenblik echter wordt het merendeel van deze productinnovatie kennis gegenereerd in ontwikkelde landen. Vanwege het lokale gebrek aan kennis omtrent productinnovatie in de komende tiental jaren moeten bedrijven en universiteiten (gedeeltelijk) vertrouwen op verwerving van kennis van buitenaf totdat voldoende lokale capaciteit is opgebouwd. De huidige overdracht van kennis omtrent productinnovatie is aanzienlijk kosten- en arbeidsintensief, en de inhoud en overdracht mechanieken passen niet altijd bij de behoeftes en eigenschappen van de kennisontvangers in de ontwikkelingslanden. Om aan deze gestegen behoefte aan productinnovatie kennis in de toekomst te kunnen voldoen zal een meer effectieve en betere aangewende kennisoverdracht methode noodzakelijk zijn. Hoewel de belangstelling voor het overdragen van productinnovatie kennis aan bedrijven en universiteiten in ontwikkelingslanden duidelijk stijgende is, is er een algemeen gebrek aan stelselmatige belangstelling bij wetenschappelijke instellingen en internationale organisaties, hoe de huidige kennisoverdracht plaatsvindt en hoe die kan worden verbeterd. Deze studie richt zich op dit onontgonnen onderzoeksgebied.

Het doel van deze studie was derhalve het verbeteren van de kennisoverdracht op het gebied van productinnovatie aan ontwikkelingslanden in het bijzonder aan het Midden en Klein Bedrijf (MKB) en plaatselijke wetenschappelijke instellingen zoals universiteiten. De twee centrale onderzoeksvragen voor dit onderzoek waren:

Onderzoeksvraag 1: Op welke wijze vindt de huidige overdracht van productinnovatie kennis naar kennisontvangers in ontwikkelingslanden plaats, in termen van inhoud (Wat) alsook de didactische overdrachtbeginselen (Hoe)?

Onderzoeksvraag 2: Hoe kan de overdracht van productinnovatie kennis naar ontwikkelingslanden worden verbeterd?

Aan het begin van deze studie was de verwachting dat een systematische benadering het keuze proces van de selectie van de inhoud (Wat) en de kennisoverdracht mechanismes positief zou kunnen faciliteren. Bij het beantwoorden van de onderzoeksvragen is gebruik gemaakt van een 'design-based' onderzoeksaanpak die opgebouwd is uit drie fasen: fase 1) voorafgaand onderzoek, fase 2) ontwikkelen en beoordelen, fase 3) reflectie. Binnen iedere fase zijn verschillende onderzoeksmethodes toegepast.

Fase 1: Voorafgaand onderzoek
De eerste fase van deze studie was een verkenning en beschrijving van hoe de huidige overdracht van productinnovatie kennis naar ontwikkelingslanden plaatsvindt, tezamen met de ontwikkeling

van conceptueel raamwerk, een lijst met focuspunten en een lijst met verwachtingen. Deze fase ving aan met een literatuuronderzoek (theorie) en werd afgerond met een case studie (empirisch onderzoek) Het resultaat was een antwoord op Onderzoeksvraag 1.

De hoofdstukken 2, 3 en 4 presenteren de rest van het literatuuronderzoek. Hoofdstuk 2 bespreekt het proces van de kennisoverdracht. Kennisoverdracht is een meer fasen proces en alle fasen zijn essentieel om de kennisoverdracht succesvol te maken. Er kunnen verschillende vormen van kennis worden onderscheiden, waarvan impliciete en expliciete kennis de twee uitersten zijn. Deze kenniscomponenten kunnen worden overgedragen aan een kennisontvanger (d.w.z. een persoon of organisatie) door middel van twee soorten van overdrachtstechnieken: een op personen en een op informatie gebaseerde overdrachtsmechanismes. Een op personen gebaseerde kennisoverdrachtmechanisme maakt gebruik van persoonlijke contacten, rechtstreekse communicatie en training voor de kennisoverdracht. Op informatie gebaseerde kennisoverdracht technieken maken gebruik van elektronische en handgeschreven documenten, databases en andere kunstmatige producten om de kennis over te dragen. Het type kennis en het type overdrachtmechanisme zijn vaak afhankelijk van elkaar. In dit geval wordt de overdracht van productinnovatie kennis vaak gedomineerd door impliciete kenniscomponenten, die het meest optimaal overgebracht kunnen worden door op personen gebaseerde overdracht mechanismes (d.w.z. persoonlijke uitwisseling van vaardigheden en kennis). Als gevolg daarvan is de overdracht van productinnovatie kennis doorgaans arbeidsintensief (en als zodanig kostbaar). Twee andere elementen spelen een belangrijke rol bij de overdracht van productinnovatie kennis: het vermogen om kennis op te kunnen nemen en de onderwijsbenadering. Het kennisopname vermogen van een persoon of organisatie is een belangrijke factor voor de effectieve acquisitie en toepassing van nieuwe kennis. Dit vermogen heeft invloed op zowel het niveau van de innovatie alsook de snelheid en de hoeveelheid nieuwe kennis die kan worden geabsorbeerd binnen een bepaalde periode door de kennisontvanger. Leren is de kern van het proces van kennisoverdracht. Productinnovatie onderwijs in ontwikkelde landen is vaak gebaseerd op een constructivistische benadering die kan worden gekarakteriseerd door probleemgestuurd onderwijs en met een focus op studenten. In het algemeen passen scholen en universiteiten in ontwikkelingslanden het tegenovergestelde toe: een meer docentgerichte benadering van het onderwijs, gegeven in een traditioneel klaslokaal (objectivistische benadering).

Het eerste deel van het literatuuronderzoek resulteerde in een overzicht van een aanzienlijk aantal factoren die het proces van kennisoverdracht kunnen beschrijven en beïnvloeden. Zij kunnen worden geclusterd in zes groepen: kennis, kennisoverdracht, kennisbron, kennisontvanger, verhouding tussen kennisbron en kennisontvanger, en het bredere verband. De twee daaropvolgende literatuuronderzoek hoofdstukken bespreken de factoren binnen deze groepen in meer detail.

Hoofdstuk 3 blikt terug op de inhoud van het kennisoverdracht proces. Verschillende soorten en niveaus van productinnovatie kunnen worden onderscheiden, variërend van incrementeel tot radicaal. Om op ieder niveau succesvol te zijn, zijn verschillende vormen van denken, werken en risico's nemen noodzakelijk. Daaruit volgt dat verschillende soorten kennis en instrumenten moeten worden overgedragen aan de kennisontvangers om de juiste bekwaamheden en vaardigheden op te bouwen. Over het algemeen passen incrementele productinnovaties beter bij de kenmerken van het MKB in ontwikkelingslanden, omdat er minder bekwaamheden, vaardigheden en middelen nodig zijn.

Productinnovatie zelf is nauw verbonden met het beroep industrieel ontwerpen. Industrieel ontwerpen is een algemene discipline, waarin de industrieel ontwerper basis bekwaamheden en

kennis met betrekking tot een breed scala aan onderwerpen moet ontwikkelen. Om de industrieel ontwerper te ondersteunen in het productinnovatie proces zijn verschillende methodes en instrumenten ontwikkeld (zoals het Delft Productinnovatie Model). Binnen het kennisgebied van de industrieel ontwerper kunnen drie soorten kennis worden herkend: domein specifieke basis- en ontwerpkennis, en domein onafhankelijke proceskennis. Om de kennisontvanger in staat te stellen het productinnovatie proces op de juiste wijze uit te voeren, zal hij of zij al deze drie soorten van industrieel ontwerpen kennis nodig hebben.

Hoofdstuk 4, het laatste deel van het literatuuronderzoek richt zich op de kenmerken van de kennisontvanger en de omgeving waarin hij of zij opereert in ontwikkelingslanden. Talrijke factoren kunnen worden herkend die de kenmerken van de kennisontvanger helpen te beschrijven evenals hoe zij de overdracht van productinnovatie kennis kunnen beïnvloeden. In deze studie zijn deze factoren in drie niveaus opgesplitst: nationaal, organisatorisch en individueel. Op nationaal niveau is het nationale inkomen (BNP) een snelle aanwijzing voor andere economische, industriële en sociale indicatoren. Veel factoren staan indirect verband met het BNP. Bijvoorbeeld in landen met een laag inkomen kan men verwachten dat een met landbouw en voedsel verwante industrie het nationaal inkomen beheerst (arbeidsintensief, kapitaal- en kennisextensief), dat het personeel binnen de bedrijven een laag opleidingsniveau heeft (met een laag kennisabsorberend vermogen), en dat er een relatief grotere informele sector aanwezig is en een beperkte lokale ondersteuning door kennisinstellingen voor productinnovatie zal zijn. Naast de sociaaleconomische factoren kan een land worden gekarakteriseerd door zijn culturele dimensies. Deze culturele dimensies kunnen een directe invloed hebben op het werken binnen een team gedurende een kennisoverdracht project, alsook op de kennisoverdracht binnen de organisaties en de wijze van lesgeven aan de plaatselijke kennisontvangers. Op het niveau van organisaties richt deze studie zich op het MKB in ontwikkelingslanden. Zij zijn vaak de ruggegraat van de plaatselijke economie; echter ze worden vaak geconfronteerd met grote uitdagingen om hun menselijke en institutionele capaciteiten te versterken. Over het algemeen hebben ze een gebrek aan middelen, kennis en vaardigheden binnen de organisatie en zodoende zijn zij afhankelijk van kennis en support van buitenaf. Daarnaast lijden zij schade door problemen als het ontbreken van kapitaal, toegang tot markten en financiën, en bekwaam management. Als gevolg daarvan bevinden zij zich in een cruciale positie. Het MKB kan worden gerangschikt alnaar gelang van hun technische bekwaamheden en de motivatie om te willen veranderen. Overeenkomstig kunnen verschillende soorten van ondersteuning worden verleend, teneinde ze in de richting van een grotere economische en duurzame groei te stimuleren. Op individueel niveau kan de kennisontvanger worden gekarakteriseerd op basis van zijn of haar professionele achtergrond, ervaring, attitude en motivatie met betrekking tot de specifieke productinnovatie kennisoverdracht. Derhalve hebben kennisontvangers verschillende manieren voor het absorberen van nieuwe kennis, andere manieren om in de praktijk met productinnovatie om te gaan alsmede voorkeuren voor specifieke gereedschappen en methoden.

Samen verschaffen deze drie hoofdstukken een theoretisch inzicht in hoe de overdracht van productinnovatie plaatsvindt. Het is een ingewikkeld en dynamisch systeem dat wordt beïnvloed door vele factoren, die vaak onderling verbonden zijn. Om het systeem minder complex te maken is er in hoofdstuk 5 een eerste versie van een conceptueel kader ontwikkeld dat gebaseerd is op het voorgaande literatuuronderzoek. Het doel is om een kader te bieden voor een meer efficiënte en adequate productinnovatie kennisoverdracht. Daarnaast werd een lijst van aandachtspunten en verwachtingen uit de literatuur verkregen die het conceptuele kader ondersteunen in het beschrijven van het proces van productinnovatie kennisoverdracht. Geconcludeerd werd dat de literatuurstudie niet voldoende inzicht bood over hoe de

productinnovatie kennisoverdracht in de praktijk plaatsvindt om als basis te dienen voor de volgende fase van onderzoek: de ontwikkeling van een systematische aanpak ter verbetering van het proces van productinnovatie kennisoverdracht. Een van de argumenten was dat veel samenhangende factoren tegelijkertijd een impact hebben; echter een groot deel van de literatuur beschrijft deze afzonderlijk terwijl een uitgebreid overzicht van alle factoren tezamen noodzakelijk is. Dus werd besloten dat er behoefte was aan een verdere op empirische feiten gegronde studie met het conceptueel kader als startpunt. Een case studie onderzoek zou de mogelijkheid bieden om (deels) de waarde te bepalen van dit conceptueel kader en de geïdentificeerde factoren in de praktijk, alsmede gelijktijdig het waarnemen van de vele factoren in de zelfde situatie (multi-dimensioneel perspectief). Voor de productinnovatie kennisoverdracht case studie werden vier cases geselecteerd, die betrekking hadden op alle facetten van het conceptueel kader, om te onderzoeken en beschrijven hoe de kennisoverdracht in de praktijk plaats vindt.

De geselecteerde cases waren gesitueerd in verschillende regio's op de wereld met verschillende niveaus van economische ontwikkeling (Tanzania, India, Centraal-Amerika en Kroatië).

Vervolgens werden de case studies gestart op basis van het voorlopige conceptuele kader en de lijsten van aandachtspunten en verwachtingen. Dit resulteerde in vier case beschrijvingen (hoofdstuk 6, 7, 8 en 9). Het doel was om overeenkomsten en verschillen op het gebied van overdracht mechanismen, doeltreffendheid en relevantie bij deze cases te bestuderen en die te verwerken in het ontwerp van het conceptuele kader. De case studies beschrijven in detail de gemeenschappelijke kennisoverdracht activiteiten zoals workshops, demonstratieprojecten, curriculumontwikkeling, train-de-facilitator sessies en activiteiten voor de verspreiding. Daarnaast leggen zij de nadruk op de bijzondere leerervaring binnen deze projecten, alsmede hun meest succesvolle toepassingen.

Een van de duidelijke uitkomsten van de case studies is dat het regelmatig voorkomt dat de aangeboden kennisonderdelen door de kennisbron niet goed aansluiten bij de specifieke kennis behoefte van de kennisontvanger. Bovendien werd er regelmatig waargenomen dat gedurende de kennisoverdracht projecten een verhoogd (beter) inzicht en begrip van de kennisontvanger en zijn of haar context werd bereikt en zodoende de kennisinhoud en overdracht mechanismen werden aan gepast, om beter aan te passen bij de lokale behoeften (meer op maat gesneden).

Naast de individuele case studies werd een cross case analyse (hoofdstuk 10) uitgevoerd. Net zoals ij de case beschrijvingen werd de cross case analyse uitgevoerd in twee stappen: een deductieve en een inductieve redenering. Zoals verwacht mocht worden uit het literatuuronderzoek bleek de overdracht van productinnovatie kennis in de praktijk een dynamisch en complex systeem te zijn. De verschillende case studies laten zien hoe de verschillende factoren gelijktijdig plaats vinden en hoe ze op elkaar inwerken. Het merendeel van de lijst met aandachtspunten toont aan functioneel te zijn in het beschrijven van het proces en het merendeel van de verwachtingen werden teruggevonden in de praktijk. Bovendien heeft het empirisch onderzoek geleid tot nieuwe aandachtspunten en verwachtingen die niet eerder waren gevonden in het voorafgaande literatuuronderzoek.

Tezamen geven zij een nauwkeurig inzicht hoe productinnovatie plaats vindt binnen MKB in ontwikkelingslanden (een van de hiaten die in de literatuurstudie werd vast gesteld). De oorspronkelijke onderzoeksvraag 1 en de uitkomsten van de literatuurstudie benadrukken hoe de WAT (inhoud) en HOE (de wijze van kennisoverdracht) het proces van kennisoverdracht

samenstellen. De case studies hebben aangetoond dat in de praktijk kennis ontvanger (WIE) en de projectvoorwaarden zeer invloedrijk zijn. Op basis van de bevindingen is een verfijnd conceptueel kader voorgesteld. Tegelijkertijd verschaften het conceptuele kader en de lijst met aandachtspunten en verwachtingen een antwoord op onderzoeksvraag 1.

Fase 2: Prototyping en evaluatie
De tweede fase van de studie was het ontwerp, ontwikkeling en beoordeling van een systematische aanpak en de bijbehorende instrumenten om de overdracht van kennis over productinnovatie aan ontwikkelingslanden in de praktijk te verbeteren. deze fase gaf een antwoord op onderzoeksvraag 2.

Als gevolg van de complexiteit en de vele (onderling samenhangende) factoren binnen het proces van kennisoverdracht moeten in korte tijd de kennisbronnen en kennis facilitatoren veel beslissingen nemen met betrekking tot de kennisontvangers, kennis inhoud en overdracht mechanismen. Vanwege deze en andere redenen, zoals is waargenomen in de case studies, kan het voorkomen dat wat aangeboden wordt en wat in de praktijk nodig is binnen het kennisoverdracht project slecht bij elkaar aansluiten. Als gevolg daarvan verminderen de doelmatigheid en de geschiktheid van de kennis de inhoud van het proces. Deze misstappen kunnen bijvoorbeeld ontstaan door het niet selecteren van de juiste kennisontvanger (Wie), het aanbieden van kennis op een te hoog innovatie niveau (Wat), of door in een keer te veel kennis over te brengen aan een kennisontvanger met een laag absorptievermogen (Hoe). Op basis van de verkregen inzichten uit het literatuuronderzoek en vooral het case studie onderzoek werd er van uitgegaan dat voor een groot deel deze misstappen kunnen worden voorkomen door het toepassen van een systematische aanpak voor het identificeren en selecteren van de juiste componenten.

In hoofdstuk 11 wordt een systematische stap-voor-stap benadering gepresenteerd, voortbouwend op de elementen van het conceptuele kader. De systematische aanpak heeft een sterke focus op de kenmerken van de kennisontvangers (personen en organisaties) en hun context vanwege hun cruciale invloed op de selectie van de verschillende elementen van de kennisoverdracht. Vervolgens zijn er, om deze systematische benadering operationeel te maken, twee soorten gereedschappen als interventie voorgesteld: een behoeften onderzoek gereedschap en een ontwerphandleiding. Vervolgens werden drie stellingen geformuleerd ten einde te bepalen of de ontwikkelde systematische aanpak, evaluatie van de behoeften assessment en de ontwerphandleiding passend en doeltreffend blijken te zijn in de praktijk. De systematische benadering en de bijbehorende instrumenten zijn met name ontwikkeld en gebaseerd op de uitkomsten van het eerste deel van deze studie (conceptueel kader en een lijst met aandachtspunten en verwachtingen) en de beste ervaringen uit de empirische studie.

Eerst werd de Inzicht, Begrijpen en Selectie (IUS) tool (een behoefte assessment tool) ontwikkeld in een serie van loops van ontwikkelen, testen en verbeteren. Dit instrument faciliteert de gebruiker (kennisbron- en/of kennisfacilitator) tijdens het proces van identificeren en selecteren van de juiste kennisontvanger (Wie) en de belangrijkste kennisinhoud elementen (Wat). Om een juiste beslissing en selectie te nemen met betrekking tot de kennisontvanger, moet de gebruiker eerst een helder inzicht en begrip krijgen van de kenmerken op een nationaal en regionaal niveau. Vervolgens is het belangrijk om over het juiste kennisinhoud te beslissen, waarvoor een beter begrip van de kennisontvanger op organisatorisch en individueel niveau noodzakelijk. Gebaseerd op eerder uitkomsten van hoofdstuk 4, werd IUS tool ontwikkeld. Vervolgens werd de IUS tool getest door praktijkmensen in een dagelijkse omgeving van een EU productinnovatie kennisoverdracht project. In de praktijk heeft het gebruik van het IUS

instrument tot het beoogde resultaat geleid: het op efficiënte wijze voorzien van een goed inzicht voor de kennisbron en de kennis facilitator en begrip van de context waarin de kennis zal worden toegepast en ook een eenvoudiger keuze biedt voor de juiste elementen. De tool heeft bewezen efficiënt in het gebruik te zijn en het leiden naar de selectie van de juiste kennisontvangers en de bij behorende kennisinhoud. Bovendien schept het indien het in teamverband gebruikt wordt een gedeelde visie binnen het kennisoverdracht proces. De behoeften assessment tool representeert het eerste deel van de systematische aanpak. Om het tweede deel van de systematische aanpak operationeel te maken, werd besloten om een ontwerphandleiding te ontwikkelen. Zoals waargenomen tijdens de case studies, heefthet gebruik van een ontwerphandleiding heeft aangetoond dat het een brede inzetbaarheid kan bieden binnen de verschillende productinnovatie kennisoverdracht activiteiten. Aangezien het doel van dit onderzoek is niet enkel en alleen bij te dragen aan theoretische kennisontwikkeling, maar alsook toepassen en testen van een interventie in de praktijk, is er gezocht naar de mogelijkheid voor het ontwikkelen en toepassen van een handleiding in de daadwerkelijke praktijk. De gelegenheid deed zich voor om een ontwerphandleiding voor het milieu programma van de Verenigde Naties (UNEP) te ontwikkelen: De 'Design for Sustainability handleiding voor zich ontwikkelende economieën' (D4S-DE). De D4S-DE-handleiding beschrijft in detail de benodigde kennis inhoud (Wat) voor de specifieke doelgroep (MKB in ontwikkelingslanden), alsook op welke wijze het kan worden overgedragen (Hoe). De eerder ontwikkelde en verbeterde behoeften assessment tool werd opgenomen in deze handleiding. Samen vormen zij het productinnovatie kennisoverdracht pakket waarin alle eerdere inzichten uit de empirische studie en de literatuurstudie zijn opgenomen. De D4S-DE-handleiding wordt gekenmerkt door een focus op incrementele innovatie (benchmarking en herontwerp), met inbegrip van modules over de basisprincipes van productinnovatie en andere domein specifieke ontwerpkennis, en een stap-voor-stap aanpak om ervoor te zorgen dat de kennisoverdracht past bij de eigenschappen en behoeften van de kennisontvanger.

De ontwikkelde D4S-DE-handleiding is geëvalueerd in twee stappen. In eerste instantie hebben 16 beoefenaars uit ontwikkelingslanden de ontwerphandleiding getest in een workshop setting waarbij deze werd toegepast op producten en bedrijven uit hun eigen lokale context. De deelnemers oordeelden positief over de hoofdstructuur, inhoud, en de 'learning by doing' wisselwerking tussen de handleiding en werkbladen. Het toepassen van de handleiding zorgde ervoor dat de deelnemers in een kort tijdsbestek duidelijk inzicht kregen in de verschillende benaderingen van productinnovatie, terwijl ook duidelijk voor hun werd op welke wijze deze toe te passen in hun eigen context. Een aantal suggesties voor verbetering werden verstrekt en verwerkt in de volgende versie van de handleiding. Deze versie werd beoordeeld op de inhoud en relevantie door een academische review board.

Fase 3: Reflectie
Hoofdstuk 11 eindigt met de reflectie over de drie stellingen en geeft een antwoord op onderzoeksvraag 2: een systematische aanpak, operationeel gemaakt door een combinatie van een behoeften onderzoek en een ontwerphandleiding, illustreert dat de overdracht van productinnovatie kennis kan worden verbeterd (in het geval van efficiëntie en adequaatheid).

De laatste fase van de studie, reflectie, wordt besproken in hoofdstuk 12: een retrospectieve analyse van de studie waarin de belangrijkste resultaten van het onderzoek, theoretische bijdragen, reikwijdte en beperkingen en aanbevelingen.

Dit proefschrift presenteert een systematische aanpak voor het verbeteren van de overdracht van productinnovatie kennis naar ontwikkelingslanden. Door het volgen van een systematische

aanpak, de juiste kennisontvanger en de bijbehorende kennisinhoud en kennisoverdracht mechanismen kunnen worden geïdentificeerd en geselecteerd, wat leidt tot een meer efficiënte en adequate productinnovatie kennisoverdracht proces. Als resultaat kunnen meer kennisontvangers (MKB en universiteiten) worden ondersteund, evenals worden voorzien van productinnovatie kennis die aansluit bij hun behoeften en eigenschappen. De resultaten zijn een illustratie van hoe een systematische aanpak en de bijbehorende ontwikkelde tools de overdracht van productinnovatie kennis naar ontwikkelingslanden kunnen verbeteren. De conclusies en resultaten zijn indicatief en beperkt tot het gebied van Design for Sustainability. Meer onderzoek en testen daarvan zijn nodig om de ontwikkelde systematische benadering op grotere schaal te implementeren in de ontwikkelingslanden.

14 Appendices

14.1 Clusters and factors

1. Characteristics related to the national context

National level

- Context or broader environment (Sagafi-Nejad 1990; Szulanski 1999; Fischer and Oswald 2001; Cummings 2003) – Knowledge transfer -
- Macro environment (Moffet, McAdam et al. 2002) – Knowledge transfer –
- Nationality - (Christiaans and Venselaar 2005) – Knowledge transfer -
- Level of national development (Sagafi-Nejad 1990) – Knowledge transfer -
- Absorptive capacity of host country (Sagafi-Nejad 1990) – Knowledge transfer -
- Government (Samli 1985) – Technology transfer -
- Political environment (Meacham and Zubair 1992) – Distance education –
- Political barriers (Johnson, Gatz et al. 1997) –Technology transfer –
- Political system - (Christiaans and Venselaar 2005) – Knowledge transfer
- Nationality - (Christiaans and Venselaar 2005) – Knowledge transfer
- Geography (Samli 1985) – Technology transfer –
- Geography (Meacham and Zubair 1992) – Distance education –
- People (Samli 1985) (Moffet, McAdam et al. 2002)– Knowledge transfer –
- Demographics (age and gender) (Marcus, Armitage et al. 1999; Zahedi, Pelt et al. 2001; Nabeth, Angehrn et al. 2004) – Internet knowledge transfer –
- Language differences (Er 1997) – International cooperation –
- Developing countries (Okunoye) – Knowledge management -

Economics

- Nature of domestic demand pattern (Er 1997) – International cooperation –
- Pattern of industrialisation (Er 1997) – International cooperation –
- Business drivers for Ecodesign (Brezet 1997) – Ecodesign methodology –
- Economical barriers (Johnson, Gatz et al. 1997) –Technology transfer –
- Economical system - (Christiaans and Venselaar 2005) – Knowledge transfer -
- Business (Samli 1985) – Technology transfer –
- Economics (Stewart 1977; Samli 1985) – Technology transfer –

Culture

- Culture (Moffet, McAdam et al. 2002) – Knowledge management -
- Culture (Samli 1985; Baren and Shabani 2001) – Technology transfer –
- Culture (Buckley) – International cooperation
- Cultural factors (Meacham and Zubair 1992; Granger 1995) - Distance education –
- Cultural identity (Geidt 1996) – Distance education –
- Cultural differences (Simonin 1999; Ford and Chan 2002) – Knowledge transfer -
- Cultural dimensions of Hofstede and Hall (Zahedi, Pelt et al. 2001) – Internet knowledge transfer –
- Cultural patterns (Bhagat, Kedia et al. 2002) – Knowledge transfer -
- Cultural knowledge (Zahedi, Pelt et al. 2001) - Internet knowledge transfer –
- Communication problems due to cultural background (Er 1997) – International cooperation –
- Culture (Delens 1999) – Education in developing countries –

- Compatible culture (Oldham 1967) – Technology transfer –
- Cultural and social barriers (Johnson, Gatz et al. 1997) –Technology transfer -
- Indigenous values and traditions (Delens 1999) – Education in developing countries –

Information and technology

- Nature of technology of use in recipient's context (Stewart 1977) – Technology transfer –
- Technological environment (Meacham and Zubair 1992) – Distance education –
- Infrastructure (Meacham and Zubair 1992) – Distance education -
- Technical constraints (Nabeth, Angehrn et al. 2004) – Distance education

2 Characteristics of the organisation

General

- Absorptive and learning capacities - (Cohen and Levinthal 1990; Szulanski 1996) – Knowledge transfer -
- Recipients context (Granger 1995) – Distance education
- Recipient context (Szulanski 1996; Inkpen and Dinur 1998) – Knowledge transfer -
- Organizational context (Sagafi-Nejad 1990; Inkpen and Dinur 1998) – Knowledge transfer –
- Organisational aspects (Nabeth, Angehrn et al. 2002) – Knowledge management systems –
- Recipient role in organisation (Marcus, Armitage et al. 1999; Moffet, McAdam et al. 2002; Nabeth, Angehrn et al. 2002) – Knowledge transfer –
- Communications problems due to differences in the process of decision making within organisations (Er 1997) – International cooperation –
- Learning culture (Davenport and Prusak 1998) – Knowledge transfer -

3. Characteristics of the recipient

General

- Beneficiaries play an important role (Delens 1999) – Education in developing countries -
- End-user (Flier and Bohlander 1997) –Design manuals for developing countries –
- Recipient current activity (Moffet, McAdam et al. 2002) – Knowledge transfer –

Personal competences

- Absorptive capacity (Baren and Shabani 2001) – Technology transfer –
- Knowledge already obtained (Granger 1995) – Distance education –
- Prior skills (Granger 1995) – Distance education –
- Language ability (Granger 1995) – Distance education –
- Recipient working style (Moffet, McAdam et al. 2002) – Knowledge transfer –
- Experience, competences and skills (Weggeman 2000) – Knowledge transfer-
- Experience (Marcus, Armitage et al. 1999) – Internet knowledge transfer –
- Professional knowledge (Zahedi, Pelt et al. 2001) – Internet knowledge transfer –
- Flexibility (Zahedi, Pelt et al. 2001) - Internet knowledge transfer –
- User's competences (Nabeth, Angehrn et al. 2002) – Knowledge management systems -

Education and learning

- Learning patterns and styles (Granger 1995) – Distance education –
- The recipient's learning predisposition (Cummings 2003) – Knowledge transfer –
- Nature of education (Er 1997) – International cooperation –
- Cognitive style (Marcus, Armitage et al. 1999) – Internet knowledge transfer –
- Cognitive style (Nabeth, Angehrn et al. 2002) – Knowledge management systems –
- Cognitive style (Bhagat, Kedia et al. 2002) – Knowledge transfer -
- Educational background (Marcus, Armitage et al. 1999) – Internet knowledge transfer –

Motivation

- Learning goals and motivation (Granger 1995) – Distance education –
- Motivations (Marcus, Armitage et al. 1999) – Internet knowledge transfer –
- Motivation (Szulanski 1996) – Knowledge transfer -
- Desire and motivations (Nabeth, Angehrn et al. 2002) – Knowledge management systems –
- Attitude (Weggeman 2000) – Knowledge transfer –

- Motivation (Bork 1995) – Distance education -

14.2 List of focal points

	Knowledge	**Ref.**
FP1	Two types of knowledge can be distinguished: - Tacit; - Explicit.	§2.3

	Knowledge transfer process	**Ref.**
FP2	Four successive stages of the knowledge transfer process can be distinguished: - Initiation (identifying source and decision); - Inter-relation (specify and select knowledge conduits and transfer mechanisms); - Implementation (unpack and apply); - Internalization (getting routinized).	§2.4
FP3	Four types of knowledge transfer can be distinguished: - Socialization: tacit → tacit (i.e. apprenticeship) - Externalization: tacit → explicit (i.e. classroom teaching); - Combination: explicit → explicit (i.e. best practice database); - Internalization: explicit → tacit (identify, acquire and apply in own organization);	§2.3
FP4	Two types of knowledge transfer mechanisms can be distinguished: - Information-based (more efficient for transfer of explicit knowledge); - People-based (more efficient for transfer of tacit knowledge).	§2.5
FP5	Two types of teaching approaches can be distinguished: - Objectivism; - Constructivism.	§2.7

	Source	**Ref.**
FP6	Innovation is the development and successful application of a new and successful idea. Successful application refers to 'successful' to the market.	§3.1
FP7	Two extreme levels of novelty of innovation can be distinguished: - Incremental; - Radical.	§3.2
FP8	Four different innovation approaches fit within 'product innovation' (as defined within this thesis): - Product innovation; - Market innovation; - Service innovation; - A combination of above.	§3.2
FP9	A company can address product innovation in different strategic ways: - Market penetration strategy; - New product development; - New market development; - Diversification. The first three strategies have a lower risk for failure than the last one.	§3.3
FP10	Four levels of product innovation can be distinguished: - Product improvement; - Product redesign; - New product; - New function fulfilment.	§3.2
FP11	Industrial design knowledge can be divided into: - Domain specific knowledge (basic and design knowledge);	§3.6

	Domain independent knowledge (process knowledge).	
FP12	Within the Design for Sustainability approach three separate aspects can be distinguished: People; Profit; Planet.	§3.7

	Project level	**Ref.**
FP13	Project objectives (funding organisation and executing organisation) ⇒ Target group ⇒ Knowledge content ⇒ Ambition (i.e. awareness, demonstrate, capacity building)	§2.3

	Recipient at national level	**Ref.**
FP14	The business environment expressed in GCI is closely related to the GDP (low GDP → low GCI → low business environment).	§4.2.2
FP15	The social development expressed in HDI is closely linked to the GDP (low GDP → low HDI → low social development).	§4.2.2
FP16	The main economical activities (agriculture, industry and service) of a country are correlated to the GDP (low GDP → more agricultural activities, middle GDP → more industrial activities, high GDP → more service activities).	§4.2.3
FP17	Whether labour or knowledge intensive industries are dominant is correlated to the GDP (low GDP → labour intensive, high GDP → knowledge intensive)	§4.2.3
FP18	The general level of education of staff in a country is correlated to the GDP (low GDP → low education level).	§4.2.4
FP19	The general level of R&D efforts is correlated to the GDP (low GDP → low R&D effort).	§4.2.4
FP20	R&D in developing countries mainly takes place in public institutions. These institutions are not well connected to the needs of SMEs.	§4.2.4
FP21	There is a direct correlation between the design competitiveness and a country's GCI (low GCI → low design competitiveness).	§4.2.5
FP22	Based upon the cultural dimensions of Geert Hofstede an indication can be made of the way of working in local companies and universities.	§4.2.6
FP23	Based upon the cultural dimensions of Geert Hofstede an indication can be made of the way of teaching and learning at local universities.	§4.2.6
FP24	Individualistic societies prefer explicit and independent knowledge, collectivistic societies prefer tacit and systemic knowledge.	§4.2.6
	At organisational level	
FP25	Based upon their size (amount of staff) four types of enterprises can be distinguished: Large sized enterprises; Medium sized enterprises; Small sized enterprises; Micro enterprises.	§4.3.1 §4.3.2
FP26	Depending on their legal way of operating two types of enterprises can be distinguished: Informal sector; Formal sector.	§4.3.3
FP27	SMEs in developing often lack off capital, access to markets, finances and marketing capabilities.	§4.2.3
FP28	Especially small- and micro enterprises in developing countries have a lack of qualified personnel and have a limited absorptive capacity.	§4.3.4
FP29	Companies can be categorized on: Their awareness of their need of change; As well as if they know how to.	§4.3.4

FP30	Companies can be categorized on their technological capabilities. 1. Low technology SMEs; 2. Minimal technology SMEs; 3. Technology competent enterprises; 4. R&D rich enterprises.	§4.3.4
FP31	The integration of innovation in SMEs should be done in a gradual manner, building upon the resources and capabilities available in a company.	§4.3.4
FP32	The majority of the innovation activities of SMEs in developing countries are of incremental level.	§4.3.3
FP33	Companies in developing countries often develop products by copying or benchmarking products from competitors.	§4.3.3
FP34	Based upon their earlier experiences with product development, two types of companies can be distinguished: - Product companies; - Capacity companies.	§4.4.4
	At individual level	
FP35	Different professional backgrounds in the field of design can be distinguished: - Industrial design; - Industrial design engineering; - Design engineering.	§4.4.1 §4.4.2
FP36	Two type of designers can be distinguished: - Novice designer; - Expert designer.	§4.4.3
FP37	A positive attitude and motivation plays an important role in the knowledge transfer process.	§4.4.4

14.3 Details projects and demonstration projects

See www.jcdiehl.nl/phd

14.4 Guidelines

Project set-up:

P1. Involve all stakeholders in an early stage in writing the project proposal.
P2. Define clear objectives and make a clear order of priority.
P3. Assess and clearly define the knowledge gap and knowledge need.
P4. Assess and clearly define the proper knowledge transfer mechanisms.

Train the Facilitator:

T1. Provide a clear incentive to the knowledge facilitators (fee, guaranteed work, etc.).
T2. Provide the trainers with clear insights and understanding of the socio-economical and industrial context of the facilitators.
T3. Decide which product innovation level is proper for the context.
T4. Assess the knowledge base of the participants. Identify how much 'basic' and 'design' domain specific knowledge the participants have.
T5. Provide training content at the appropriate product innovation level.
T6. Include teaching and trainings skills.
T7. Apply constructivist, problem-based learning approaches.
T8. Fine tune training program according to 2, 3, 4, 5 and 6.
T9. Ask participants to identify beforehand a local company and to bring some of their products as well as company information.
T10. Use example of the local context of the participant. Alternatively use of examples from countries with a similar socio-economical and industrial development.
T11. Preferably a longer training period (3-4 weeks) in order to make time for applying and internalizing the gained knowledge.
T12. If second TtF, involve or make local (earlier trained) staff responsible.

Selection of demonstration organisations:

S1. Make explicit the project objectives for the demonstration projects into account.
S2. Allocate sufficient financial and staff resources for the company selection.
S3. Get a good insight and understanding of the socio-economic and industrial development.
S4. Make a stepwise selection starting at macro level, next sector level and finally company and individual level.
S5. Define clear selection criteria for each step of the selection.
S6. Make a short list of companies and visit them.

Demonstration projects:

D1. Make clear what the objectives (and their priority) of the demonstration projects are for the different stakeholders. Communicate the objectives openly to all stakeholders.
D2. Ask a (limited) financial contribution from the company to get commitment and involvement of staff and management.
D3. Assess the product innovation experience and skills of company and staff.
D4. Assess the absorptive capacity of the company and staff.
D5. Select innovation level accordingly to 3 and 4.
D6. Decide upon the setup of the demonstration projects. Student variant A or B, as well the involvement of (inter)national experts.
D7. Preferably a minimal duration of 6-8 months.
D8. Work towards tangible outputs like mock-ups or prototypes.
D9. Organize a sequence of demonstration projects within the same company in order to internalize the knowledge in the organisation.

Workshops

W1. Make clear what the objective(s) of the workshop are.
W2. Workshops for industry should be short, preferably on-site and focussed on short term solutions.
W3. Workshops with academics, NGOs and other stakeholders can be more prolonged and focussed on more radical innovation approaches.
W4. Workshops for SMEs should be preferably with hands-on exercises.
W5. Identify the appropriate innovation level for the audience.

Tools

Z1. Provide basic tools for structured product innovation.
Z2. Provide basic tools for goal finding and market research.
Z3. Provide basic tools for benchmarking.
Z4. Tools for SMEs have to be simple, request limited time and should lead to direct results.
Z5. Put more focus on internal drivers.
Z6. Add also people aspects

14.5 IUS Needs Assessment Tool

See www.jcdiehl.nl/phd

14.6 D4S-DE Design Manual

See www.jcdiehl.nl/phd

14.7 Changes

Content in general

Incremental innovation	Focus on benchmarking and redesign (product innovation level 1 & 2).
People	Consistent consideration at all stages for the People (social) aspects next to the Planet and Profit aspects.

Writing style	Simple, non-academic and practice oriented.

Structure

Clear parts	Part 1 'What and why D4S', Part 2 'How to do D4S, and Part 3 'Reference information'.
Modular	Depending on the user, different modules can be selected.
Product innovation	A module on product innovation has been integrated to introduce and explain the product innovation process.
D4S Needs assessment	A module on D4S Needs Assessment has been integrated to facilitate the selection of knowledge recipients and knowledge content.
D4S Benchmarking	A module on D4S Benchmarking has been integrated.
Cases	A module with case descriptions from developing countries has been integrated.
Creativity techniques	A module on Creativity Techniques has been integrated.

Module Design for Sustainability

Drivers general	Examples of drivers for developed as well as for developing countries.
People drivers	Next to Planet and Profit drivers also People drivers.
Internal drivers	Emphasis on internal drivers and examples of cost reduction opportunities.

Module Product Innovation

Innovation levels	Clear explanation of the differences between incremental and radical innovation approaches.
Vision & Mission	Strong emphasis on developing a clear vision and mission development.
Product-Market Strategy	Attention to product-market strategies to make the user aware and to confront with the current product strategy by using Ansoff and Porter Matrix.
Developing Economies	Attention to the role of product innovation in (companies in) developing economies.

Module D4S Needs Assessment

Project Level	To confront the team with objectives of the project and the demonstration projects, and to create a shared vision.
National Level	To provide insight and understanding in the socio-economical and industrial development.
Benchmarking	By comparing the national data with other countries more insight in the relative value is gained.
Sector Level	To provide insight and understanding in characteristics of the sector.
Company Level	To provide insight and understanding in the characteristics of company.
Support Level	To provide insight and understanding in local support for product innovation.
Action Plan	To make an action plan which activities, regional stakeholders, funding options etc. can be included (see figure underneath).

Figure: Making an action plan for a D4S project as part of the D4S Needs Assessment.

Module D4S Redesign

Steps	Additional steps have been added to take the user more by the hand through the process.
Goals Company	A the start a focus on the goals of the company to become aware of the their goals within the project.
Product vs capacity	Assessment to become aware of the design competencies of the company (product versus capacity company).
SWOT & D4S Drivers	To use the SWOT-analyses and D4S Drivers first to assess the company and next for the selected product.
Life cycle thinking	More emphasize on lifecycle thinking by developing a clear lifecycle of the total value chain.
D4S Matrix	The D4S matrix has replaced the MET matrix.
Priority D4S Matrix	The team is requested to decide on which impacts are most critical for the project and to indicate their priority in the D4S matrix.
Identify D4S Strategy	The user has to define D4S strategies based upon the 'D4S Matrix' as well as based upon the 'D4S-Drivers' and has to decide based upon this which strategies are the best to focus upon (see figure underneath).

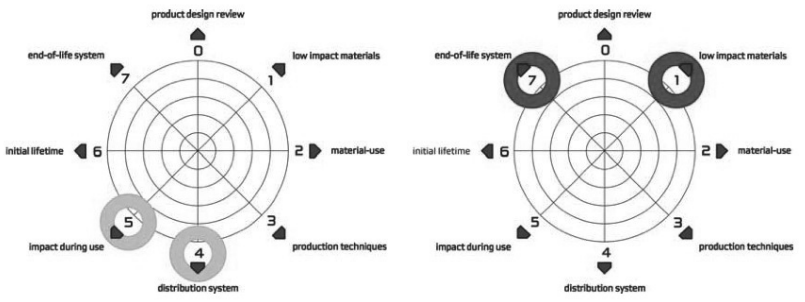


Figure: Example of D4S strategy selection based upon priorities of the D4S Matrix and the D4S Drivers.

Chapter D4S Benchmarking

Steps	Additional steps and clear instructions have been added to take the user more by the hand through the process.
Virtual Benchmark	A 'virtual' benchmark approach has been introduced based upon internet research and visits to fairs and shops.
Light Version	A light, simplified 'all in one sheet' benchmark has been developed for companies with limited time and resources.

Flexible Focal Areas	The focal areas have been made flexible and can be adjusted to the goals of the project or specific sustainability context aspects.
Sector Specific	For specific sectors like the food-processing, tailor made benchmark worksheets have been developed

	BASED UPON INFORMATION OF PRODUCT OF COMPETITORS	BASED UPON PHYSICAL PRODUCTS OF COMPETITORS
Light version (All-in-one worksheet)	A	B
Extended version (10 worksheets)	C	D

Figure: The different kind of D4S Benchmark approaches.

Worksheets and tools

Step-by-step	Additional steps and clear instructions have been added to take the user more by the hand through the process.
Connection	Each step of the approaches is connected to its own worksheet. Clear reference to the worksheets is provided in the manual.
More	An extended range of worksheets (75 pages)
Clear Instructions	Clear instructions are provided in the manual how to fill in the worksheets (see figure underneath)
Priority Setting	A stronger emphasis on prioritising and selection within the results in the worksheets.

> *Based on Step 2, what are the product selection criteria?* > ***Worksheet R3***

If possible, the product should:
> Have sufficient potential for change;
> Be relatively simple (in order to achieve fast results and to avoid extensive research); and
> Be affected by the identified D4S drivers for the company.

> *Select a product out of the company portfolio that fits defined D4S product selection criteria.*
> ***Worksheet R3***

Figure: Instructions for the use of the worksheets within the D4S manual.

Cases and examples

Short examples	Short examples in the D4S Redesign and D4S Benchmark modules and detailed case descriptions in the D4S case studies module.
Specific sectors	Examples and cases are mainly related to agro-related, food, packaging and simple products.
World-wide	Examples of all continents have been included
All stages	Examples for all stages of the D4S process have been included
Priority Setting	A stronger emphasis on prioritising and selection within the results in the Worksheets.

Dissemination

Internet	Digital version for free on the internet

15 Short Curriculum Vitae of Johan Carel Diehl

Johan Carel Diehl (1969) after finishing his study in Industrial Design Engineering he worked several years as consultant in Ecodesign. He currsently works at the Design for Sustainability (DfS) research program at Delft University of Technology (DUT) as an assistant professor. Within the DfS program he is managing the international projects on sustainable product innovation especially in emerging markets. Since 2004 the main focus of his research is on 'Design for the Base of the Pyramid (BoP)' and has he been involved in over 60 BoP projects mainly in Asia and Africa (i.e. Philips, Procter and Gamble, Microsoft, PeePoople, Tough Stuff, Kiva and Kamworks). Next to his position at DUT he is consultant for UNIDO and UNEP and invited lecturer at universities in amongst others Portugal, Colombia, Mexico, Turkey, Japan and Austria. He is co-author of the UNEP Design for Sustainability manual for Developing Economies (D4S-DE) and the Design for Sustainability Step-by-Step (D4S-SBS) manual.

More information can be found at:

www.jcdiehl.nl
www.d4s-de.org
www.d4s-sbs.org

Delft University of Technology

Design for Sustainability program

The transfer of knowledge on product innovation to small- and medium-sized enterprises and local knowledge institutions in developing countries is expected to be one of the key drivers for competiveness and economical growth, and a part of the solution to environmental and social challenge. In that respect, this PhD study focuses on how the process of the current knowledge transfer takes place and how it can be improved. A combination of literature review and empirical research has resulted into a conceptual framework to describe the complex and dynamic process of product innovation knowledge transfer to developing countries. In order to improve this process, a systematic approach has been developed and operationalized by a needs assessment tool and a design manual: The UNEP Design for Sustainability for Developing Economies (D4S-DE) Manual (www.d4s-de.org). Both tools have been tested in practice by practitioners and have been evaluated by an academic review board.

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