PRODUCT AND PROCESS NOVELTY IN SMALL COMPANIES' DESIGN PROCESSES: A MULTIPLE CASE STUDY

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ABSTRACT

This study explores the design processes in small established companies and investigates how these design processes are executed. How two different kinds of novelty influence the design processes is further examined: the relative novelty of the product being developed and the relative novelty of design processes. The relative novelty of the product is high if it is a radically new product to develop. High relative novelty for design processes typically means no experience or knowledge about design processes. Based on an embedded multiple case study of three small established companies in Sweden, eight different design processes are described and analyzed. The results show that the design processes differ, even within the same company. The results also show that relative novelty affects the design process. If the relative novelty of both the product to be developed and of design processes is low, a linear, structured, and systematic design process was found to work. A design process that is cyclical, experimental, and knowledge-creating seems to work no matter the relative novelty.

Keywords: Design process, small companies, novelty, new product development, innovation

1. INTRODUCTION

Most literature in new product development and design is derived from research on large companies (Larsson 2001; O'Shea & McBain 1999; Tidd et al. 2005) and its relevance for smaller companies is doubtful due to small and large companies' different economic and technical environments (Audretsch 2001). Design processes are a poorly researched area in small established companies (Larsson 2001; Moultrie et al. 2006; Moultrie et al. 2007), as is the impact of novelty aspects on the same design processes. This lack of knowledge justifies this explorative study on small established companies´ design processes.

1.1 PURPOSE

The purpose of this study is to expand knowledge of design processes in small established companies by empirically analysing them within the companies' new product development processes. The explorative research questions are:

- *How do small established companies execute their design processes within their new product development activities?*
- *How do the relative novelty of the product being developed and the relative novelty of design processes to the designers and others involved affect the design process?*

2. FRAME OF REFERENCE

2.1 *SOME CHARACTERISTICS OF DESIGN PROCESSES AND DESIGN PROCESS MODELS*

This study sees the design process as a part of the new product development process and uses a generic design process model by Cross (2008) as model of reference. The model is depicted in Figure 1 below.

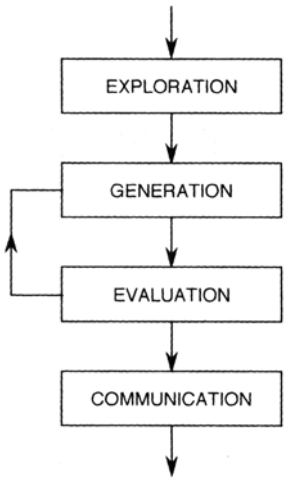

Figure 1. A four-stage model of the design process (Cross 2008).

The design process model by Cross (2008) has four stages. Stage one consists of exploring the design problem. A design problem can be vague, messy, fuzzy, incomplete, inconsistent, and even imaginary in places (Cross 2008; Jonassen 2000), and must be explored and defined more clearly before it can be solved. Stage two consists of the generation of possible solutions to the design problem, when different solutions are created and the solution space is explored. In stage three the evaluation of the solutions is conducted, aimed at finding the best overall solution that solves the design problem. The final and fourth stage is about the description of the final design for communication of the result, to incorporate it in the later parts of the new product development process. Iteration is common in design processes; an iteration loop is present between the evaluation and generation stage. The design process model is quite linear because all exploration of the design problem is completed before the generation and evaluation of different solutions to the design problem.

A point that distinguishes different models of the design process is that the models can be linear or cyclical (O'Shea & McBain 1999) with iterative loops of learning experiments. In more linear design process models, most of the analysis of the design problem is done prior to the generation and evaluation of different solutions. In more cyclical design process models, the analysis is not completed prior to the generation and evaluation of solutions; rather analysis, generation, and evaluation are done after each other in cyclical loops. Linear design process models are suitable if the product to develop is incremental, the design problem to solve is well-defined, and the product's characteristics and properties are well-known in advance. Cyclical models are suitable if the product to be developed is radically new, with an ill-defined design problem and more unknown characteristics and properties (O'Shea & McBain 1999). The cyclical part is a knowledge-creating process in which different solutions are generated and tested on the largely unknown design problem to gain more knowledge of the product to be realized. Linear and formalized design processes can be counterproductive and unsuitable due to the need for flexibility when high uncertainty is present, as the case

normally is in the development of radically new products (Herstatt & Verworn 2001; Lynn & Akgun 1998).

Tidd and Bodley (2002) examined how project novelty (i.e., the novelty of the product to be developed) influenced the new product development process. The novelty is the relative novelty, in practice the novelty experienced by the designers and others involved in the new product development process. Tidd and Bodley (2002) found that companies had different new product development processes within the same companies, and used different methods and tools depending on the relative novelty of the development project. For projects with high relative novelty, some methods and approaches were seen as more useful and more commonly used, such as focus groups; customer cooperation, involvement, and development; market experimentation; prototyping; heavy-weight project managers and cross-functional teams; marketing; and R&D involvement. Most of these methods and approaches are used to facilitate and increase interaction and communication with the market, customers, and users. Indirectly this means that good contact and communication with the market, customer and users are needed in more radical new product development activities. If the relative novelty of the product to develop is high, it becomes hard to rationally plan the design process in a linear manner, because the goal of the process, the product, is so ill-defined and fuzzy (O'Shea & McBain 1999; Karlson 1994; Herstatt & Verworn 2001). What can be perceived as highly novel for one company can be routine for another company; with increased experience developing a certain product the relative novelty will decrease (Tidd & Bodley 2002). High relative novelty of the product to be developed can mean no experience or knowledge of similar products or the context the product will work in, abstract and ill-defined properties and characteristics, and a highly complex and large design problem. The relative novelty of the product is probably the highest the first time a certain product is designed by a company.

Although not investigated by Tidd and Bodley, it seems interesting to examine whether the novelty of design processes to the designers and others involved has an impact on the design process. Design processes are risky, highly complex, and difficult (Tidd & Bodley 2002), and for a new and inexperienced designer they can be hard to manage and execute. It is probable that the relative novelty of the product and the relative novelty of the design process are connected. Designing an ill-defined and complex product with a large design problem probably represents an extensive and complex design process, which will probably increase the relative novelty for that process. It is reasonable to expect the relative novelty of design processes to decrease with increased experience and knowledge about design processes.

2.2 SMALL COMPANIES AND DESIGN PROCESSES

This study looks at small established companies in non-high-tech businesses with less than 50 employees. What is meant with the word established is that the companies are not in their start-up process, have been established within their markets for several years, and have developed their own products that they sell. The companies also have their own new product development and design activities that are mainly run in house, with the companies' own resources. These small companies often have scarce resources (Rothwell 1989; Rothwell & Dodgson 1994; Welsh & White 1981), flat organization and are often working in a turbulent organization (Moultrie et al. 2007) within a highly uncertain environment (Ratcliffe-Martin & Sackett 2001; Westhead & Storey 1996). Other common characteristics are flexibility, fast, and informal communication, low bureaucracy, and rapid decision-making (Adams 1982; Cannon 1985; Vossen 1998).

Small companies are often close to their customers and users (Rothwell & Dodgson 1994; Schmidt-Kretschmer et al. 2007).

Design processes in small companies are a poorly researched area; studies have mostly been done on a managerial level (Larsson 2001; Moultrie et al. 2006; Moultrie et al. 2007). Exceptions to this are studies done by Guimarães et al. (1996) and Larsson (2001). Both found that the design processes in small companies were informal, unstructured, and without formal control. The small companies used their own informal design methods and their use of formal methods was limited, with the exception of prototyping and sketching. The owner/manager was usually involved, together with other employees, and often the owner/manager was the creative engine. The use of external expertise was rare; knowledge needed in the process was mainly gained from suppliers or other small company owners/managers. The small companies were close to their customers and feedback from customer and users during the design processes and afterward was common and extensive. Previous experience and common sense were used in the design processes; lack of knowledge and resources necessitated improvising and creativity in the use of existing knowledge and resources. The design processes were highly search-oriented, dynamic, and iterative, with cyclical loops. Larsson (2001) alone found concurrent design activities with early attention paid to economic, manufacturing, and marketing aspects. Commitment to design activities was often combined with marketing activities. Tacit knowledge and intuition were also found to be important in the design processes. Small companies often lack the qualifications and resources for a methodologically systematic design process (Franke et al. 2003).

3. METHODOLOGY

Design processes are often complex and have unclear boundaries (Cross 2008). A qualitative, embedded multi-case study approach was chosen because it allows the researcher to understand the studied phenomenon and its context in more depth (Yin 2003).

3.1 SAMPLE SELECTION

Small established companies with their own products and design activities were recruited for this study. Three small established companies in Sweden that fulfill these criteria were studied. These companies were chosen to represent the range in the number of new or improved products launched. The number of new or improved products launched presumably indicates the existence of a working design process that fosters new products. One of the companies, a software developing company, can be considered a technology-based service company, which may be seen as an odd one to include when design is frequently equated with engineering (Veryzer 2005), which traditionally deals with the design of physical artifacts. But research into design processes in service development firms shows that service companies' design processes are quite similar both in content and theory (Candi 2007; Smith et al. 2007; Berkley 1996). Moultrie et al. (2007) claim that design processes can be applied to all kinds of creative processes, and Ullman (2002) explicitly states that design methodology is directly applicable to software design processes. Some differences between design problems do appear when considering design in software and in physical artifacts. Ullman (2002) states that all design problems are ill-defined, which means that the information needed for solving the problem is initially missing and must be filled in to understand the problem. Design problems in software design are better structured and defined than most other design problems due to the constraints of language and systems

(Jonassen 2000). Design problems in software development are also relatively free from issues relating to purchasing, production, materials, logistics, and distribution, all of which are normally much more important in the design of physical artifacts. Table 1 displays some of the characteristics of the three companies in the study.

Table 1. Some Characteristics of the Three Companies in the Study

Characteristics	**Company 1**	**Company 2**	**Company 3**
Firm Type	B2B Manufacturer	B2B Software	B2B and B2C Manufacturer
Products	Technical floors	Booking systems for tourism industry	Small wood refinement machines
Number of New or Improved Products Launched per Year	Approximately one small improvement of an existing product	Several improvements of an existing product	Several new or improved products
Employees	23	9	25
Customers	One big, many small	Many small	Many small
People Executing the Design Processes	2	6	3
Leadership, Strategy and Resources Committed to New Product Development	Unclear leadership and strategy. Few resources for NPD	Clear leadership and strategy. Resources committed to NPD	Clear leadership and strategy. Many resources committed to NPD
Organization that Suits and Supports NPD	Poor delegation of power, low communication and creative climate	Delegation of power and authority. Intense internal communication and highly creative climate	Delegation of power and authority. Intense internal communication and highly creative climate
Proactive Linkages between NPD Activities and Internal and External Actors	No, only reactive to customer requests. Poor linkages between NPD activities and other actors	Proactive and reactive. Many different linkages to internal and external actors, with intense communication	Proactive and reactive. Many different linkages to internal and external actors, with intense communication

3.2 OBSERVATIONS AND INTERVIEWS

The design activities and their context were observed in companies 1 and 2 four days a week over a period of five months and documented in field diaries. Usually many activities were going on simultaneously at the companies, so design activities were often put aside for more urgent business. A lot of the research time at the companies consisted of waiting for the design activities to occur, but this waiting approach made it possible to study design activities when they occurred naturally in their natural

environment. Tacit knowledge (Polanyi 1967) of the design processes could be captured with this approach.

Semi-structured interviews were also carried out with persons involved in or related to the design activities within companies 1 and 2. In Company 1 five interviews were conducted, in Company 2, six interviews. In addition to these interviews many new product development and design subjects were discussed informally with the persons interviewed and others at the companies or in the companies' contexts. Field notes were used during the interviews. In an attempt to recollect as much as possible, the data was analyzed within a 24-hour period. Important questions and issues that arose in earlier interviews were asked in later interviews. The answers given during the interviews were cross-checked in the observations done.

Company 3 had a substantial amount of secondary data available about the company and its design activities. Examples of these secondary data were brochures, newspaper articles, the company's own newspaper, extensive website information and different manuals. Neither Company 1 nor 2 had much secondary data. Secondary data from small companies is often rare or unavailable (Davis et al. 1985). This secondary data from Company 3 made it possible to get a good understanding of their design processes. The studies of companies 1 and 2 were performed prior to the study of Company 3. Later a visit was paid to Company 3 with a two-and-a-half-hour semi-structured interview with the product development manager, a 15-minute informal meeting with the manager/owner/founder of the company, and a short guided walk around the company premises. The findings from the studies already conducted of companies 1 and 2 made it possible to fine-tune questions and to focus more upon the most relevant and interesting areas in small company design processes.

4. FINDINGS

Each case study is described below with the design processes found.

4.1 THE DESIGN PROCESSES IN COMPANY 1

The development and design of new products is rare in Company 1, although they have plenty of good ideas for new product development. New products launched are merely incremental variants of existing products that are requested by the largest customer. There are doubts about how to execute design processes in the company. Three different design processes could be observed: the realized small modification design process, the unrealized small attempts design process, and the large new product design process.

4.1.1 THE REALIZED SMALL MODIFICATION DESIGN PROCESS

This design process is informal and done by the product development manager. In this design process smaller modifications are made to the company's existing products. It is a kind of trial and error approach, where existing designs are manipulated with experience in mind and then tested to see whether they still work. The relatively novelty of the product is low when seen from the designers' point of view, but the relative novelty for design processes is high due to the product development manager's limited experience and knowledge about design processes. Usually the design problem to be solved is somewhat fuzzy and ill-defined but not so complex. To examine the design problem sketches are done and needed knowledge is collected informally with contacts within the company and with the customer. Geometry, assembly, and strength studies of existing designs and informal sketches of some new design proposals are then done, and

a first virtual proposal is designed in a 3D CAD program, with the help of an external consultant. Rendered pictures of the new design are then shown to the customer at a fine-tuning meeting. If the customer is pleased with the design and thinks it will work, design drawings are done and a prototype is built and tested in an external research institute. If the customer is not pleased, a new proposal is designed, and so on in a cyclical manner. If a customer-approved prototype passes the test, the new product is manufactured and assembled and later sent and installed at the customer's location. If the design does not pass the test, it is modified and tested again in a cyclical manner. In relation to the design process model of reference by Cross (2008), exploration, generation, and evaluation are done in a cyclical way when the parts contain different contents, activities, and actors. The communication stage is present when a working prototype is finished.

4.1.2 THE UNREALIZED SMALL ATTEMPTS DESIGN PROCESS

Company 1 sometimes makes smaller attempts to develop new products that usually do not go through the whole design process and become realized. These small attempts consist of informal sessions when the actors, such as the product development manager, other managers, employees and external experts in the company's external network, meet and discuss different development ideas. This work can be described as a cyclic and iterative process of analysis, synthesis, and evaluation, aiming at understanding the design problem and finding different solutions to the problem. Informal sketching is common in this design process. The product ideas to develop usually have a high relative novelty, but the design process has a medium relative novelty and the way of working is quite natural for the participants. Difficulties arise when finishing the design process. These attempts often become shelved or abandoned due to scarce resources, difficulties in getting the right information, technical difficulties and uncertainties, and/or disturbance from other more urgent activities in the company. There is not always a customer to buy the potential new product in the end and that can contribute to a decrease in motivation to finish the design process if difficulties and uncertainties occur. In relation to Cross's generic design process model (Cross 2008), this design process is more cyclic when exploration, generation, and evaluation are done in cyclical loops. The communication stage is not present because the ideas are usually not realized.

4.1.3 THE LARGE NEW PRODUCT DESIGN PROCESS

Upon request from the largest customer, Company 1 tried to develop a completely new version of one of their existing products. A specification of the new product was done by the customer but it was poor and ill-defined in several areas and unrealistic in others. To execute this design process the company tried a systematic, linear approach that they had never tried before. A formal project plan of the design work was created and time, resources, goals, and activities were specified and planned in time, but in reality this plan was never followed and the way of executing the design process slipped over to a more cyclical approach. Resources allotted to the project were scarce and day-to-day activities in the company stole time and resources from the project. The relative novelty of the product to develop was high and the relative novelty of a systematic, linear design process to those involved was also high, because there was no history, experience, or deeper knowledge of systematic design work in the company. Internal communication and external communication with the customer were also low during the process. The design problem to be solved was never analysed properly and the work was quickly reduced to finding a solution to a design problem only partially known. Jonassen (2000) concludes that the most important key to problem solving is to

construct the design problem, which was not done. Alternative solutions were not investigated properly and one solution inspired by a competitor product was developed and designed in detail. This solution was later criticized and abandoned because it was not more flexible and not cheaper than their current product. No more design work was done on the project and the result was wasted time and resources and unsatisfied team members. The initial planned, systematic, and linear design process was quite similar to Cross's generic design process model (Cross 2008), but that changed to a way of working that consisted of exploration, generation, and evaluation in a more cyclic way that was more natural for those involved. The communication stage was not present because the project was abandoned.

4.2 THE DESIGN PROCESSES IN COMPANY 2

Company 2 practices both formal and their own informal methods to execute their design processes. The company is well skilled in project management and planning. The design problems to be solved by the company are quite limited and structured. This, together with their familiarity with the domain, experience with similar design problems, and extensive knowledge about and communication with their customers and users, all contribute to the company planning the design work and executing it in a systematic and linear way. They can accurately determine in advance the final product's characteristics and properties, which make the novelty low for the products being designed. Those executing the design processes are also well skilled and educated in systematic approaches. The company's extensive experience in design processes makes the relative novelty of design processes low. The company has three different design processes: the small standard design process, the customer-specific design process, and the large standard design process.

4.2.1 THE SMALL STANDARD DESIGN PROCESS

In the small standard design process the relative novelty is low both for design processes and for the product to be developed. The products are usually small, relatively uncomplicated upgrades to the main software product. The design problems are well defined, structured and not so complex, and they do not need extensive analysis. The exploration of the design problem is done by informal talk with others in the company and/or phone contact with customers and users that experienced the problem to be solved. The generation, in this case the programming, is done more directly and the code often becomes untidy. The new code is evaluated by the company before it is communicated and implemented in the main software product. This design process is usually done by one or maybe two employees. The design process is similar to Cross's generic design process model (Cross 2008) and is quite linear, with some iteration between the evaluation and generation stages.

4.2.2 THE CUSTOMER-SPECIFIC DESIGN PROCESS

The customer-specific design process is used for larger development projects that aim at solving a specific customer's problem or need. The design process starts with a formal analysis phase. This analysis phase is usually done in close interaction with the customer to get the right specifications for the project. It is common that this work is done at the customer's location with the customer in the real environment for the new product. Design work can even be done by the customer. Later all requirements for the new product are gathered in a specification and a project document with planned activities that all involved must approve. The synthesis starts with an abstract analysis

of the design problem, where the overall structure and function and sub-functions are investigated and the connections are analyzed and described. Visualization and abstraction are commonly used methods. This work is later followed by detailed programming of the sub-functions that solve the abstract design problem. Interface and usability aspects are handled in an ad hoc way during the programming. Prototypes and mock-ups are commonly used for testing concepts and solutions and to get feedback and ideas from others at the company, as well as the customer and users. The product developed is later tested in several steps. The code is tested by the company and the functions are tested both by the company and the ordering customer. When satisfactory, the product is delivered to the customer. The design process is similar to Cross's generic design process model (Cross 2008) and is quite linear, with some iteration between the evaluation and generation stages.

4.2.3 THE LARGE STANDARD DESIGN PROCESS

The large standard design process is used for large development projects that can take several years. One design process of this kind aims at improving the interface of the main software product. Extensive planning and specification activities and some synthesis activities have been done in this project so far. Annual customer and user meetings are held to get feedback and ideas about the project. Overall this design process includes all activities, aspects, and characteristics of the customer-specific design process, with the exception of its size and time horizon. The design process is similar to Cross's generic design process model (Cross 2008) and is quite linear, with some iteration between the evaluation and generation stages until the design problem is solved.

4.3 *THE DESIGN PROCESSES IN COMPANY 3*

Company 3 has an official description of how they work with their design processes, but no distinct design process model. Most activities in Company 3 concern marketing and new product development; all production and almost all assembly are outsourced. The company has a strong tradition of, and applies considerable resources to, new product development and design. The relative novelty of design processes is low due to the designers' great experience with designing products. The relative novelty for the products to be developed is usually high because the final properties and characteristics of the products often are fuzzy and unclear. The design activities are not formally planned and several design processes are usually executed concurrently in a somewhat chaotic manner within certain frames and constraints. These frames and constraints can be seen as a general and abstract specification of properties and characteristics that all products developed by the company should fulfil, but that can be questioned if good reasons exist. The company's contact with customers and users is intense, friendly, and close. Two different design processes could be identified: the open experimental design process within certain constraints and the lead user design process.

4.3.1 THE OPEN EXPERIMENTAL DESIGN PROCESS WITHIN CERTAIN CONSTRAINTS

Most of the work with this design process is done by the new product development manager and one engineer. Sometimes the owner/manager also contributes. The design process is open; customers, users, employees, external experts, manufacturers, and others are free to take a look and contribute ideas and feedback on the design process, and they do take advantage of this freedom. The company actively searches for feedback during the design process, because they value the different knowledge and

way of thinking each person brings. Marketing, in this case relation marketing (Gummesson 2002) with existing customers and users, is closely related to this design process. The company finds it hard to evaluate their ideas without developing them further. The usual approach is to run many design projects concurrently and develop the projects as far as is feasible in order to evaluate them properly. Approximately one-fourth of all projects survives and become new products.

This design process usually has a fuzzy and unclear starting point. It typically starts with sessions of sketching to externalize the ideas and to communicate and examine the design problem and possible solutions. This is usually done by the product development manager. Function and form are concurrently developed during these sessions. The solutions are a mix of rough overall solutions and more detailed sub-solutions. There is early consideration of production, economic, logistics, and marketing issues. Between the sessions there is an incubation time, when totally different work is performed. Paper models, mock-ups and simple prototypes are built to evaluate ideas and solutions. Later a working prototype is built to see if the final concept works. The working prototype is the basis for the later stages of the new product development process.

In relation to Cross's generic design process model (Cross 2008), this design process is cyclic with iterative loops of exploration, generation, and evaluation. Different solutions are tested on the ill-defined design problem and evaluated with customer and user feedback to gain new knowledge about the problem in order to generate more solutions to test, and so on. This approach brings the overall design process forward, due to the design problem and solution space being explored. The communication stage is present when a working prototype is finished. The company does not want to work in a more structured manner because it would decrease their flexibility. A more linear, structured, and systematic way of working would also not fit with their close, unstructured, and flexible customer and user interaction. Extensive external feedback, past knowledge, new knowledge, constraints and intuition all keep the design processes on track in the right directions.

4.3.2 THE LEAD USER DESIGN PROCESS

The company has many lead users (von Hippel 1988) that modify and develop the company's products on their own. The customer and users are free to come and visit the company whenever they want to; they do so and show their inventions to the company and give them away for free. How the lead users execute their design processes when developing their inventions is not covered in this study but if the company believes in the lead user invention they adopt it, which gives them the solution for an identified user problem for free and saves design work. The company usually cannot adopt a lead user invention directly without modifying or adjusting it so it will fit within the company's frames and constraints. In relation to Cross's generic design process model (Cross 2008), the design processes done by customers and users are unknown, but if the company adopts a lead user invention a cyclical design process starts that is similar to the open experimental design process within certain constraints. The communication stage is present when a working prototype is finished.

5. DISCUSSION

5.1 THE DESIGN PROCESSES ON A GENERIC LEVEL

The design processes examined differ considerably due to the different products and contexts. On a generic level, the model of reference, Cross's generic design process

model (Cross 2008), mirrored the more linear design processes of Company 2. The processes were more linear because most exploration and analysis of the design problem was done before the generation and evaluation of different solutions. Companies 1 and 3 had more cyclical design processes similar to the small company design processes described in the studies by Guimarães et al. (1996) and Larsson (2001). Most of the analysis of the design problem was not done before the generation of solutions but rather in several steps in the cyclical iterative loops of exploration, generation and evaluation. This cyclical process would be more accurately captured by Cross's design process model (Cross 2008) if an extra feedback loop were added between the evaluation and exploration parts, as depicted in the left part of Figure 2 below.

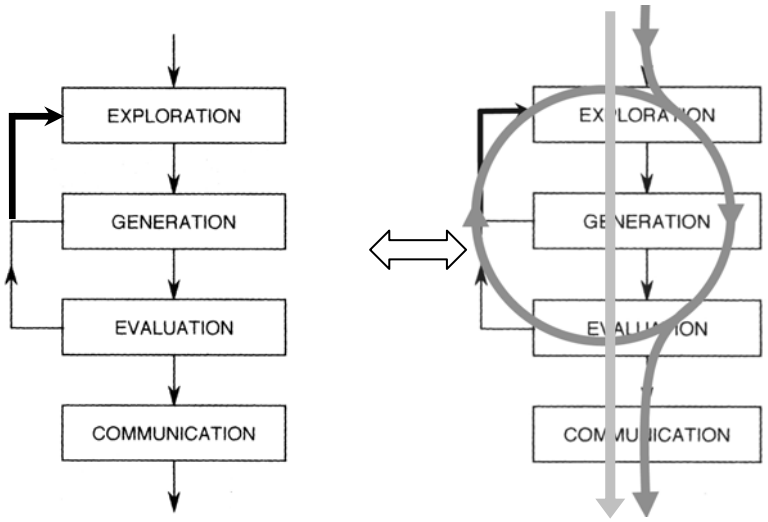

Figure 2. A modified four-stage model of the design process.

The modified generic design process model above manages to mirror all design processes in this study on a generic level, because design processes can be both linear and cyclical in the model, as shown in the right part of Figure 2.

5.2 THE RELATIVE NOVELTY OF THE DESIGN PROCESSES

Tidd and Bodley (2002) concluded that (a) the project novelty (i.e., the novelty of the product to be developed) influenced the new product development process and (b) increased market, customer, and user communication were more important when the relative project novelty was high. Both of these conclusions were the case in this study too, but an unexpected finding was that extensive market, customer, and user interaction were also present in design processes when there was low relative novelty. The examined companies' natural and close relations with their customers and users, as well as the turbulent and uncertain environment, could be the explaining factors for this. A turbulent and uncertain environment is common for small companies (Ratcliffe-Martin & Sackett 2001; Westhead & Storey 1996). It is possible that this extra uncertainty affects the design process and adds extra relative novelty to the design processes, making closer contact and communication with the market, customer, and users needed in the design processes with the least relative novelty as well.

The relative novelty of design processes was also examined in this study. The matrix in Figure 3 shows the different design processes mapped against the relative novelty of the product to be developed and the relative novelty of design processes. Unfinished design processes are marked with a white dot and realized design processes with a grey dot.

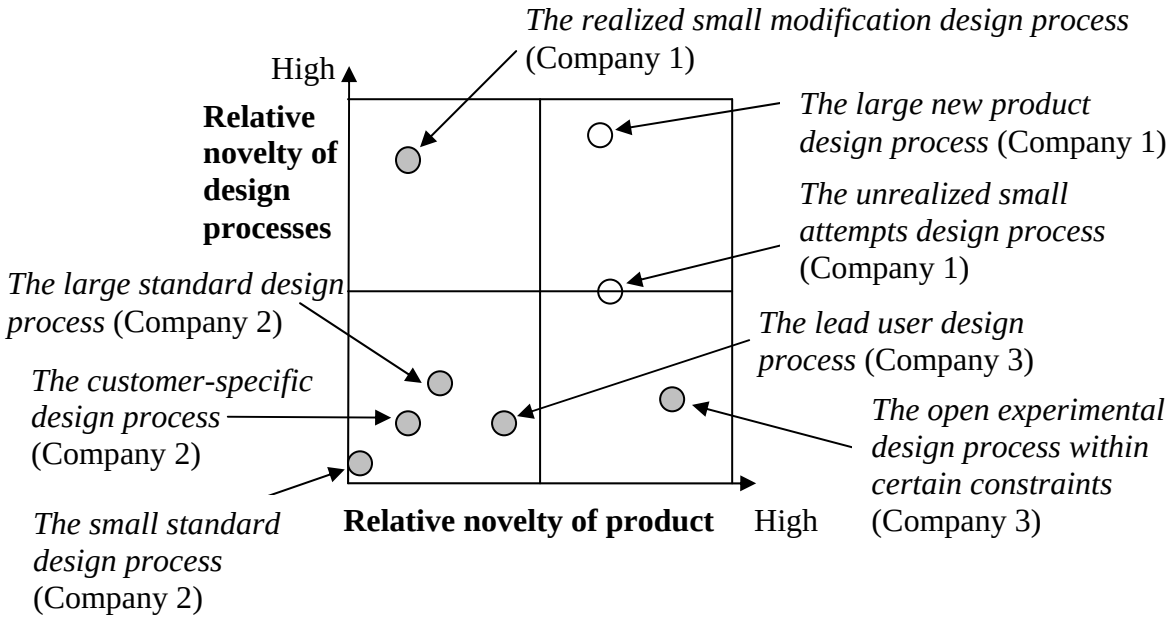

Figure 3. The relative novelty of the product and design processes.

Note that the three examined companies have design processes in all fields of the matrix and that in the most novel part of the matrix the design processes were discontinued. This indicates the difficulty of managing and executing design processes with high relative novelty. A more cyclical, experimental, and knowledge-creating design process was used when either (or both) the relative novelty of the product to develop or the relative novelty for design processes was high. If the relative novelty of both kinds was low, both cyclical, experimental, and knowledge-creating design processes and linear, systematic, and structured design processes were used.

Companies 2 and 3, which execute many design processes, were also best at performing their design processes, in the sense of launching the most new products. They had experience and knowledge about design processes that lowered their relative novelty. In Company 1 there were doubts about how to execute design processes and the relative novelty for design processes was high. Only in the products that were least novel to develop were the design processes finished (the realized small modification design process). Company 1 seems to lack the experience and knowledge needed to manage to design new products with a high relative novelty; they probably need to train and learn more to accomplish that. To clarify, all design processes and products being designed at Company 2 were low in relative novelty. The relative novelty only increased with the size of the design problem. Company 3 manages to design highly novel products because of their great experience and knowledge about design processes. In the lead user design process the relatively novelty of the product to be developed is lower than in the open experimental design process within certain constraints, because when the lead users present their inventions for the company the company will see and understand most of the characteristics and properties of the product to be developed. In other words, they will know with high certainty what the product will be in the end, and that lowers the relative novelty.

5.3 STRUCTURED, SYSTEMATIC, AND FORMAL DESIGN PROCESSES AND SMALL COMPANIES

According to Larsson (2001) there is an upper limit of about 25 employees before a manufacturing company must begin to add structure to different processes. With

increased company size it becomes more difficult to coordinate, communicate, control, and manage different activities and processes within the company. Companies 1 and 3 are manufacturing companies with about 25 employees each, at Larsson's (2001) limit for increased structure. In Company 3 the informal structure of the design processes consists of the overall constraints and frames that all the companies' products should fulfil. Company 3 does not want more structure within their design processes because of a perceived decrease in needed flexibility. Company 3's customers and users are an important and fairly large constituent in the design processes, and the interaction with them is informal, unstructured, and uncoordinated. If Company 3 tried to formalize and structure the design work more, it would be unrealistic to expect them to formalize and add structure to the interaction with their market, customers, and users. The forces controlling the design processes in Company 3 are the extensive external feedback from the market, customers and users in combination with the employees' great experience and knowledge of design processes. In Company 2 the same mechanisms control the design processes in addition to the project planning. An extensive push for external feedback from the market, customers, and users during the design processes in small companies was found by Larsson (2001), Guimarães et al. (1996) and Moultrie et al. (2006) and seems to be an efficient way to gain extra resources and to steer and control the design processes in small companies. It is reasonable to assume that Company 3 has found a good balance between control, coordination, formality, experimentation, and flexibility in their design processes.

It may be harder to say something about the structure need for Company 1's design processes, because of their lack of experience and knowledge of design processes. In the large new product design process, it is clear that when a formal, linear, systematic, and structured design process was tried, it was less successful. A more flexible, informal, cyclical design process turned out to be more natural for those involved. Although the result of this process was unsatisfactory, the first formal, linear, and structured approach cannot be blamed alone; even Herstatt and Verworn (2001) state that a linear and formalized design approach might be counterproductive and unsuitable if high uncertainty is present, which was the case when the relative novelty was high. The scarce and insufficient resources for the project are another explanation, as was the poor communication and feedback from the market, customers, and users during the project. It is also possible that the frequent lack of structure and coordination in Company 1's other activities and processes created difficulties for interaction with a structured and systematic design process. That design processes in small companies interact with other processes in the company is common (Tidd et al. 2005; Bodin 2000; Pilemalm 2002). In Company 1's realized small modification design process, a cyclical, informal, experimental, and knowledge-creating approach was used that was more successful and natural for those involved. The relative novelty of the product to develop was low due to a modest and limited design problem. The relative novelty of design processes was higher but could be managed because of the limited design problem. There was some contact with the customer during this design process and the feedback contributed to the successful result. The unrealized small attempts design process in Company 1 was also executed in a cyclic, experimental, and knowledge-creating way by employees at the company and other invited external experts, but the design processes were usually not finished.

Company 2's linear, structured and systematic design approach did not work well in Company 1's large new product design process. What distinguishes Company 2's design processes from the large new product design process in Company 1 is that the

design problems were well structured and better defined, as is typical in software design (Jonassen 2000), and the relative novelty was low both for the products to be developed and for the design processes. What can be said from the realized small modification design process in Company 1 and Company 3's design processes is that a cyclic, experimental, and knowledge-creating design process worked and was quite natural for the employees involved if there was contact, communication, interaction, and feedback from customers and users. From examining Company 2's design processes we can conclude that a linear, structured, and systematic design process is working if the relative novelty is low for both the product to develop and design processes and when there is contact, communication, interaction, and feedback from the market, customers, and users.

Combining these observations, this study shows that contact, communication, interaction and feedback from the market, customers and users are crucial for small companies during all their design processes. Yet it is still reasonable to assume as Tidd and Bodley (2002) found that more communication is needed and the need increases as relative novelty increases. The study also shows that increased experience and knowledge about design processes decreased the relative novelty of the design process for the actors involved. Another interesting thing is that either a cyclical, experimental, and knowledge-creating design process or a linear, structured, and systematic design process can work well if the relative novelty for the product to develop and the relative novelty of design processes are both low. Modifying Figure 3 above to depict the different kinds of design processes, we obtain a picture of the approaches in the design processes of small established companies (Figure 4).

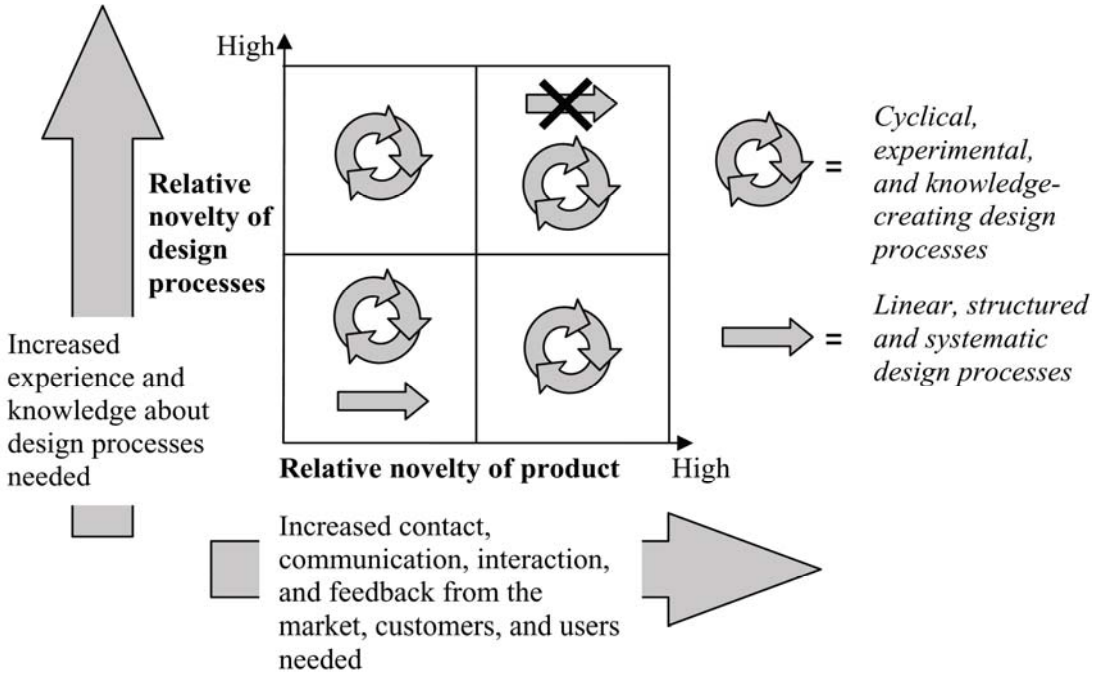

Figure 4. Design processes in small companies in relation to relative novelty.

6. CONCLUSIONS AND FURTHER RESEARCH

The findings show that small established companies have different design processes even within the same company. All design processes examined included exploration, generation, and evaluation stages, executed either in a linear or a cyclical manner. The communication stage was only present in realized design processes. The generic design

process model of reference by Cross (2008) was found valid in the more linear design processes. If the model of reference is slightly modified with an extra feedback loop it manages to mirror all realized design processes in the study on a generic level.

If the relative novelty of design processes and the product to be developed is low for those involved in the design processes, a linear, structured, and systematic design process was found to work. The same design process was found not to work if both examined novelties were high and there was poor external communication, interaction, and feedback from the market, customers, and users. A cyclical, experimental, and knowledge-creating design process was found to work if the relative novelty of design processes and/or the product to develop was high for those involved in the design processes, but this cyclical approach also worked when both the examined relative novelties were low.

Interaction with the market, customers, and users was found to be a crucial activity in all design processes examined. Customers and users seem to have several important functions in the small companies' design processes. They give feedback during the design processes that helps to steer and control the process, and they do actual design work either with the companies or on their own that they then give away for free to the companies.

Further research could consist of taking a closer look at the concept of relative novelty, examining its content in more detail, and determining how its details influence the design process. Another interesting topic would be to take a closer look at the formal and informal design methods that are used within the design processes described above.

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