IN SEARCH OF WHAT IS MISSING – NEEDFINDING THE SIRIUS WAY

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ABSTRACT
"Listen closely to your customers, and you are more likely to design products that actually meet or even exceed their needs.": such statements have come to dominate company innovation strategies in the last decade, but in reality involving customers in product development (the development of physical artefacts) is not as straightforward as it sounds. Customers, it is becoming clear, cannot always express their needs adequately. Especially, in the case of innovative products where the starting position by definition includes no existing solution, applying a user-orientated approach is paramount. We argue that techniques for '*needfinding'* must be the point of departure. This has importance both in terms of methodological issues – how to find customer needs? – and for organizational work – who should be engaged in finding customer needs? In our view, engineers must be involved in identifying and understanding those needs. We have learnt through a series of studies, that structured needfinding by engineers during the earliest phases of product development could better support the process of identifying needs and thereby guide design projects. In this way, two basic problems are overcome. Firstly, identifying needs which are otherwise difficult to articulate becomes possible. Secondly, translation difficulties between customers and engineers are eradicated.

KEY WORDS
Product development, innovation, needfinding, education, and collaborative decision-making

1. Introduction

Finding and understanding customer needs are at the heart of developing innovative products. Traditionally, people at sales and marketing departments have been responsible for identifying and understanding customer needs. They interpret and put together the needs into requirement specifications, which in turn are interpreted by the design teams into product specifications that finally guide product development. This describes product development as having its starting position in a customer orientation, i.e., a customer segment is decided on, a market investigation is done by the marketing people and the result serves as input to design activities. In this approach, the investigation of needs does not affect the design of the product; merely informs it in minor ways [1]. This does not represent a *need-driven* approach to innovative product development, since designers and engineers do not interact directly with customers and may have no direct knowledge of the customer domain. In contrast, we apply an intertwined approach to identify needs *and* solutions early in product development to sustain the needs with the highest fidelity throughout the process.

Thirty years ago, Robert McKim, the head of Stanford University's product design program understood that engineers had to be involved at the earliest stages of product development to understand needs [2]. He developed an approach, named needfinding, which focuses on those needs that people have difficulty articulating [2], [3]. People can not always be precise about what their needs are; they might just be able to tell that they feel that something is missing. Sometimes, people are not even aware of a need until it has been met. In such situations, it is naturally more difficult to identify more exactly what is missing. It is obvious that this will be even more important with innovative or radical product design. This leads us to question if product development really can be driven by something that is missing? And if so, can the search for that missing something be trained for in engineering education? Thus, the purpose of this paper is to describe and discuss the needfinding activities conducted in student projects to contribute to the understanding of how decision-making in collaborative product development is affected by a need-driven approach.

2. Methodology

The case presented in this paper includes three student projects in the SIRIUS course at Luleå University of Technology. The choice of theoretical framework for this paper emerged from the underpinning rationale in the

course, i.e., identifying customer needs with the objective to drive innovative product development. The authors of this paper have interacted with the students during the total project time (approx 8 months per project) to generate data. Observations and participative observations have been performed in collaborative meetings with the students. The meetings have been of both formal and informal character. In addition to this, two group interviews have been performed. The interviews lasted approximately between 30-45 minutes. Five students participated in the first interview and seven students in the second. The interview sessions consisted of semi-structured but informal dialogues between students and interviewer. A set of general themes were predefined during the sessions to provide a focus for discussion. The themes were focused on the students' experiences from; product development, design activities and needfinding. The interviews were tape recorded. In addition to this, written material provided by the students has enriched the data.

These methods were used in order to identify as best we could the experiences of the student teams involved in these projects. Accordingly, they produce primarily qualitative data [4]. Qualitative data is based on interpretations or understandings, and are aimed at producing a 'rich' and 'contextual' understanding of experiences, rather than scientifically verifiable results. The justification for such an approach is that it may provide a rich understanding of rationale in a way that would otherwise be impossible using more conventional methods. Interpretation, analysis and categorising occur along the way when qualitative data is in focus. The choice of relevant data and the interpretation of that data are integrated and iterative activities. So, data has been analysed and reflected upon during the observations and conversations with the students. Data based on texts has been read in a non-cross-sectional way. This is a practice guided by a search for both the particular and the holistic.

3. Needfinding in Theory

The word *needfinding* implies the interplay between needs and recognition. A need is in itself a perceived lack of something [3], and such needs are difficult to express in terms of a potential solution. Something is a dilemma when the actors realise that all choices lead to unsatisfactory solutions [5]. Hence, a relation between dilemmas and such difficult-to-articulate needs can be recognised here. When people become used to their dilemmas, they often develop work-arounds to circumvent a need. Doing so makes them blind to the existence of that need. *"Needs are obvious after the fact, not before"* [3] (p.420).

The motivation for a focus on needs is firstly because *"Needs last longer than any specific solution"* [2] (p.38). Patnaik and Becker [2] write that the underlying needs for storing computer data endure longer than the solutions embedded in specific products, like punch cards, magnetic tape and 5 ¼" floppy disks. The need to store computer data continues to exist today, is continuously met by new solutions and will probably exist beyond the lives of those products. If a company sees itself as a provider of a specific solution, the company continues to improve that solution, but it rules out entirely new products and offerings that satisfy the need in different ways. Despite an interest and focus on customer needs, it can be concluded that they do not always guide product development [1]. There is a second dimension to the needfinding problem. Failures in product development can also be explained as a lack of knowledge concerning who might use the product; *"The engineers involved assumed that because they personally would like to own and use such state of the art devices, everyone would. They were wrong"* [3] (p.422). This tendency to focus on a product that designers might want to use themselves often leads to a product that is too complex [6].

Maslow uses the word *need* to represent a whole spectrum of circumstances in the Needs Hierarchy. The scale starts with basic needs, e.g., air, water, food, shelter, followed by defence needs, e.g., safety, security. The next levels are social needs, e.g., love, belongingness, and esteem needs, e.g., recognition, respect. Finally, there are self-actualisation needs, e.g., beauty, goodness [3]. However, to be able to categorise needs into the Needs Hierarchy, they first have to be identified or recognised.

3.1 The Principles of Needfinding

A main principle of needfinding is to *look for needs*, *not solutions*. It is important to keep all possible solutions open for consideration and avoid prematurely limiting the possibilities. A second principle is to make *research and design 'seamless',* meaning that the needfinder is involved in both studying people and conceptualising new products. Furthermore, it is important *to go to the customers' environment and let the customer set the agenda*. This is done to avoid people relying on their memory etc. as well as keeping the study open to unexpected insights. *Looking beyond the immediately solvable problem* implies that the problems which are not currently solvable can be fixed in the future. Yet another principle is to *make findings tangible and prescriptive*. A perceived lack of something that has led to work-arounds is better understood when supplemented with drawings, photos, audio recordings and/or video. Many quick passes to study people, rather than one long effort allows design work to proceed in parallel with the needfinding phase, thus allowing designers to *iterate and refine the findings* [2].

3.2 A Needfinding Process

The principles of needfinding are manifested in a four-stage process for studying people [2]. The first stage, called (1) *frame & prepare*, involves decisions about, e.g.,

the scope or coverage of the project, the goal of the study and the definition of the people to be studied. The second stage is (2) *watch & record*, and the third stage is (3) *ask & record*. In these stages, the needfinder uses e.g., observations and interviews. Observations alone can not tell the needfinder everything, and talking to people can give the needfinder insight into why a person acted in a certain way. The fourth stage, (4) *interpret & reframe*, emphasises that the interpretations of people's needs should be framed in terms of what problems have to be solved to improve the situation. These interpretations are translated into need statements and are prioritised into a hierarchy of importance. The last stage should be reframed and repeated to provide an increasing level of focus and detail.

Such methods have been implemented in a small number of cases. IDEO, a leading design firm in the US [7] bases its product development on a need-focused approach. The IDEO approach to innovation, they admit, can seem totally chaotic, but there is in fact a well-developed and continuously refined methodology guiding the work, *"…it's just that we interpret that methodology very differently according to the nature of the task at hand"* [7] (p.6).

The basic steps, or as IDEO calls it *"a method to our madness"* can be summarised in the following (pp. 6-7):

- Understand the user and the constraints the user perceives
- Use a variety of techniques to observe real people in real-life situations.
- Visualise concepts and the customers who will use them. Brainstorming is frequently used here as well as different ways to visualise the design ideas. Avoid frills and details.
- Evaluate and refine prototypes in a series of quick iterations. "*No idea is so good that it can't be improved on"* [7] (p.7).
- Implement the new concept for commercialisation, a long and technically challenging activity.

Instead of targeting similarities in focus groups, the IDEO way suggests *unfocus* groups covering a diverse group of people. *"We're not big fans of focus groups. We don't much care for traditional market research either. We go to the source. Not the 'experts' inside a company, but the actual people who use the product or something similar to what we're hoping to create"* [7] (p.25). Crazy users, rule breakers and the understanding that *"people are human"* are seen as sources for creativity, not the problem to be solved. Hence, being involved with people and keeping close to the action is an inherent part of the rationale behind the IDEO way.

Additionally, the organisation has to embrace a creative environment where you *"...feel comfortable enough to poke fun at each other – even at the boss – because you're among friends"* [7] (p.180). An informal context is essential to make people more open to share ideas and thoughts.

4. The SIRIUS Course

We aimed to evaluate these methods through observing their application on our SIRIUS course. SIRIUS is one of the final-year courses for students in the Mechanical Engineering MSc degree programme at Luleå University of Technology. Students from other MSc engineering programmes at the university can also attend the course. During the course, the aim is for students to acquire, apply and integrate knowledge essential for product development in modern manufacturing industries. To achieve this, the course has two main elements, which consists of a set of lectures and a product development project 'owned' and managed by the students themselves. These are organised in parallel. Each year approximately 50 students are divided into roughly 6 to 7 projects teams. The projects are running during an eight-month period. Project management, generation of creative concepts, collaborative engineering design and computer-aided design are knowledge areas in focus. All stages in innovative product development, from need analysis to a finished product, are carried out under realistic industrial conditions, in co-operation with affiliated companies and/or organisations.

Collaboration between students from other universities is also included in the outline of the course. However, how to collaborate, what activities that should be shared and how to share experiences and knowledge are up to the student teams to decide. Collaborative and geographical dispersed design teams are situated, for example, in Gothenburg, Sweden (Chalmers University of Technology) and in Stanford, CA, USA (Stanford University). Collaboration is mediated by computer technology, but face-to-face meetings have, despite distance and high travelling costs, also taken place.

The projects in the SIRIUS course start with an informal kick-off, recognised by the supervisors as important for getting to know each other. The kick-off activities are planned and carried out by the students; the coaches are invited to join the event. The course supervisors are called coaches to highlight their supportive, encouraging and non-directive roles in the projects. During the time the projects are running, the student team has to, besides design and develop a product/prototype:

- Attract sponsors to the project, especially for travels
- Perform four design reviews as the project unfolds to account for project status
- Keep record, on a weekly basis, of their activities in a Designer's Logbook
- Write material for marketing brochures
- Document the process into an examination report
- Design and prepare a presentation of the project and an exhibition of the product.

The period ends with a public presentation of all student projects, where affiliated companies are invited to participate. Participation of geographically distributed design teams is enabled by the use of distance-spanning technology.

One of the directions in the SIRIUS course is oriented towards, and called, Design for Wellbeing (DfW). The DfW projects are generally considered to have the strongest focus on customers needs in relation to the other projects in the course. DfW is planned as a multidisciplinary project with the aim to design innovative products to increase humans' feeling of wellbeing within a predefined area. The initial information from the client is ill-structured in its nature. The studied student teams in this paper constitute three Swedish DfW projects performed during 2004-2006.

5. The Design for Wellbeing projects

The Future Playground project was initially given the overall and broad aim of developing *something* for a playground or a meeting place. No direction towards a particular market, segment or target group was decided by the course management. Hence, those who should benefit from the product, in form of increased wellbeing, were to be decided by the student team. At the beginning, the student team consisted of four students. The task to form and decide on the project organisation was initially not considered as important by the students. The student said: *"at this point, being only four people, it seemed pointless to have a project organisation at all. We didn't need a particular person to assure that the project was running. We just put some names on the list in a haphazard way"*. After approximately two months, three additional students joined the team, but not until during the later part of the project, when prototyping started, did the students decide that the project leader role was important.

The Future Playground design team exchanged ideas and communicated with people from the company Onomy Labs in USA. However, the students and the company staff did not work together in the sense of a collaborative effort. The final product of this project is implemented at 'Teknikens Hus', a science centre in Luleå.

The initial information for *the Future Elderly Environment project* was in a similar way covering an overall and broad aim of developing *something* to increase the wellbeing of elderly persons. No further directions for the target group was given, so the students had to decide for whom they were going to develop the product, e.g., elderly people themselves or people in their surroundings. The project has been performed in parallel with an EU-project called NeedInn (from needs and innovations, also the client for the project) and the innovative product designed by the students is going to be implemented in a new and high-tech enabled elderly home. The Future Elderly Environment project had a close collaboration with students from Stanford University in USA. Four students from Sweden and four students from USA formed the design team. The design teams have had separate project organisations and have developed one product respectively; however the products are based on a common design idea. The needfinding phase was conducted separately by the design teams. The early design phases have been a collaborative effort enabled by videoconferencing technology, shared online workspaces, email etc. The design teams have visited each other, so the collaboration has also been performed in face-to-face meetings and workshops.

The Abbott project has had a company as client, Abbott Laboratories in Alameda, CA, USA. The product to be developed was restricted to the user interface of a glucose meter for people with diabetes. The Swedish team consisted of four students and they have collaborated with four students in a design team at Stanford University. The collaborative efforts have been sharing ideas and knowledge in the needfinding phase as well as in the design phase. Besides two face-to-face meetings of about a week each, the collaboration has been enabled by videoconferencing technology, shared online workspaces, email etc. The design teams had separate project organisations and have developed one product each. The Swedish design team formed their project organisation and decided to evaluate the organisation and their roles when the project had run for a while. This team developed a communication style where the levels; *we* as in the Swedish group and *we* as in the whole design team, became apparent in relation to the individual team member.

6. The Master Plan - P^2I

A generic master plan consisting of a timeline and a number of sequences to go through, guides the students in the product development activities. The master plan does not point out the sequences in detail and the purpose is to provide the students with an overview tool to estimate the efforts required for the whole project, as well as a map to keywords useful for searching relevant literature. The students are encouraged to develop and improve the master plan. The master plan can be described as a hybrid of needfinding [2] and the product development process suggested by Ulrich and Eppinger [8], and is called the Participatory Product Innovation (P^2I) process. The underpinning philosophy for P^2I is inspired by the IDEO [7] approach to product development. Practically, this means that the students are encouraged to use a variety of creative methods, e.g., the IDEO method cards and different brainstorming techniques, especially in the needfinding and concept generation phases.

At the moment, P^2I include seven overall sequences, (1) Planning, (2) Design space exploration, (3) Roadmap, (4) Concept design and prototyping, (5) Detail design and

manufacturing, (6) Pre-launch and (7) Product launch. Issues related to step 1 are presented (above, in section 5) and needfinding activities in step 2 are described and discussed (below, in section 7) in this paper. The planning sequence is broken down into activities focusing on team roles, goals, coaching, budget and deliverables (in terms of expected deliverables to course management, i.e., project documents and reports). At this stage, the expectations from students on the coaches and vice versa are talked about.

Besides the needfinding process, the second sequence, design space exploration, includes benchmarking, related technology and scoping. These activities are guided by the questions - *What? Who? How? Why?* The needfinding activities emphasise the 'why question' in particular to understand the customer's context and priorities. The 'what question' is posed to understand the customer's daily activities in detail. Within this interplay needs can be more carefully discerned. The scoping activities limits the design space by analysing data generated in previous activities. This activity prepares for the third sequence, the roadmap. A mission statement is included in the roadmap sequence. The mission statement establishes the general direction of the project without prescribing a particular way to proceed. Those who should benefit from the product and a description of how the target group should experience those benefits are to be included in the mission statement. A detailed presentation and discussion on P^2I as a whole will be reported on in a forthcoming paper.

7. Needfinding in Practice

The starting position for the needfinding phase is to create the frames for what kind of needs to search for and where to search for them. The projects Future Playgrounds and Future Elderly Environment had similar starting positions, that is, a wicked or ill-structured design problem. To find a focus for the needfinding activities, i.e., to have a feeling in a wide sense for what is sought for, the student teams started with a brainstorming session based on the words wellbeing and the respective topic, i.e., playgrounds and elderly environments.

At first, the Future Playgrounds students seemed to be confused, but rather quickly they seemed comfortable in the sessions. During a reflective discussion, the students were asked to describe what they thought about the project after that initial meeting. *"Spaced out"* the answer was, followed by laughter, then looking serious *"…until we started the brainstorming. We realised that we had all possibilities to do something new".* They realised that the potential for innovations was present in their project, and that the degree of novelty depended on their decisions.

During the brainstorming sessions the understanding of what wellbeing meant to the team members emerged and gave direction to the projects. The results of the sessions were that the target groups were decided on. The target group for Future Playgrounds was decided to be children and the objective was to increase their willingness to take part in outdoor activities and play games. The students contacted a school and were allowed to interact in the daily activities to observe and talk to the children. These studies highlighted the creative way that children actually play. One identified need was captured in the words 'creativity challenging'; in turn this need was met in the product by flexibility.

For Future Elderly Environment the persons in focus were decided to be the elderly themselves. At this stage the project was perceived by the students to be very ill-structured, and the students were asking for instructions. The supervisors were willing and did discuss their concerns; however no detailed direction were given. The students were encouraged to 'go to the customer' and 'let the customer set the agenda', i.e., to do observations and talk to old people in an elderly home using an open minded approach to visit the daily lives of elderly. During this period of time and in dialogue with the American students the focus for wellbeing was gradually detailed. Their separate need analysis showed the way to a common focus on social activity and stimulation for elderly persons.

The Abbott project group had the target group, people with diabetes, from the client as a pre-defined starting position. However, the students experienced the project tasks as ill-defined, not knowing who should benefit from the user interface and in what way. They started with benchmarking and related technology activities. Glucose meters were compared with each other and the students started to think about how people read and interact with displays, e.g., thermometer and speedometer. The students arranged a meeting with adult people with diabetes and started to learn a lot about the disease and how it is to live with diabetes. They also talked to medical care people. This knowledge was used to design a survey aimed at the target groups of both adults and children. After a dialogue with the client and the Stanford students, the target group was decided to be children and young people with diabetes. This target group was found to have difficulties in understanding the disease in relation to their behaviour. So, one need that the user interface was going to meet was expressed as 'understand and learn'.

The needfinding sequence in P^2I is experienced to be performed as separate from the following sequences, including several iterations within the steps. Iterations have been done to the needfinding sequence later in the design process, particularly when important decisions were discussed. The students have learnt that these iterations back to the needfinding make you aware that *"you are not doing the product for yourself; you are doing it for someone else".*

When reaching milestones for important decisions, the students said that they lacked something clear and obvious to base their decisions on, such as a weight or size. This is interpreted as related to the problems of expressing needs. The needs have been made invisible by those who act in the context where the need is situated, so they, as well as the needfinder, have problems to express the needs. In Future Elderly Environment identified needs have been captured in words by the students, e.g., 'rehabilitation' and 'feel good-looking'. Rehabilitation can be seen as a solution to a problematic situation. Feel good-looking can be seen as the increased wellbeing. The categorising and analysis that ended up in the words are conveying what needs that are included in the words and what needs the solution should meet. However, those who have not been involved in the needfinding and discussions cannot easily grasp the intrinsic meaning of the word. Thus, passing the knowledge to a new project member can be difficult. Another, difficulty has been to arrange the needs in a hierarchy of importance.

The student teams have identified needs and they have captured them in words. The students experience that the needs have affected their product development, but it is not obvious how the needs have been communicated into the development activities. The students have explained the third sequence, the roadmap, as a boundary or interface mediating between the needfinding and later activities.

The study of DfW projects uncover a challenge that can be interpreted as calling for a 'mental twist', i.e., to completely change the reasoning model for future engineers involved in ill-structured design projects. The traditional reasoning is explained by the students, *"As an engineer, I like to take a thing, a product, look at it, twist and turn it, and then improve it or make it better"*. In a need-driven approach to product development the engineers start with identifying a perceived lack of something [3].

Furthermore, the students have said that: *"We are trained to read books and look for the right answer or to listen to the teacher to get the right way to do things. We are used to do as the book or teacher says. We have never looked for the right answers by ourselves"*. In a need-driven approach, the teachers are not equipped with the right answers. They can support and coach the processes so that the students can develop necessary skills to use needfinding interchangeably with engineering knowledge.

8. Conclusion

The purpose of this paper was to describe and discuss the needfinding activities conducted in student projects to contribute to the understanding of how decision-making in collaborative engineering design is affected by a need driven approach. We have described the needfinding activities in three student projects. Needs have been identified by the students; needs which have been difficult to express in words. It became apparent from our observations that certain aspects were problematic and solutions not always easy to find. Firstly, even where needs were identified, finding a clear language to describe them was not always easy. As a result, assumptions often remained 'tacit' although they evidently informed decisions-making. Hence, a constraint in needfinding activities which has to be recognised is the difficulty of capturing and defining needs in such a way that they can be easily communicated.

We have also found that a challenge in such an approach is the change of reasoning model in early phases. Projects starting with identifying needs are experienced as difficult to understand, but also as enabling innovations. During this study the advantages of introducing students to a need-driven approach early on in the education can be distinguished. Our focus has been on early phases of product development. We have not considered how the needs affect the downstream activities. Future studies are to focus on the third sequence, the roadmap, in the master plan, P^2I, since it appears as it is here the needs are translated into engineering knowledge.

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