HELSINKI UNIVERSITY OF TECHNOLOGY

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Process and Methods of User-Centered Concept Development

Licentiate Thesis

Supervisor:

Professor (pro tem) Marko Nieminen

Espoo, February 13th, 2006

HELSINKI UNIVERSITY OF TECHNOLOGY	ABSTRACT OF LICENTIATE THESIS

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The development of new products and services in a user-centered manner is a challenging and in parts uncharted territory with multiple stakeholders and viewpoint. This thesis enlightens user-centered concept development with process descriptions and theory behind the commonly used methodology. The derived process is constructed from prior-art and lessons learned from 23 case studies. It joins together the general product development process, user-centered design approach and creative design processes to create new innovative product concepts. The characteristics of user-centered concept development depicted in this thesis are based on the attached four publications describing the process, developed methods and their evolution.

Keywords: Human-centred design, user-centred design, product development, concept development process, user research methods, idea generation methods, visualizations and envisionment methods, concept evaluation methods

TEKNILLINEN KORKEAKOULU	**LISENSIAATINTUTKIMUKSEN TIIVISTELMÄ**

Tekijä: Mika P. Nieminen

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Valvoja:	ma. Professori Marko Nieminen

Uusien tuotteiden ja palveluiden kehittäminen käyttäjän tarpeet huomioiden on haastava ja osittain tuntematon tutkimusalue, jossa on useita osapuolia ja näkökulmia. Tässä työssä kuvataan käyttäjäkeskeinen konseptisuunnittelu prosessinmallien ja siinä sovellettavien menetelmien avulla. Kehitetty prosessi rakentuu aiemman teorian ja 23 tapaustutkimuksen pohjalle. Se nivoo yhteen perinteisen tuotekehitysprosessin, käyttäjäkeskeisen suunnittelun periaatteet ja luovat suunnittelumenetelmät, pystyäkseen tuottamaan uusia innovatiivisia tuotekonsepteja. Tässä työssä kuvattu käyttäjäkeskeisen konseptisuunnittelun prosessi ja menetelmät pohjautuvat oheisiin neljään julkaisuun, jotka kuvaavat prosessimallin, kehitetyt menetelmät ja niissä tapahtuneen kehityksen.

Avainsanat: Ihmislähtöinen suunnittelu, käyttäjäkeskeinen suunnittelu, tuotekehitys, konseptisuunnittelun prosessi, käyttäjätutkimusmenetelmät, havainnollistamismenetelmät, konseptien arviointimenetelmät

Foreword

The roots of my interest towards concept development can be found from the Digital Media Concept, a project in Nokia research center during 1995-1996 as I spent a year developing first concepts for digital television interactive service offering [32]. Later, without my further participation, the set-top-box came about, but alas none of the services were to be found.

Later when re-entering the service of Helsinki University of Technology (TKK), after six bustling years of Internet frenzy [39], I took upon myself the responsibility of teaching the course “User-Centred Concept Design”. Not having sufficient amount of time for preparations during the first year I merely reproduced the curriculum based on the earlier course materials heavily biased towards capturing the user experience and introducing design laden with almost mystical secrets of inner sight.

Time and again the same questions surfaced from the eager engineering students: How do you exactly know what the users need? How to proceed as we do not know what we are doing?

As I did not know, I could not help them and the results of that year’s course were various to say the least. Some students came up with breath-taking concepts of virtualized working arrangements, while others just reworded the assignment with existing products. Somehow to an engineer this kind of uncontrollable development was unacceptable.

During the next three years I tried to formulate and define the process of user-centered concept development and courageously applied it to all my side-projects, those of my own device, some funded by EU or National Technology agency of Finnish. I shamelessly used the course and its students as guinea pigs for my goal. To come up with a plan.

> A way to create new product concepts in a way that is understandable,
> does not require magical designer talents and yet
> produces above average concepts…
>
> **– every time –**

And while doing that another problem raised its head. How does one differentiate a good concept from a bad one? At the end did we reach the goal?

In a way this thesis is something to get you started on all things new. I courageously claim that there is no need to separate real-life product development from a job well done at a university course. To you as the reader this may be a process model to apply or a course textbook to learn from.

I must admit this is only part one of the book. The iteration with developing and testing the process and methodology in projects and courses takes time. Thus, at this thesis I am reporting with conviction and published proof the process and its evolution and methodology for the first half of it. The latter half, while applied in abundance at the course, is still untried on real development projects.

Acknowledgements

I would like to first and foremost thank UPJ for making this licentiate thesis necessary, quick and cost efficient. I would also like to thank all the partners that have contributed to the projects making this work possible: EU, Tekes, Nokia, Nordea, Senaatti-kiinteistöt, Polar Electro, Lasipalatsin mediakeskus and Tiedekeskus Heureka to name but a few…

My warmest thanks to my supervisor professor Marko Nieminen for unwavering direction and a very strict deadline. Timely feedback assures continuous progress.

A very special "thank you" to Dr. Marjo Kauppinen for reviewing this thesis and for the many priceless comments and suggestions for improvements to it.

Many thanks and apologies to my distinguished colleague Petri Mannonen, for many hours of joined labor on the articles.
May you always stay safe from the process monsters – use the silver coated bullet!

Above all I would like to thank my wife Eija for continuous support and encouragement during the writing of this thesis and the many years preceding it; our son Eero and our future daughter Tyllerö (ETA five weeks) pretty much just being there, both our dogs Milla and Taavi for taking me out at least once a day…

…and my parents: Hi mom, I wrote another book!

Through the wind and rain, and in the gloom of the night,

Mika P. Nieminen

Espoo February 13th, 2006

List of Publications

This thesis is based on the following four publications:

I Nieminen M. P., Mannonen P., and Turkki L. (2004). User-Centered Concept Development Process for Emerging Technologies. In *Proceedings* of *the Third Nordic Conference on Human-Computer Interaction*. Tampere, Finland, pp. 225-228.

Mr. Nieminen was the primary author of the paper and produced the final wording of the paper. After joint discussions Mr. Nieminen also contributed the process model and its division to four phases and their subtasks, and provided most of the underlying case studies. Mr. Mannonen researched and collected most of the references, while Ms. Turkki scrutinized the process model and publication in general.

II Nieminen M. P. and Mannonen P. (2006). User-Centered Product Concept Development. In W. Karwowski (Ed.) *International Encyclopedia of Ergonomics and Human Factors,* 2^{nd} edition. Taylor & Francis. New York, NY. pp. 1728-1732.

This paper was written and edited during the last two weeks of December in 2004. Mr. Nieminen was the primary author of the publication and provided the changes to the process and redefinition of the terms, while Mr. Mannonen engineered the visualizations and the fictional example scenario.

III Nieminen M. P. and Mannonen P. (2005). Capturing Mobile and Distributed Work for Concept Development Using Photograph Probes. In *IASTED-HCI 2005 Conference Proceedings*. ACTA Press, Anaheim, USA. pp. 191-196.

In this paper the authors more formally defined and applied a derivative of the earlier published method of photography based artefact analysis [28]. Mr. Nieminen was the primary writer of the paper in formalizing the method description and process of applying it to mobile and distributed work. Mr. Mannonen contributed the prior art of artefact analysis especially in using photographs and developed the used analysis tools.

IV Mannonen P. and Nieminen M. P. (2005). Design Perspectives: Sampling User Research Data for Concept Development. *Helsinki University of Technology Software Business and Engineering Institute Preprints 13*. Otamedia, Espoo, Finland. pp. 1-7.

In this paper the primary author was Mr. Mannonen, whose original idea (with Ms. Turkki, who unfortunately was resource-limited to contribute to this paper) was to develop a more detailed framework for user research analysis. Mr. Nieminen identified the lack of cross-category analysis mostly caused by the heavy emphasis of user, context and tasks presented in the ISO 13407 standard [18]. Mr. Nieminen also developed the phenomena/category/design perspective taxonomy for the analysis framework.

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1 Introduction

Creating new products is difficult at best, creating new products that correspond to the needs and wishes of their future users is even more challenging. User or human-centred design (known as usability engineering in the mid-1990's when the seeds of this work were planted) builds on understanding the users and evaluating the products for instance by means of usability testing [18], but how to go forward when there is no product. This is the landscape of concept development; to fulfil unknown needs, excelling in creation of yet inconceivable products. To improve the lives of users in a way they cannot even imagine.

1.1 Motivation

This thesis aims to bind the existing knowledge of product concept design to a framework of technologically oriented engineering sciences and product development by providing an easily adoptable process model for practitioners of concept development. It does not claim to master the process to a degree to produce highest quality concept with a clockwork precision, but to increase the odds of creating a good yield of concepts with every time applied. Problems surrounding management of creativity are yet unclear, but by utilizing proven methods one gets proven results.

Concept development is very dependent on the field it is used. While engineering sciences thrive to apply a structured process, more creative approaches, for instance those coming from the industrial design side of product development, may wish to leave more degrees of freedom to the designer herself. Figure 1 illustrates the various contributors and points of view relating to creation of new products. Krishnan and Ulrich [26] state that product concepts are illustrated through decision about the physical form and appearance of the product, activities generally known as industrial design. They also claim that "industrial design has received almost no research attention". Likewise, all fields of expertise have their own anomalies, blind spots and best practices that are too often difficult to combine with each other. Literature on general purpose concept design models is almost nonexistent, this is partly due to the fact that most of product design practices are highly guarded trade secrets and are rarely made public.

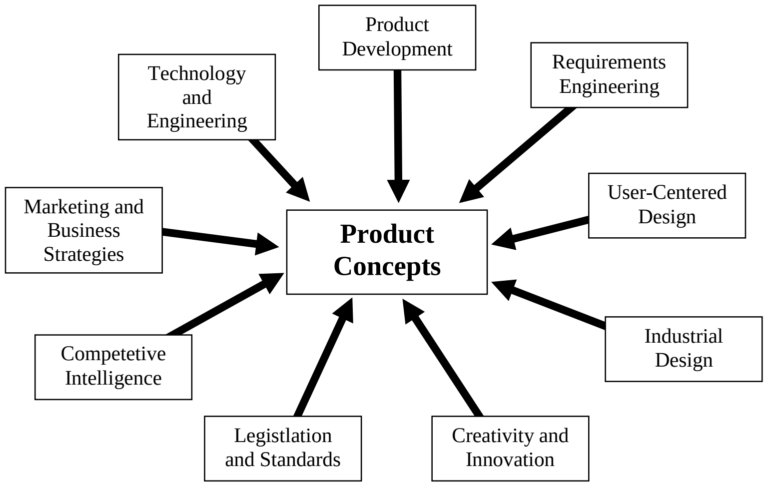

Figure 1. Contributors of concept development

The noble goal of this thesis is to describe a generic concept development process allowing the integration of the above perspectives – or at least point out a place in the model where to inject each expertise as needed. Some of the key terms are explained in the following chapter, while process models from prior art are introduced in chapter 2.

1.2 Putting Concept into Perspective, Definitions and Framework

This thesis tackles the problems of user-centered concept development from the viewpoint of product development in engineering. In this chapter some of the relevant terms are explained in order to position the described process and maybe even clarify some of the underlying hypotheses.

1.2.1 Concept

The basic term concept has several different flavors depending on the viewpoint of the practitioner. Literal definition of “an abstract or generic idea generalized from particular instances” [29] gets more concrete when viewed in the product development context suggesting that a concept is either a product, service or communication tool. Keinonen et. al. define concept as a future-oriented, wellfounded and understandable description of a product [24]. Concept can also be seen as a yet non-existing product [21].

Another important factor is the time window relating to realizing a concept. In some cases conceptual improvement to existing products can materialize in months, some concepts target future applicability in years or even tens of years.

In this thesis Concept shall have the meaning of

Description or model of a product, service or concretized idea
to support decision making about its usefulness and production potential
within a set time window.

1.2.2 Concept Development or Concept Design

Even the name of the activity leading to new products is dependent on the orientation of the practitioner. Term concept development is more accustomed in the engineering side to refer to a sequential construction of a new product. Concept design emphasizes the creative step of the process and the individual talents of a designer.

The generic product development process by Ulrich and Eppinger [36], shown in Figure 2, positions concept development as its first phase right after planning. The purpose of concept development, thus defining a concept, is set to create a description of the form, function, and features of a product using specifications and competitive and marketing analysis.

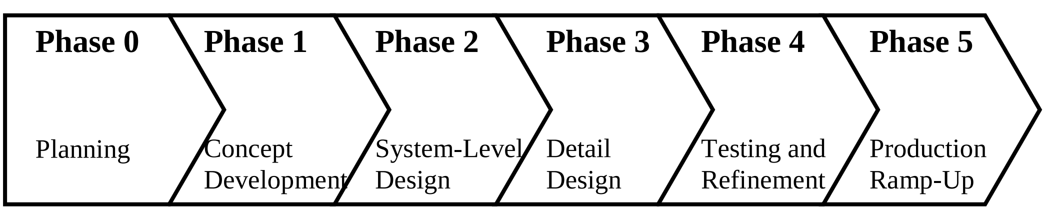

Figure 2. The product development process

They further include the following activities into the concept development phase with the final outcome in the form of a development plan [36]: Identify Customer needs, Establish target specification, Concept generation, Concept selection, Concept testing, Setting final specifications and Project planning. Parallel to these tasks the process will benefit from ongoing (continuous during the process) Economic analysis, Benchmarking of competitive products, and Modeling and prototyping.

Keinonen et. al. [24] refer to this type of concept development, aiming to a wholesome product specification, *definitive concept design*, and suggest term *creative concept design* for more exploratory projects targeting to unleash the potential of new technologies or user needs. Moreover, *visionary concept design* addresses the need to provide better tools to support decision making for future products and product lines.

In this thesis Concept Development shall have the meaning of

Well-defined, reproducible process to create new concepts.

1.2.3 User-Centered Approach

User-centered processes try to include the actual users to the development process at earliest possible time in an effort to produce products that correspond with the needs of the users and the restrictions of the context of use. The basis of this is the ISO 13407 standard for Human-centred design processes for interactive systems, depicted in Figure 3, defining the iterative user-centered process to include the following phases 1) Plan the human-centred process, 2) Understand and specify the context of use, 3) Specify the user and organizational requirements, 4) Produce design solutions, and 5) Evaluate designs against user requirements [18].

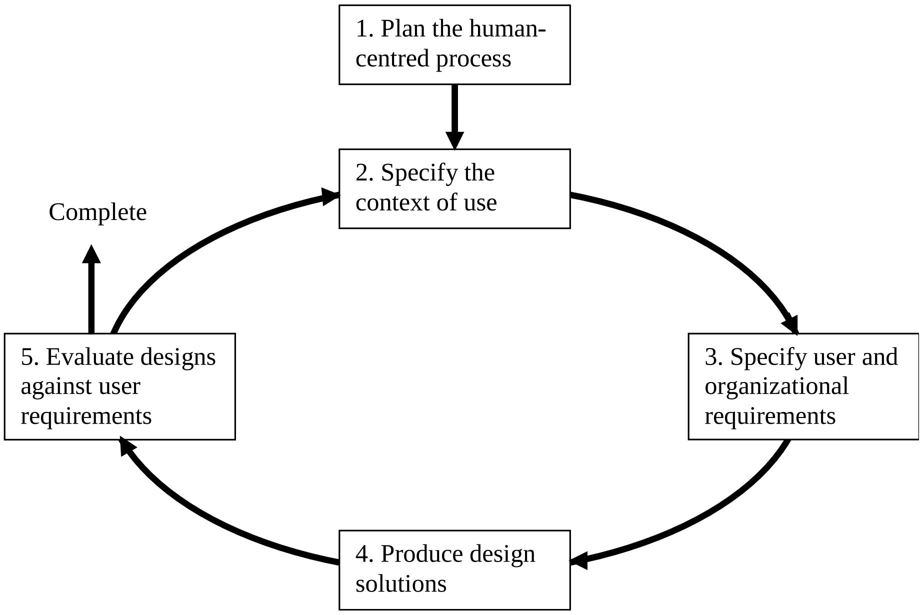

Figure 3. ISO 13407 Human-centred design process for interactive systems

> In this thesis User-Centered Concept Development shall have the meaning of
>
> Practical steps to create concepts based on
> factual understanding of its potential users.

1.3 Research Themes

This thesis discusses the role of user-centered approach in the framework of concept and product development. It suggests a generic process for user-centered concept development that would have meaningful serialized steps to support a creation of concepts targeting various fields in a reproducible fashion.

- What are the main difficulties in applying the proposed user-centered concept development process?

One size fits all, if its large enough. The process is deliberately detailed at a higher level, so that it could be applicable to wider variety of concept development projects. Otherwise the distinction between service and product concepts, immaterial and physical products or the chosen viewpoint within user-centered approach, such as user task analysis [16] for needfinding or emotional design [33] for creating pleasurable products, would bias the process to niches and effectively make it unsuitable for others.

- Does the proposed user-centered concept development process cater to the needs of different kinds of concept development projects?

Usability engineering has matured during the past few decades. It has evolved from ergonomic-oriented design to user-centered design. The user-centered approach still lies comfortably on the bedrock of usability evaluation of products. Concepts are non-existent or future products often not functionally fully realized during the visualization phase.

- Are the usability evaluation methods applicable when rating or validating new product concepts?

1.4 Structure of this Thesis

This thesis has five parts:

1. Introduction, definitions and research themes are presented in chapter 1.
2. Description of prior art, introduction of the cases and used research methods, and the construction and evolution of the developed process model in chapter 2.
3. Detailed description of the user-centered concept development process and conclusions thereof respectively in chapters 3 and 4.
4. Future work in chapter 5.
5. Four publications founding the work are attached at the end of the thesis.

2 Constructing the User-Centered Concept Development Process

This chapter describes the rationale for the construction and evolution of the user-centered concept development process. The different explications of the process models are respectively presented in chapter 2 and 3 of this thesis and in the included publications I and II.

2.1 Prior Art

Already in the seventies French [14] in his book "Conceptual design for engineers" described a design process to develop product specifications depicted in Figure 4[1]. In many ways French emphasizes the skills of the designer to define the need with necessary accuracy, their ability to generate new solutions to identified problems and finally concretize the solutions to detailed plans. Although it defined the end results of conceptual design as schemes instead of concepts, it does portray the basic steps to iteratively develop product designs.

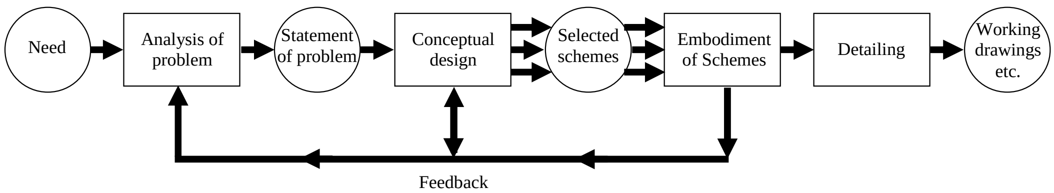

Figure 4. Design process [14]

Chakravarthy et. al. [7] use a term concept management when describing similar concept development activities. They introduce a four step process for:

1. Concept Creation and Generation: Use various methods of creativity to produce very large number of concepts.

[1] Circles represent process deliverable, while boxes denote actions by the designers.

2. Concept Focus and Evaluation: Group and evaluate the concept based on organization's core values (design strategy) and competences.

3. Concept Engineering: Convert the fuzzy concepts into usable (consumer oriented) ideas.

4. Concept Integration and Finalization: Evaluate the remaining concepts or concept clusters prior to integrating them to the product development cycle.

Many of the process descriptions in the literature are more case descriptions than generally applicable process models. In most cases they portray distinct features that are not necessary or desirable in some other development projects. For instance Häggander [17] depicts a process used at Volvo Aero Corporation when developing a new main engine for the European Space Agency's Ariane 5 launcher rocket shown in Figure 5. To a true engineering tradition it is more concerned with the documentation and control of the development tasks due to the safety critical nature of the product. Also it omits to depict a concept prototyping or visualization phase included in most of the other process models.

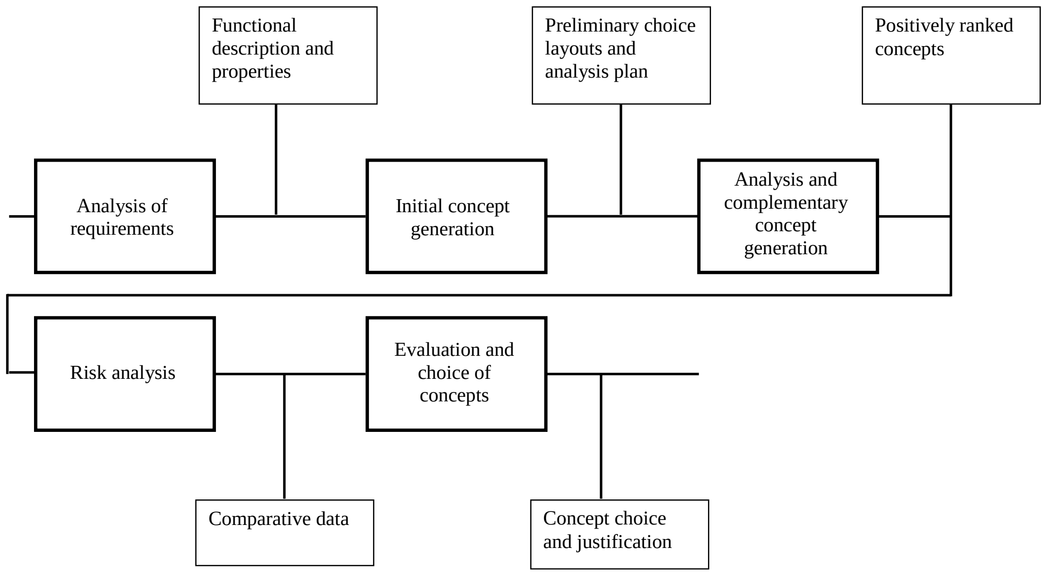

Figure 5. Concept design process, activity steps and checkpoints [17]

Kankainen [22] elicits the importance of user experience when combining user-centered approach to concept design. She describes a UCPCD (User-Centered Product Concept Design) process depicted in Figure 6. In it the framing of the design problem (design brief) is followed by a user research phase prior to creating concept ideas. Prototypes are to be built to illustrate these ideas and they are then exposed to the users before refining them for final selection. Kankainen argues that this sub process (user research-build-evaluate) must be performed two times in order to first capture the motivational needs, or "why a person is doing what she is doing", and second time to detect the action level needs, or "how a person is doing; what she is doing". Kankainen describes her approach "not [to] include a marketing or technological perspective but a design approach focusing on user experience" [21].

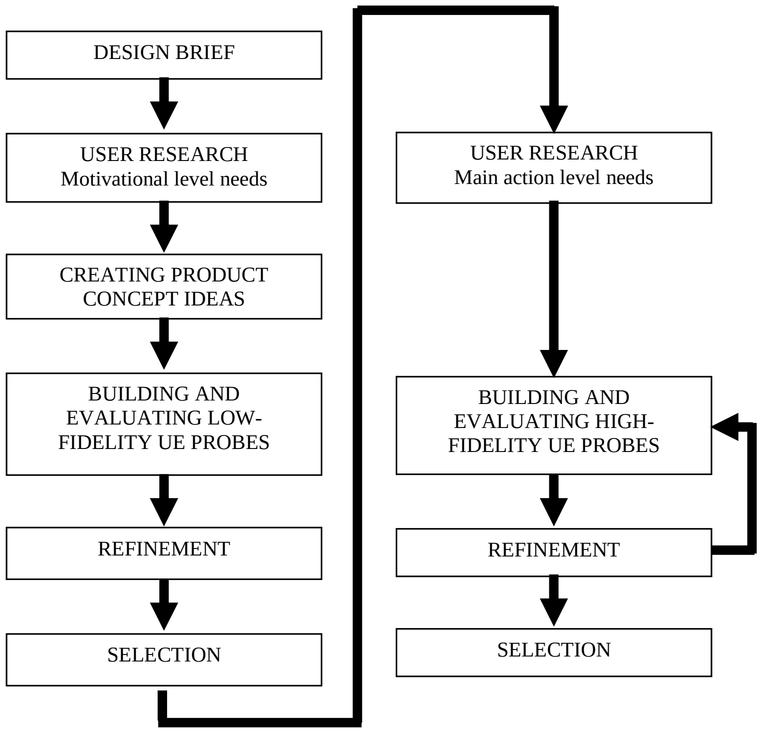

Figure 6. UCPCD process [22]

Last of the illustrated processes UCPCD [22] was the baseline for this thesis. The need to augment it came from the observed difficulties of applying it in engineering projects due to the lack of clearly formulated technology focus and strong emphasis on user experience and (industrial) design practices.

2.2 Case Studies

The experiences driving the development of the presented process are based on 23 cases at the Helsinki University of Technology according to a breakdown in Table 1.

Table 1. Details of the available case data

Case projects	Number of teams	Number of team members (in each)
Student projects	**20**	**85 (3-5)**
Research projects	**3**	**11 (3-4)**
Total	**23**	**96**

The technology focuses in the cases were:

- Proactive computing,
- Telepresence and large scale displays,
- Augmented or mixed reality, and
- Distributed, mobile or remote work.

Use of mainly student projects was assumed to produce a process also applicable to the real life development projects, as the course is one of the last courses taken in the master’s degree program. With a few exceptions all students had educational level equaling European Bachelor of Science. Thus, they had compliantly similar expertise level to a junior development engineer working in the industry.

In the included three research projects the participants had average of 3-6 years worth of experience in user-centered development.

As majority of the empirical data is based on student projects conducted in the user-centered concept design course the following subchapters depict the structure and contents of the course, the author’s participation as the responsible teacher for the course and the practices used in analyzing the needs for improvement relating to the cases. Reader may note that the terminology in the given course description is different to those presented in the following process models as it describes the state prior to the formulation of the initial process model. At the time of writing this thesis the terminology and deliverables used in the course adhere to those described of the final process model in chapter 3.

2.2.1 Contents and Timeline for the Course

During years 2003-2005 the course was lectured during the spring semester starting in mid January and ending in early May, thus the average length was 17 weeks with 7-8 lectures and two student team presentations each lasting three to four hours depending on the subject matter and level of discussion. The structure of the course is depicted in the following Table 2 by the means of its lecture contents and deliverables. During the course the project teams produced five reports and held two presentations.

Table 2. Course schedule

Course schedule			
Week	Lectures	Deliverables	Tutoring sessions
1	Introcution to the course and practical issues Introduction to user-centered concept design		
2	Introduction to the assignments and technology framework Forming the student project teams		
3	Testimonies from previous customer cases	Project plan	
4	User research methods		Project plan
5		User research plan	
6			User research plan
7	Analyzing the user research data		
8			
9	Creative problem solving and idea generation		
10	Results of user research (student presentations)	User research report	
11			User research report
12	Concept visualization and validation		
13		Validation plan	
14			Validation plan
15			
16			
17	Final presentations (student presentations)	Final report	

Separate guidelines for each of the deliverables were offered to the students. They included tentative tables of contents for the reports, and some minimum requirements for the tasks in each phase (to manage the student's workload during the course). Table 3 shows an excerpt of the tentative table of contents for the final report, while the following Table 4 characterizes some of the set requirements.

Table 3. Excerpt from the tentative table of contents for the final report

Cover page

- Names, student numbers and email addresses

Table of Contents

Summary

- Summary of the most important i.e. the results
- 1 page

Introduction

- Team members and their individual strengths
- Assignment, research questions

Final concepts

- Minimum of two validated concept finalized and presented here
- Detailed enough for the customer product manager to decide future steps
- Include all visualizations to the appendices or project portfolio

Process and Methods

- Assignment focus
- User research and analysis
    - User group and context of use
    - Used methods (both user research and data analysis
    - User profiles or personas
    - Summary of observed phenomena and needs (remember traceability)
- Brainstorming
    - Used methods and evaluation of their usefulness

…

Table 4. Example course requirements for different phases

Phase/Deliverable	Requirement
User research	Study minimum of 2 users per team member, using minimum of 2 different user research methods
Concept validation	Evaluate minimum of 3 concepts with minimum of 2 users each

The initial assignments for the student projects outlined the technology focus, the primary user group and the context of use or location for the concepts which the project teams then focused in more detail. Following Table 5 gives a few examples of these original parameters and samples of concepts developed in the course.

Table 5. From assignments to concepts

Technology Framework	User Group	Context of Use	Concepts
Telepresence	Developer: Immaterial goods	Distributed product development	Personal interaction cubicle for software engineers with life-like video walls
Mixed Reality	Married with children	Science park or museum	Virtual hologram puppy that follows the kids around guiding and helping them
Wearable Computing	Ticket inspector	Public transport	Inflatable airbag suit to protect against collisions while working in moving vehicles

2.2.2 Participation and Supervision of the Student Projects

The author of this thesis acted as the responsible teacher for the course and thus defined the schedule and contents for the course, selected the assignments and technology focuses, gave majority of the lectures and led the group of tutors guiding the student teams.

Each group had a dedicated tutor (each tutor guided one or two teams) that held tutoring session after each deliverable to give feedback on the teams' plans and reports within a week following a deadline. The times of these tutoring sessions are shown in the right-most column in Table 2. All tutors had 1-3 years of prior experience on concept development or user-centred design.

The author of this thesis also reviewed all the deliverables and held the meetings with the tutors prior to their tutoring sessions with the student groups. At these meetings the student groups' deliverables were discussed and graded (normalized in quality by cross-checking all deliverables) and any common problems or questions rising from the students were addressed. On top of the direct feedback at lectures these meetings among the course personnel were the primary means to collect the observations and suggestions to enhance and develop the process model.

After the course, during the final grading in a workshop with the responsible teacher and the tutors, the observations and comments were collected and discussed as a basis for future changes to the course. Resulting observations and concluded changes were also presented at the joint meetings held with all the teachers of the user interfaces and usability professorship.

Separately to this internal evaluation of the course by its personnel, the students' feedback was collected using a questionnaire after each course. Additionally to the overall quality of the course and its pedagogic methodology the questionnaire also encouraged the students to submit freeform suggestions for improvements. Students' proposals included comments regarding the schedule and workload of the course and were appreciated when fine tuning the lecture program and improving the instructions for course deliverables.

2.2.3 Summative Analysis of the Observations

Following the third instance of the course had finished in May 2004[2] the so far collected observations, suggestions and student feedback was processed by the authors of the included publication I, as a basis for the article. At this point similar experiences from other available cases, i.e. at that time running or past research projects, were integrated to the shared knowledge base. During May and June the materials were processed in several workshops and the initial formulation for the process, depicted in the following chapter, was drafted into a publication.

Similar workshops and interactive authoring process were used at the end of 2004 to define the final process model described in publication II and in more detail in chapter 3.

2.3 Initial Formulation of the Process

The previously illustrated process models, in chapter 2.1 Prior Art and the generic product development process depicted in Figure 2, share a similar basic structure which was generalized and reproduced as a basis for the new process model. The main addition to prior art was the introduction of separate technology focus to the process that rose from the empirical case data. This was highlighted by adding a definition of a Technology Framework into the launch of a concept development and explicitly stating the need to conduct technology research parallel to the user research. Closer study of the technical possibilities increases the understanding of the context and usage potential of the developed concepts. These additions aimed to better extend the concepts to the future and help find genuinely new concepts.

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[2] During the spring of 2004 the course was given twice in parallel to each other as part of a separately funded “XU - eXtreme Usability” teaching experiment that compacted the course into six calendar weeks.

The empirical data used to define the initial process model included 16 of the 23 cases.

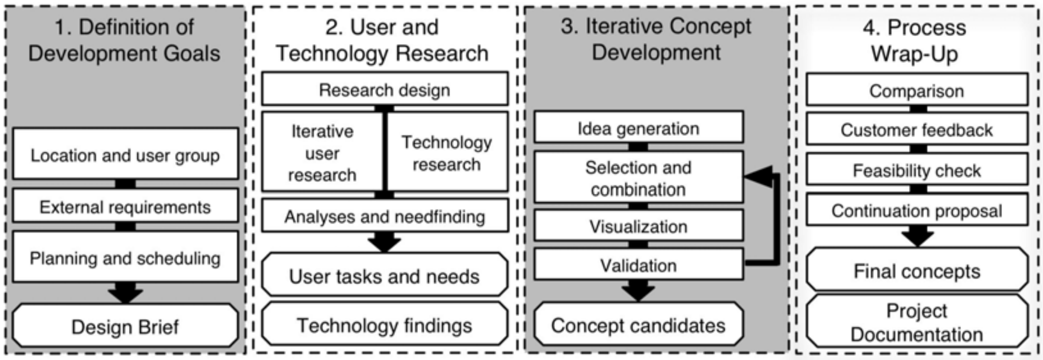


Figure 7. User-centered concept development process

As shown in Figure 7 the process is divided to four phases. For more details please refer to the included publication I.

1. Definition of development goals, where the focus of the concept development is captured using a working hypothesis in the form of "*Framework* concepts for *UserGroup* in *Location*" for instance "*Mixed reality* concepts for *Family visitors* in *Science museum*". The result of the definition phase is a design brief describing the prerequisites to start a concept development project.

2. User and technology research, where the needs of the users and the potential of emerging new technologies are understood and analyzed to form a solid base for creating new product concepts. Proposed methodology includes observation and interview methods drawn from contextual design processed by qualitative analysis tools and presented with user profiles and narratives. Technology research is based on current state of the art and observed future trends.

3. Iterative concept development, where the analyzed user and technology research data is transformed via idea generation, selection and combination, visualization and validation into concept candidates.

4. Process wrap-up, where the developed concept candidates are evaluated against original criteria and accepted concepts are packaged for customer's decision whether to start the actual product development.

As in any development, and especially in one based mainly on qualitative analysis, the importance of traceability throughout the process is critical and should be emphasized. This means explicating the decisions and interpretations with enough detail that afterwards it is possible to trace individual observations that lead to the made decisions as illustrated in Figure 8.

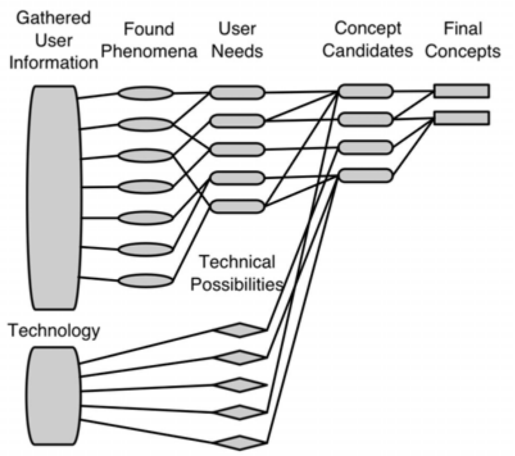


Figure 8. Traceability in user-centered concept development

2.4 Towards the User-Centered Concept Development Process

The experiences with the initial version of the process model emphasizing technology research were found to potentially limit the innovation of new ideas. It seemed that in half of the cases the concepts were limited by the definition of the technology framework and merely reproduced the existing solutions, and in half the concept were able to extend beyond. This was analyzed to be caused by the rapid or even abrupt transition from user and technology research to the creative phase, so that the team members were unable to distance themselves from the facts in order to innovate new ideas. This suggested a modification to the process model, to clearly explicate and separate this potentially hazardous stage in the process and improve guidance during the innovation phase.

Other needs for improvement were to include the innovation step into the iteration cycle, i.e. explicitly allow additional innovation sessions, and a suggestion to augment the development team with additional members during the innovation phase.

3 User-Centered Concept Development Process

User-centered concept development process is a cross-breed mixture of generic product development [36], utilizing technological advances and human-centred approach [18]. It is designed to formalize and partition the development to manageable phases for easier adoption. This allows existing good practices and methods to be suggested and utilized in each part with the ability to take into account different phases' individual characteristics.

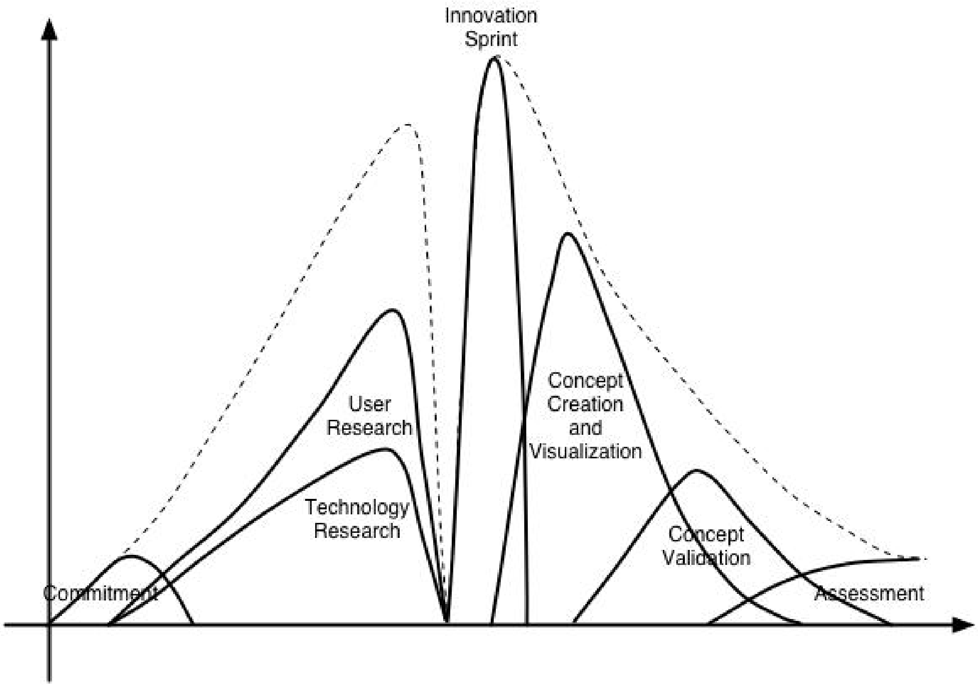


Figure 9. Phases of the user-centered concept development process

The found problems in applying the initial process model to the last seven cases are reflected by the current version of the user-centered concept development process. Most noticeable change is the introduction of a separate "Innovation sprint" phase, shown in the center of Figure 9, to overcome the observed difficulties in the migration from pedant user and technology research phase to more creating innovation and concept development phases.

The new process model also redefined the names of the phases to more accurately describe their main objectives. The new titles for the phases were 1) Project commitment, 2) User and technology research, 3) Innovation sprint, 4) Iterative concept creation and validation and 5) Project assessment.

Table 6 illustrates the main phases of the process with their respective subtasks and outcomes. The following chapters describe each phase with suggestions and descriptions of suitable methodology to accomplish the required tasks.

Table 6. Phases and outcomes of the user-centered concept development process

1 Project Commitment	**2 User and Technology Research**	**3 Innovation Sprint**	**4 Iterative Concept Creation and Validation**	**5 Project Assessment**
Define user group and context Select technology framework Schedule the project	Select research methods Conduct user and technology research Analyze data	Generate ideas Be creative Do not criticize	Select and combine Visualize Validate	Evaluate concepts against requirements Collect customer feedback Prioritize concepts and propose future steps
Outcomes				
Design brief	User tasks and needs description Technology trends and possibilities	Hundreds of ideas	Validated concept candidates	Final concepts Project documentation

It should be noted that the model is meant to be iterative, so that if a need arises the process can repeat a completed phase to improve the overall results of the development effort illustrated in Figure 10. Also depicted is an iteration to a earlier phase in the project, in this case validation task has found a need to refine earlier user research. If not planned these kinds of leaps backward can be awkward as a multi-disciplinary team relies on its experts who may have already moved to other duties.

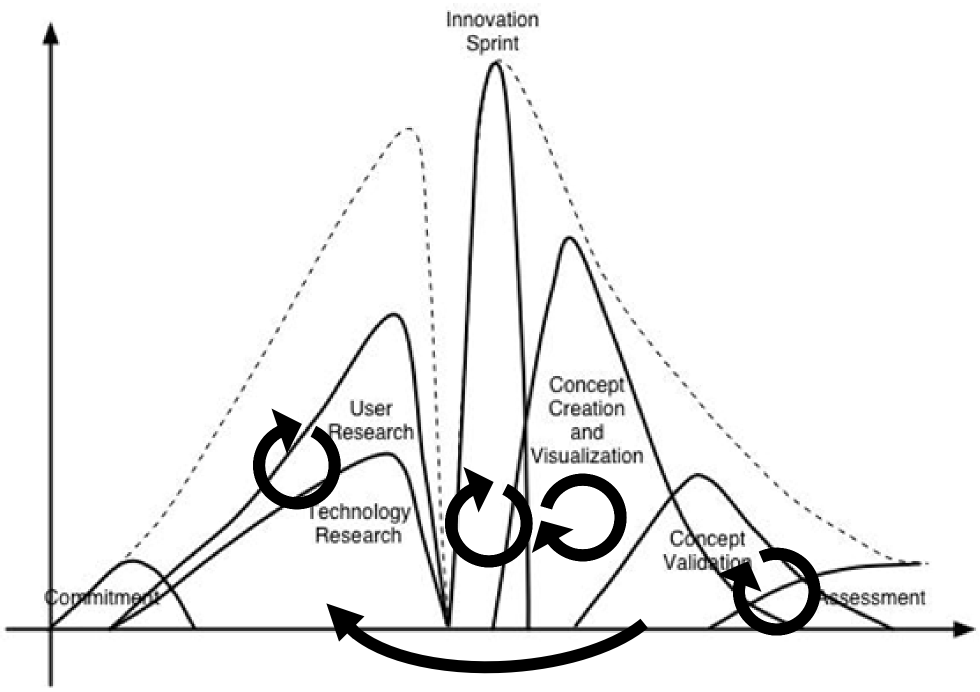


Figure 10. Iterations within the phases and to earlier phases

One way to reduce the problems with iterative steps backward and to encourage easier use of iteration is to assume them imminent and plan for them. When implementing the process one could handle each process cycle as a single atomic task i.e. in stead of jumping back and forth in the process always cycle it in full and correct the found blind spots in the next iteration. This requires that the final project assessment is transformed fluently into a new project commitment or a more focused design brief. The steps that do not require additional tasks or further study can be passed quickly and thus the phases are only executed anew as needed. This morphing of the process during each recurring passes is illustrated in Figure 11. The first pass is as presented in chapter 3, with another modified cycle following it.

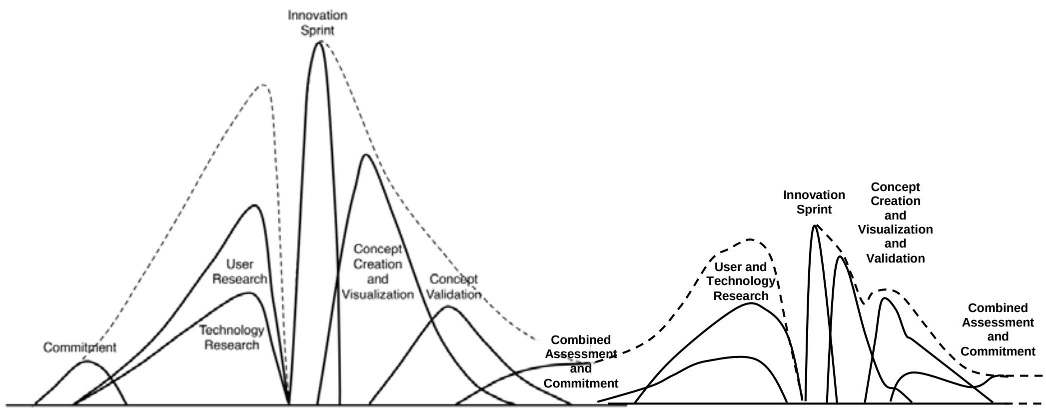


Figure 11. Process level iteration

3.1 Project Commitment

In the start the task is to define a generally accepted focus to the project, launch suitable project management practices (not within the focus of this thesis) and find the right participants for the work at hand.

The outcome of the project commitment phase is a design brief describing the prerequisites, goals and schedule for the product concept development effort.

3.1.1 Project Focus

Obviously any user-centered process is very dependant on the accurate and concise selection of the *user group* it is studying [18]. Unfortunately in successful concept development this alone is not enough, also the *context of use* and *technology framework* must be decided to some degree so that a fruitful project can be launched. All of the mentioned variables contribute to the breadth of the task [36]. With too limiting selection the results may turn out obsolete or trivial, with too broad criteria one may exhaust all resources without ever reaching the finish line.

{*Technology framework*}
concepts for
{*User group*}
in
{*Context of use*}.

In order to form a clear understanding of the development goals it is advisable to verbalize the focus as a working hypothesis.

Examples of this could be

"*Mobility* concepts for *distributed work* in *knowledge work*", or

"*Proactive computing* concepts for *maintenance men* in *customer premises*".

3.1.2 Participants

Selecting the right combination of talents to the concept development if often linked to the size of the project and organization [18]. In the fields of Human-Computer Interaction (HCI), User-Centred Desing (UCD) and usability engineering the availability to draw on multidisciplinary team is often taken for granted as these fields are based on wide scope of knowledge from engineering, psychology, cognitive psychology, anthropology, ethnography, communication studies, marketing and design [16].

The presented process for user-centered concept development is structured in phases to help augment the team with additional members as need be. This enables the project to draw, for instance, the expertise of marketing department, customer relations or consultants to phases 1, 4 and 5.

3.2 User and Technology Research

The goal of user research (also referred to as user study or field study) is to build a holistic view of the users and their contexts of use including the tasks performed therein [4][16][18][31]. Using several (qualitative) research methods in parallel and in iteration generates a more wholesome picture of the users and deepens the gained knowledge [3][20] allowing the team to modify or change their research approach if gaps in knowledge are found or new interests arise.

Technology research focuses on understanding the current state of the art on the selected technology framework and making it useful to concept development by extending it to the future based on predicted trends. Valuable information can be gained by competitive and market intelligence, following research and trade journals, patent research and projecting the past technological advances to the future. Maybe the best example of this is the twenty years ago made and still valid prediction of the increase in number of transistors per computer chip more commonly known as the Moore law [30].

3.2.1 User Research Methods

Conventional palette of methods includes interviews, focus groups, observations, cultural probes, artefact analyses, surveys and questionnaires [15][16]. The less common ones are described below.

Contextual Inquiry [4] is a method combining observations with interviews described in Contextual Design, a prepackaged user research process by Hugh Beyer and Karen Holtzblatt. In it, after a brief introductions, the users are observed in their own contexts of use for 2-3 hours. Normally this intrusion to the user’s territory is softened by using the master and apprentice approach where the researcher is a novice bystander beside the veteran worker. If the user’s tasks can be interrupted the researcher may ask questions about the tasks or artefacts/tools relating to them. After the observation period the user is interviewed about the things that the researcher has learned and any misinterpretations are corrected. Later the gathered data is analyzed.

Artefacts analysis collects the meaningful objects or items surrounding the user for further study. It is widely accepted that artefacts are an excellent means to depict user behavior [4][16]. Analyzing the used tools or memorabilia surrounding the user also enables complex or rarely occurring tasks to be made visible to the researchers [12].

Cultural probes [15] are one form of self-documentation methods, that rely for the users themselves to create or collect the necessary data for the researchers based on their instructions. Cultural probes produce a rich view to the users own world. If compared to observational methods cultural probes focus more on the users' personality and meaning of product than to environment or interaction [19]. Usually the probing packages include a plethora of inspirational memorabilia such as post cards, maps, sticker, diaries and cameras, but the main idea is for the users themselves to invent and control the creation of data. Following text box details a developed variation of a cultural probe based solely on photographs.

Photograph probes consist of a camera with simple instruction on what aspects of the users' lives the researchers are interested in. The method combines natural interpretation of photographs embedded in the western societies to non-intrusive self-documenting practices found within cultural probes.

Photograph probe method comprises from the following steps:

1. Photographing assignment, where the users are instructed on the theme of things to document.
2. Photographing, where the participating users take pictures according to earlier assignment.
3. Pre-Analysis of photographs, where the researchers screen the pictures to prepare for the interviews.
4. Debriefing group interviews, when the pictures are discussed in groups sessions including 2-4 users.
5. Analyzing the data, where the researchers analyze the gathered information as a basis for (concept) development.

Photograph probes are non-obstructive towards observed users activities, and natural enough not to require training. The method encourages various way to analyze and interpret the taken pictures at the interviews and provides a rich understanding of the user and her environment suitable for multi-disciplinary research team. More detailed description can be found in the included publication III.

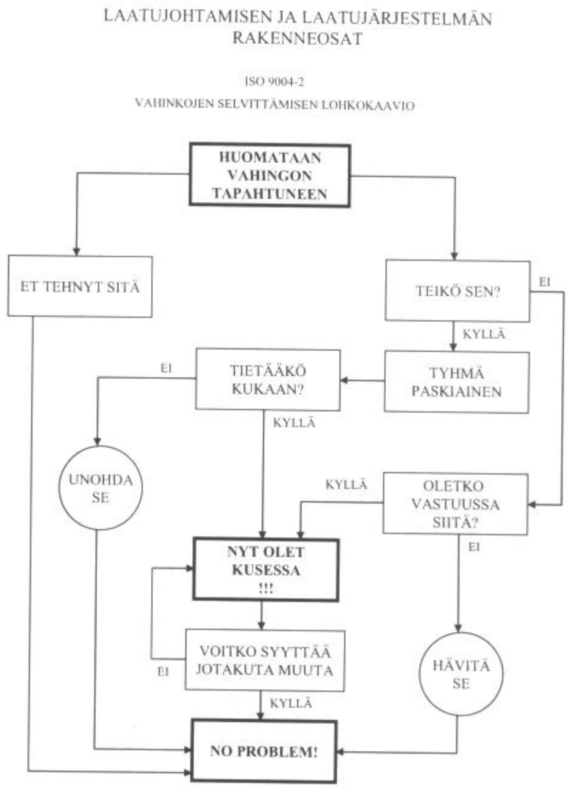
3.2.2 Analyzing the User Research Data

Analyzing any given data set is very dependent on the method it was collected with. Outside purely quantitative surveys or questionnaires (i.e. methods where the answers are strictly deterministic to have a codeable value) this requires qualitative analysis. Qualitative analysis relies on the absorption of all collected data and by condensing and reorganizing reflects on the data to raise and crystallize the key findings from it [1][9][13]. The available materials may be iterated several times to reach sufficient detail and understanding.

Affinity diagram [4] (also known as KJ diagram by Brassard [5]) is one form of associative data analysis method. In it the recorded notes are transcribed onto notes, usually Post-It™ notes, that are then organized based on their relation or closeness to others belonging to the same theme. After placing a note any member of the analysis team can place another one close to it, or move the note to other location. Potential disagreements are discussed during the process to find a location for each note. Each group is categorized under a label and these hierarchies under higher level labels. Beyer and Holtzblatt [4] also propose a specific color coding for these group labels, but in most cases this kind of presentation issues are dependant on the data, and should be agreed during the process. Example of an affinity diagram is shown in Figure 12.

Figure 12. Affinity diagram

User and task analysis by Hackos and Redish [16] is a methodology to dissect and analyze work processes, although it is highly effective way to analyze any sequential user interaction. It concentrates on the users' tasks, goals and perceptions in relation to their (work) environment or context of use. The analysis methods are identified by the outcomes of the analysis. Creation of task lists and diagrams, sequence and workflow diagrams enable deeper understanding of the interaction. For easier adaptation these structured models can then be transformed to scenarios, storyboards or even video dramatizations.



Representing the user as a person in an accurate and understandable way is one of the most important and at the same time one of the most difficult goals of user research. Common tools to describe the users include scenarios, user profiles or personas [8][16]. Usually a user profile is a brief narrative of the individual user, but it can be augmented with more graphical elements to include pictorial of the immediate surroundings of the users' [23].

Design perspectives are another way to further extend the analysis of user research data. In this approach the once evaluated results are subjected to resampling so that even singular events that conventionally would disappear during the qualitative analysis may add value to the final results. In a nutshell the design perspectives are created from observed phenomena and categories derived via associative methods like affinity diagrams. Their strength lies in observing the interconnectedness of these two different layer entities, phenomena and categories, shown in Figure 13.

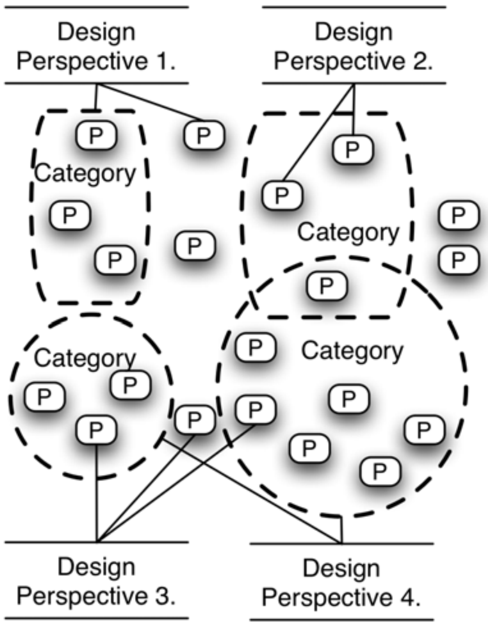


Figure 13. Analysis framework for sampling design perspectives

- Design perspectives sampled from categories and singular phenomenon outline potential contradictions (rf. design perspective 1).
- Design perspectives local to a category emphasize concurring or supporting tendencies (rf. design perspective 2) or
- When merging two or more categories potential out-of-scope synergies (rf. design perspective 4).
- If the sampled phenomena are local to a user or an event (rf. design perspective 3) design perspective can emphasize an observation that

would otherwise be lost during the conventional data analysis aiming for generalized consensus opinion.

Design perspectives are described in detail in the included publication IV.

3.2.3 Outcome of User and Technology Research

The outcome of this user and technology research phase are detailed descriptions of the users and their context of use. These include task analyses and user needs, and a description of relevant technology trends and the potential opportunities or limitations within the chosen technology framework.

3.3 Innovation Sprint

Innovation sprint is a fast and intensive period when majority of the ideas and solution candidates are created for further development to concepts. In line with the practices of brainstorming[3] the goal is not to halt the innovation by stopping to criticize the ideas while they are born but to wait the appropriate time to select and mature the thoughts. The use of formal methods help to unleash the creativity of the development team, and in most cases also provides a traceable way to document the process of idea generation for analysis or improvements at a later stage.

3.3.1 Idea Generation Methods

Brainstorming, as defined by its maker Alex Osborne "a conference technique by which a group attempts to find a solution for a specific problem by amassing all the ideas spontaneously by its members" [38], is a method of easy four steps: 1) Criticism is ruled out. Adverse judgment comes later, 2) “Free-wheeling” is welcome. Wildest ideas are the best, 3) Quantity is wanted. Large amount of ideas increases the possibility of useful ideas, and 4) Combination and

---

[3] Originally a method developed by Alex Osborne in 1953, nowadays synonym to idea generation.

improvement are sought. Do not just contribute ideas, also make other's contributions better [35].

Rossiter and Lilien expand this with their six principles for brainstorming [35]:

1. Brainstorming should have clear and explicit instruction emphasizing number of ideas over quality of ideas.

2. Brainstorming should have an in advance set target number of ideas to generate. This number should be high.

3. Initial ideas should be created by individuals not groups.

4. Ideas should be analyzed and refined in groups.

5. Final rating of the ideas should be left to the individuals to increase commitment, and

6. Time allocated to the brainstorming activity should be remarkably short.

An interesting variation of the common brainstorming is bodystorming, where the pen-and-paper idea generation is augmented with physical and social interaction in a form of roleplaying. The team can create "a bus" from meeting room chairs to generate ideas for new interior design in public transport, or a team can hold the brainstorming session in a kitchen to innovate new household appliances. Adding the real context allows the team to get accurate yet immediate feedback to their ideas, while enjoying a memorable and inspirational group session [34].

Brainwriting allows participants to pour out their (first) impressions of a given subject, i.e. document their thought in a rapid fashion. First brainwriting technique, proposed in 1970, was method 6-3-5 [27]. It instructs a group of six people to write down three ideas on a piece of paper in five minute (hence the number in the name). After the time is up, the papers are circulated and for the next five minutes the participants first read any preceding entries and then again write down three ideas. In its original form this method creates 108 ideas in 30 minutes.

Edward de Bono's six thinking hats [11] is a simple yet powerful method to create new ideas and especially to further develop them. Its basis comes from lateral thinking, i.e. solving a problem by approaching it from different angles. Six thinking hats method describe six different viewpoints as follows:

- White Hat: Knowledge. Objective and neutral based on facts and figures.
- Red Hat: Emotion. Allows the use of feelings, hunches, and intuition.
- Yellow Hat: Positive. Produces only positive, optimistic and constructive ideas.
- Black Hat: Negative. Pessimistic, judgmental, and cautious.
- Green Hat: Creativity. New ideas and creative thinking, no restrictions.
- Blue Hat: Control. Any decisions relating to the innovation process.

During a session all participants wear the same hat to assess the problem from that hat's perspective. Having a uniform viewpoint decreases tensions and arguments within the group, while changing it during the session provides multifaceted reflection to the subject matter.

The Delphi method [27] continues from where the brainstorming ends until a consensus has been obtained on the best ideas. In it a selected judge or "jury" collects the created ideas and evaluates and ranks them according to importance. This list is then returned to the team for discussion, which can be facilitated in an anonymous fashion if needed. After is discussion round the jury modifies the list and iterate the cycle until a joined agreement is reached. Beyond the idea generation and ranking the Delphi method has also been used as a communication tool for larger groups or organizations.

3.3.2 Outcome of the Innovation Sprint

The goal and outcome of innovation sprint is a large collection of (hundreds of) product ideas, variable in detail, maturity, originality or relevance, but nevertheless all inspired from the earlier gained knowledge of the concept development focus: the users, technology framework and context.

3.4 Concept Creation and Validation

Affinity diagrams [4] are also a useful tool to organize and categorize the abundance of ideas migrating from the innovation sprint to the concept creation phase. It allows easy combination of singular thought or (interaction) features to larger units and eventually to concepts. Similarly the use of narrative methods such as written scenarios [6] are a good tool to condense the ideas to product or product-feature sized concept candidates.

In the start of the fourth phase of the user-centered concept development process the aim is to select and combine the ideas thus reducing them to a manageable number of concepts (depending on the resources available to the development effort). The best suited ones are then given more concrete form in order to evaluate and refine them.

3.4.1 Concept Visualization or Envisionment

In order to evaluate and select the potential killer applications from the generated concepts, the development team must make must make them available to the users. The selected visualization, or sometimes also known as envisionment [2], method depends entirely on the concept itself, its context of use and the user group it is targeted to.

Scenarios, or written stories describing in detail the concept and its users; its interaction and context of use, are a very powerful tool to mediate the functionality of the concept to the users. Carroll argues that scenarios are cost-efficient against time constraints, and that they can be written at multiple levels and can be easily revised while maintaining the cumulative design knowledge [6].

Sometimes words are not enough and as the old saying goes; picture is worth a thousand words. This is where the storyboards come to play. They are easily derived from scenarios or other concept description and enable more easily capture the context of use, not just the functionality embedded in the concept [4]. In order to create a storyboard one must identify the key tasks involved in the use of the concept, write a script for the storyboard and finally sketch the board to match each task with a single picture [2]. Figure 14 illustrates a storyboard of a mobile phone operated vending machine. As can be seen from the example, drawing skills are a benefit, but not compulsory.

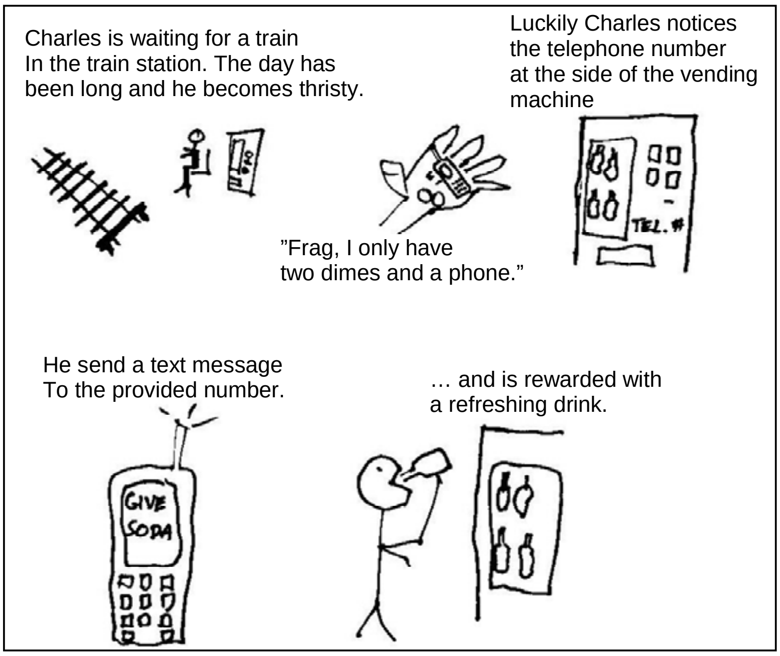


Figure 14. Storyboard of a mobile phone operated vending machine

If an artist more apt than the author of the previous storyboard is available to the team, a set of 2D/3D conceptual drawings, not unlike to architectural panoramas, can be made to depict the concept. If these kinds of higher quality images can be augmented to enact also the functionality in the concept they can create a semi-functional paper prototype of the product.

For certain types of concepts even functional prototypes can be rigged together using existing products or software simulations with close enough look-and-feel and functionality to enable the user to experience the concept features in a hand-on manner.

In some cases there is a danger that a too high-quality visualization of a concept harms the evaluation of the concept, as the users start to treat the concept as the real thing (more on this in the next chapter).

> The goal of concept **visualization** is
> not to make the concepts as **pretty** as possible, but
> to make the concepts' message as **clear** as possible.

3.4.2 Concept Evaluation and Validation

Evaluation of the concepts can be two-fold: 1) an expert evaluation without users performed by the development team (the product champion model) or an external third party evaluator (customer model), or 2) a formal or informal testing conducted with the potential users of the concept under development.

Many of the methods of now well-matured usability evaluation practices are also of use when evaluating a concept, although it is important to notice the distinct difference in the goals of the performed tests. When usability testing a finished product, the primary goal is to find usability errors that can then be corrected to improve the product. It is customary to before hand define the usability criteria as a metric for successfully passed usability test [31]. When evaluating a concept the primary goal is to find combined benefits from even contradicting concepts in order to merge and develop the concepts further and then pass them again to the evaluation phase.

Keeping this in mind the classic usability testing or pair testing using thinking aloud methods [31] are good sources for user feedback when the concept has been envisioned up to a functional prototype or a simulation using the Wizard of Oz method can be performed (for further details on the Wizard of Oz, please refer to [10]). The evaluation of many concepts with limited functionality can be compensated by increasing the contextual aspects. Performing the concept validations in their real environments or motivating the evaluating users with rich contextual description will increase the relevance of the evaluation results.

On the case of expert evaluation the available set of methods include previously discussed task analysis, conventional usability inspections (most suited are various accessibility testing or cognitive walkthroughs [31] to ensure proper functional flow within the concept) or scoring methods. In scoring the concepts are exposed to inspections against matrix of criteria usually with preset weights, either numeric or +/0/-, to their relevance to the acceptance of the concepts [25].

3.5 Project Assessment

In the final phase the developed concepts are matched against the original or evolved requirements from earlier phases. During the assessment the concepts are prioritized based on the evaluation results and a judgment for further development (iterate or migrate to production) or dismissal is given to each concept. For those concepts exiting the process successfully a full set of documents must be prepared, so that the knowledge of decision making and design criteria is passed on to the next phases of product development and manufacturing.

4 Conclusions

This chapter draws together the gained experiences on user-centered concept development during the last three years based on the 23 cases while governing the user-centred concept design[4] post graduate course at Helsinki University of Technology of past and ongoing concept development tasks in research projects.

The main contribution of this thesis is the definition of a process model to develop concept in a user-centered manner targeted to the practitioners or future practitioners of concept development. It illustrates a set of methods for each step in the process in a textbook fashion, to help new to the field to kick-start their concept development project planning and offer suggestions for its execution.

In the following chapters offer pointers to the relevant parts of this thesis and further clarification to discuss the research themes presented in chapter 1.3.

4.1 Process for User-Centered Concept Development

In general a concept development is a creative process that utilized several of the design, engineering and human-computer interaction talents to produce innovative, esthetically pleasing and useful new products. If this is done in a user-centered manner to improve the accuracy of the initial development goals and the usability of the created concepts, it does demand the inclusion of a user research phase. So in its simplicity the described process is a nested iterative model constructed from generic development and project management injected with a user-centered design and usability evaluation approach to a creative development process at its core as illustrated in Figure 15.

[4] Yes, the name of the course does not reflect the chosen terminology in thi thesis.

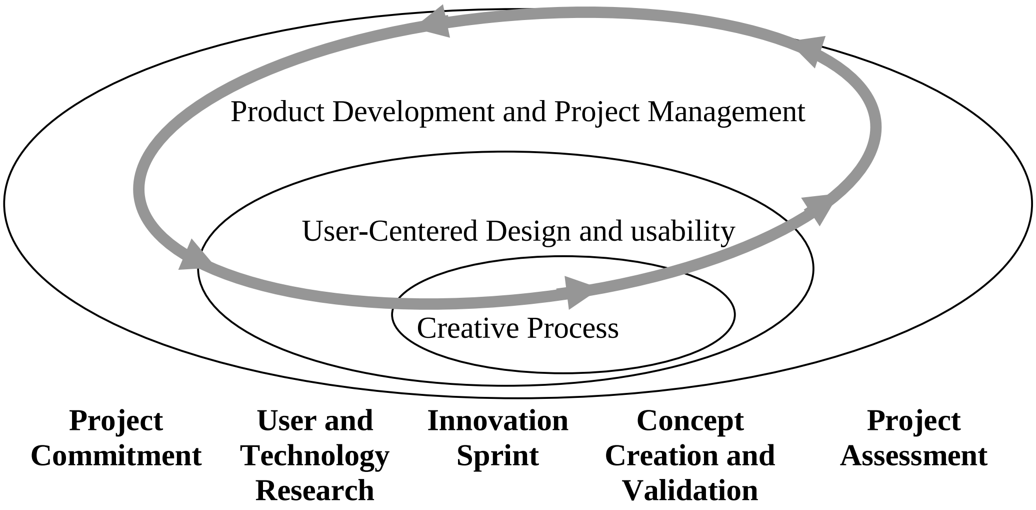


Figure 15. User-centered concept development as a nested iterative process

The process described in chapter 3 interconnects the aforementioned fields and offers guidance on iterating the process to improve its results.

4.2 Applicability of the Process

In the case projects the presented process has been applied to create concepts for wide variety of themes and user groups. Based on the case evidence the process is suited for concept development in several timescales. The selected technology frameworks can be seen to project a timeframe of 5-10 years to the future with relative credibility, while other more liberally innovated concepts catering the users' needs tend to slip further to unforeseen future.

The targeted user groups, experiences ranging from software developers to work trainees or from public transport ticket inspectors to children, do not offer any unsurmountable obstacles. That said, one should be vary for the inevitable change in user behavior or change in their context of use as their surrounding socio-technical environment evolves. I doubt that a researcher interviewing bank clerks in the 80's could have foreseen their absence in the late 90's due to self-service Internet banking services.

4.3 Validating Concepts via Usability Testing

On method level the same usability evaluation practices, i.e. usability inspections and testing, can be used to validate concepts as are used to perform usability evaluations for finished products (with the usual case-by-case fine-tuning). The main difference is the goal of the evaluation. In usability testing the goal is to find usability problems, make suggestions for improvements and pass the product based on set criteria [31]. When evaluating concepts with limited functionality one can only inspect its available features [37], thus the aim must be set to find good solutions among the set of concepts and combine them to a potential killer application.

Another difficulty in evaluating concepts is the variance in the detail of their visualizations. Some of the concepts may be in the form of scenarios, some fully functional prototypes. In either case the presentation of the concept may get more attention than the idea behind the concept. Unnecessary critique towards the implementation over function can be avoided with the use of interviews and focus groups as they do not rely on the actual use of a concept demonstrator.

4.4 Observed Difficulties in Applying the Process

This thesis includes two publications describing the process for user-centered concept development presented in chronological order. Some of the observed problems were corrected for the process described in chapter 3, yet some remain and they are addressed in this chapter and in the following Future Work chapter.

User-centered research or development tasks are inherently very demanding on the multi-disciplinary skill set of the development team and quite laborious. Above that the process has a few potential weak spots. The modifications to the process suggest the acknowledgement of the difficulties in migration from one phase to the next and the common overlapping of the phases.

Especially the transition from research phases to the creative phases seems to be problematic. In Figure 9 at page 19 this discontinuance, at some point nicknamed as “The Gap of Creativity”, is clearly visible on the left side of Innovation sprint.

The need to switch from analytical research perspective to creative frenzy, needed at the brainstorming sessions, is not an easy one and takes considerable amount of time and effort. Although the evolved process does not solve the problem it can alleviate the pain by making the problems known in advance, thus allowing the development team to prepare and reflect on it.

The overlapping of the phases cannot be seen purely as a hindrance as it does emphasize the need for iteration to gain maximum results from the process, but it does set higher demand on the flexibility of the project management and the availability of specialized expertise required at the different phases of the process, thus requiring a watchful eye from the project manager to avoid uncontrollable delays.

4.5 Discussion

The author of this thesis set to work to develop and document an easily adoptable concept development process that would take to account and flourish on real understanding of the users' needs. The approach of defining several versions of the process and then testing them on live concept development projects, whether student projects at a course or research projects, has proven useful. It offered a concrete way to iterate, adopt and formalize some of the best practices relating to creation of new product concepts. Although the process has mainly sprung out of "artificial" student projects it has promise to work well in real projects and organizations with some fine tuning relating to resource allocation and focusing of the concept development targets.

Due to the manner of its inception parts of this thesis have been tested in abundance and found well-suited to be used as educational textbook to introduce its subject matter and guide developers through their first concept development project.

5 Future Work

In this chapter the future challenges and some of still missing pieces of the puzzle are discussed. Some of these shall be tackled in the continuing research, some may be more optimistic and shall await further into the future.

As stated in the foreword the shown publications only reflect the first half of the process and by solving some of the below dilemmas the process can be validated and augmented to its full form.

5.1 Validation of the Process in Real Development Projects

The development of the described process is based on experiences from student projects at a university course and a few research projects. While the skills and prowess of the concept developers can be shown to be equal to their industrial colleagues, the motivation and character of student or research projects are somewhat different to real life product development. When the target is to create a potentially commercial product the actual work practices, available resources and tighter time schedule may hinder the applicability of the process. The required product development project experiences should become available when the suggested process is more widely implemented in the industry or applied as a whole in a solely constructive part of a research project.

5.2 Traceability of Collected User Knowledge

The available user case data from the cases is quite extensive and growing all the time. One challenge is to make this information and its implicit decisions more visible. One way to approach this challenge would be to create a data repository of user and context data with enough freely addressable attributes to support wide range of search functions. In a sense this would be explicating the (tacit) knowledge, earlier suggested to be governed with the traceability graph, into a database. With large set of observations, analyses and design perspectives one could reuse the prior studies in order to strengthen or even augment future concept development activities. The suggestion is not to dismiss the importance to conduct thorough user research on every project, but to enable sharing of knowledge to focus the research to those areas not yet fully covered.

5.3 Giving the Concept Better Forms

Evaluating the concepts is always very dependent on the form they are presented. The selection criteria for best possible visualization medium are not yet fully understood. Some work on the usability testing of future products i.e. concepts (therein referred as functional concepts) using mainly scenarios can be found in the literature [37], but the actual medium of presenting the concept is not in the focus of the discussion. Evaluation of concepts is more subjective than that of finished products as many aspects are left for the test users' (evaluators') imagination. It would be very fruitful to have a set of rules on what kinds of concepts should be presented in a form of a scenario or a storyboard, which ones require a physical prototype or dramatically enacted usage situation.

5.4 Simulating the Users in Validation

After a concept has been made concrete via visualizing it in the most appropriate form, there is still the case of evaluating it. Conventional usability solution is to conduct user tests, but how to go forward if the concept is targeting a future product with no existing user base. Where would one find adequate amount of astronauts to test a zero-gravity cooking utensil? One solution could be to improve user modeling from the now available profiles and personas to more action and ability oriented templates that could then be "played" as characters in a roleplaying game. This would enable access to otherwise unavailable user groups and potentially transition of some of the user testing tasks to a dramatically-performed expert evaluation method.

5.5 Finalization of the Concepts

As majority of the case studies founding this thesis have been performed by students at a university course and not as a part of a product development effort, the final "goodness" of the concepts have not seen the ultimate screening of a commercial production decision. Further studies are needed to find out what additional materials or tasks are necessary to prepare the concepts produced by the depicted process for this real life go/no-go test.

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