# 6 PROTOTYPING — A WAY TO THINK TOGETHER

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The descriptive study presented in this paper is based on the empirical data generated by observing a global student design team. Their prototyping process are described and discussed to feed input to the facilitation of team based innovation. The emerging of a shared design vision as early as possible is vital for the subsequent design activities, in particular for innovation projects. Every day items, body language and simple rough prototypes are used by the student team to communicate their ideas, to generate feedback on the ideas and to put forward new ideas. The study indicates that the process of doing rough prototypes enables designers to make their implicit understandings visible in such cases when the development starts from scratch, e.g., innovations. Thus, prototyping, i.e., the use of rough prototypes and body language etc, assist designers to collaborate and share experiences in early phases when no agreed upon design vision exists.

*Keywords:* Prototyping, Innovation, Engineering Design, Design Thinking, Early Phases.

## 1. INTRODUCTION

Generally, the Voice of the Customer (VoC)[1] is expressed as requirements on existing products, where the customer can for example, rank features according to their preferences. But, the VoC can also be fuzzy and elusive. That is, customers might not be able to express their needs, since these needs are commonly perceived as a problematic situation where every existing solution does not solve that situation. Customers cannot adequately express such needs; however they are important for innovative and new products.[2] 'Being visual' is a recommended approach when these kinds of needs are generated at the customers' place; therefore photos and video clips are used to show human behaviors.[3] Still, the process to go from these insights of customer behaviors to a new product is far from trivial; rather it has been found that the practice of communicating needs within a design team is a challenging task.[4] In an innovation project, needs provide the design team with the basic knowledge of the users, the context and their goals. Several perspectives within the team support the generation of new ideas, but, also, becomes a difficulty in the communication and the creation of a shared design vision.

The creation of a shared understanding of what to develop and insights into how that product should meet the customer needs depends heavily on a dynamic dialogue within the design team. For engineers, things, objects or tangibles are in mind and included in their 'natural language'. Language and words are commonly used by designers to transform everyday things to early on describe and become representations of abstract objects,[5] for example products that do not yet exist. In Italy, "vasca di pesce" or fish bowl was used within a car design team to describe the area where the windscreen wipers sit and runoff is directed.[6] Besides metaphors, people make use of more aspects than words and context to interpret each other's intentions and to derive meaning of the elusive contents of the dialogue, e.g., utterances, eye movement, facial expressions and body language.[5] In short, the process of interacting with things and objects has a rich communicative value in the collaborative design work,[7] they help focus thoughts and the topics of discourse,[8] and gesturing with physical objects enables design thinking.[9,10] Hence, including objects or prototypes in the design process is vital for the team to improve their performance, but the type of objects and prototypes that are used have different effects

on the communication. Some prototypes nurture a dialogue of the holistic design vision for radical innovation projects and some support the team to focus on features of the product in incremental innovation projects. Traditionally, in engineering product development, the actors are acquainted with and have well established methods to embark from an existing product and make improvements on that product. But, if they are facing a situation where there is no existing product to start from, as in radical innovation, their training that has focused on problem-solving might be a barrier. How to start from 'nothing' to do 'something'? What is the design problem? And, how can the vision of that design intent be supported?

In our research context of engineering design, it becomes interesting and vital to gain insights into how design teams apply prototyping to communicate and build a shared design vision. *Hence, the purpose in this paper is to describe and discuss the prototyping process in a team based innovation project*. The effort in the description is to highlight proto*typing*, rather than proto*types* (rough or preproduction). The overall aim, for future work, is to get insights that feed input to the facilitation of radical innovation projects and to the use of information- and communication technology for geographically dispersed teams. So far, the *enabling* role of technology highlights that it has to allow the teams to act as if they were in the same room.[11]

The disposition of this paper is as follows. First, the method used for the study and the case (the student project) is presented. Second, the concept of prototypes and prototyping is shortly outlined. Third, the empirical results are presented and discussed, and fourth, the paper ends with a conclusion and suggestions for further work.

## 2. METHOD

The empirical basis for this descriptive study is found within a global team-based innovation project conducted by master students from Luleå University of Technology, Sweden and master students from Stanford University, USA. The study reported on in this paper is based on ethnographic methods, namely observations. Access to the student project has been enabled by being teachers, coaches, in the Swedish course, however the contents in the student project has been 'owned' by the student team, and the design process has been performed under realistic conditions sponsored by a client. The student project has been followed for about 8 months, i.e., during the whole course. Data has been continuously generated during both collaborative co-located and collaborative distributed meetings. The students' collaborative activities have been videotaped. The analysis of the students design activities has been supported by 'field notes' when watching the videos.

### 2.1. The Student Project and the Nösphere

A European Commission-funded project called NeedInn (from needs to innovations) has been acting as the corporate sponsor for the student project and supplied the initial task; innovative products with a focus on the wellbeing of patients, to be implemented in a newly built and high-tech enabled elderly care home in Sweden. The frame for both NeedInn and the student project has been Design for Wellbeing,[12] which focus the development of products for people with physical limitations and/or people facing other constraints. Wellbeing as a concept has more to offer than merely remedying problems of specific disabilities. One basic element in Design for Wellbeing is to provide added value for people, enabling them to increase their active participation in society.

Four students from Sweden and four students from USA formed a global design team. Due to the fact that the students have participated in organizationally separated courses, they had to, for the reason of proper examination procedure, develop their prototypes and products respectively. The teams in Sweden and in USA have identified customer information; the interpretation of that information and the translation into needs has been a collaborative effort. In the every day work, the geographical distance has been partly bridged by using videoconferencing technology, shared online workspaces, email etc. The design teams have also visited each other. In particular, the face-to-face meetings and workshops was planned and performed in the beginning of the project.

Initial information to the students was that they were going to develop 'something' that would help increase the wellbeing of elderly persons. The Swedish team studied elderly persons at a retirement home and found that *nothing happens, they just sit in their chairs or rests in their beds*. In relation to additional information, for example that pictures and photos triggers memory and help people who suffers from dementia to communicate, the idea to develop a product that enabled activity and communication emerged. The finished product, named the 'Nösphere',[13] is a novel design where pictures are projected on the inside of a big plastic ball, and to change pictures the elderly spin the ball. The product stimulates the tactile movement and the mind of the elderly. Caregivers or relatives can upload images, by this, individual and personal pictures can be displayed and the elderly can stay in touch with current events in their lives and in the lives of their relatives.

## 3. PROTOTYPES AND PROTOTYPING

Commonly, in manufacturing industry, two or three product ideas are represented by prototypes. These prototypes are often in the state of preproduction, that is, they look like products ready to launch. The goal when developing such prototypes is to capture the functions and appearance of the finished product. These prototypes are used for customer testing and evaluation, and provide useful for the customer to rank the products or the features. But, it can be argued that prototypes of this kind constraint the communication in the design team. *"The more 'finished' a prototype seems, the less likely its creators will be to pay attention to and profit from feedback"* (Ref. 14, p. 87). The use of such preproduction prototypes in early stages is, by hampering the communication, also preventing the team to innovate.

In the early stages of innovative product development, rough prototypes are suggested. These rough prototypes should be as simple as possible, for example in the development of a new device for surgery, a designer took a whiteboard marker, a film canister and a clothespin and taped them together to visualize how he had interpreted the customers information.[15] Hence, every day items are used as stand-ins for more complex or abstract ideas to enable dialogue. And, the goal of prototyping *…isn't to finish. It is to learn about the strengths and weakness of the idea and to identify new directions that further prototypes might take.* (Ref. 14, p. 87). Accordingly, numerous of rough prototypes are suggested to convey, e.g., a feeling, the user experience or to learn from. Beside objects, the body is used to animate and visualize ideas, i.e., embodied representations.[16] Embodiment of ideas is, hence, a method of prototyping. To support communication and prototyping, creative methods are suggested[17] For instance, bodystorming[18] is useful to gain knowledge for how a product can be used.

## 4. COMMUNICATION IN THE STUDENT TEAM

In the following section the work within the student teams are presented. The prototyping process, i.e., how body language, items etc. is used, is visualised by images extracted from the videotape and the prototyping activities are discussed in relation to the presented excerpts.

### 4.1. Embodied Representations in Front of the Whiteboard

In this collaborative session the Swedish student team was visiting the USA team at Stanford University, hence this describes a face-to-face co-located meeting. Before this session the team had developed a simple prototype based on the idea of a 'scroll of parchment'. The elderly was thought to interact with the product by using their hands to scroll a canvas, but the teams discovered that elderly people has inflexible, soft and dry hands so it was impossible for them to among other things, gain enough traction on the surface to use the device. The idea for a ball evolved in the reflections of that prototype. So, in this session the teams had just started to explore the ball idea.

The global student team use a conference room to perform a brainstorming session. The room has ordinary furniture, huge table, many chairs and a whiteboard. The brainstorming rendered up in a joint concept, at this time all students had gathered in front of the whiteboard. They were drawing sketches and discussing new ideas. One student reconfigured an idea by adding a new feature while

simultaneously explaining: *we have a rod here that holds this…and a hole here*. Another student jumped into the discussion and builds on the idea: "*…well the access is here…so the hole is here…so the rod is in this…*" pointing on a specific spot on the sketch. The first student responds by nodding in agreement, and adds a new feature; he draws a ruff mechanism on the whiteboard next to the primary idea. To show how the mechanism would function, he uses his hands and moves them to show that the mechanism will tilt the ball. Yet another student enters the discussion and tries out with his hands directed towards the whiteboard how the motion would look like. As he moves his arms in a circular motion, he says: "*the whole thing moves like that*". The student who has added the feature replies "*Yes…the whole thing would flip like that.*"

The dialogue between the students in this session shows that they explore how the ideas would fit into a concept. The embodiment representations initialize the development of a physical prototype, in essence they are 'experiencing' the function of the tilt mechanism and the ball. However, the prototyping process in this session provides a basis for what to build. During this session, the use of embodied representations helped create a shared vision of the design intent. This interpretation is supported by the turn-taking in the conversation, where one student explains an idea, another student clarifies how he has understood the explanation and finally, yet another student shows how the concept would look like. That is, they were adding to a shared idea of the design, rather than questioning each others ideas ending up in a number of distinct ideas. The size of the ball was a topic in the next session (described in 4.2), but already here a vision of the size had emerged since they 'measured' using their hands. Further, using sketches on the whiteboard enabled the whole group to participate in the discussions and contribute to the idea generation. The embodied representations that were used extended and improved the arguments for a particular feature, but did also enable all to experience the design idea.

### 4.2. Experiencing the Design of the Ball

In this second session, the students are again gathered in a co-located meeting. During this meeting the idea of the ball is further enhanced by the team. In particular, the focus was to discuss an interface that was meeting the need of being as simple as possible.

The session started with a short discussion and reflection of what was learnt during the previous brainstorming session. Talking about the idea of a ball, the students started to talk about the dimension of the ball. They have by the testing of the 'scroll of parchment', identified a need for the product to be fairly large to compensate for the elderly persons' limitations in fine-tuned movements. Also a fairly large surface to display the images contributed to the idea of a large ball. A Pilates exercise ball was available in the room, and two students started a side-conversation using the ball to experience the use of a ball in that size. After a while, the students used the Pilates ball to show the rest of the group what they had discussed. One of the students held the ball up in the air and encouraged the group to try out the interface and to find a suitable axis.

In this session, available items were used as part of the prototyping process. The Pilates ball enabled the team to experience the size and the interaction with their intended product concept. Moreover, a ball pinned between two hands made it possible to experiment with the axis on which the ball could swivel around. Comparing how the students used the embodied representations in the previous session, and the chosen size of the ball indicates that there was a tacit and shared vision for the dimensions of the ball. Going back to Figure 1, the student is actually showing a tilt mechanism, but the distance between his hands is almost as if he is holding a Pilates ball.

### 4.3. A Physical Prototype Emerges and Experiences are Shared

In the third session, the student team has started to develop more rigid prototypes to prove the feasibility of their idea. This session is distributed and is performed by the use of videoconferencing technology. The team is in this session discussing what materials they have planned to use. The teams should respectively develop a physical prototype and the access to materials differs between Sweden and USA. They also elaborate on user needs and how the work with the prototypes will be performed.

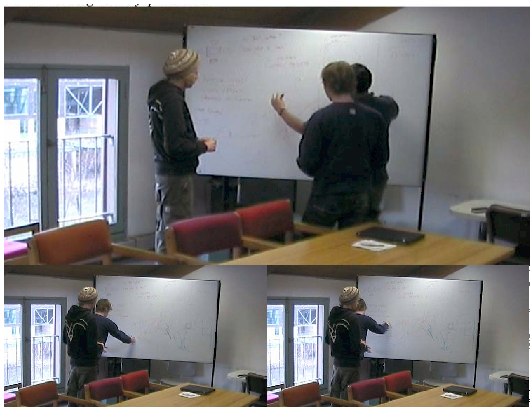

**Figure 1.** Students using embodied representations to discuss the ball idea and its functions. At the top, the student shows the motion of the tilt mechanism.

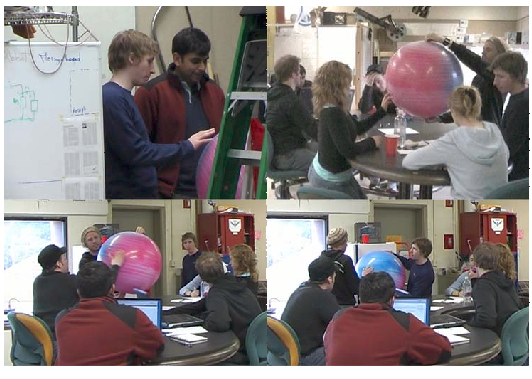

**Figure 2.** The use of available items to prototype interaction. A Pilates ball is used to experience the dimension and the use of the intended product.

The Swedish student team had found a plastic ball that, in their opinion, had the dimensions that they had agreed upon when using the Pilates ball as a prototype. The ball is showed for the USA students; however, as they communicate through videoconference, they cannot judge the size of it or the hole at the bottom of the ball. A USA student says: "*Put the ball on your head…*" The Swedish students all respond: *It won't fit. Put it on your head, astronaut style…* the USA student persisted *…we all tried that with our ball*. A Swedish student puts the ball on his head and says: "*Look it does not fit*". "*Wow…that is a small neck…*", the USA students reply, having the opening on the bottom of the ball in mind.

The students continued the session discussing the position of the technology that should be used to display the pictures and the solutions for the swivel function. At this point, when starting to envision a product, the need for space in front of the ball so that people in wheelchairs can use the product was also a concern. The ball is placed on a simple rack to convey the agreed axis and to enable a discussion for how to mount the technology. The students use their hands to show and to emphasize their arguments.

After discussing the Swedish prototype, the USA students used their prototype to share what they have learnt. They had experienced a technological problem. "*Using just one mirror means that we need a projector that opens up much. The problem here is that a lot of the times the image may hit the bottom of the ball right here, and the image on the top side becomes disrupted*", while explaining the USA student used his hands and their prototype to visualize the problem.

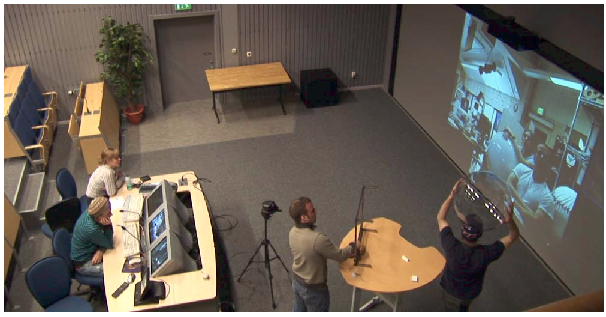

**Figure 3.** A Swedish student uses his head to help the distributed group judging the opening, the neck, of the ball.

**Figure 4.** Interacting with a rough prototype to discuss solutions and identify new ideas.

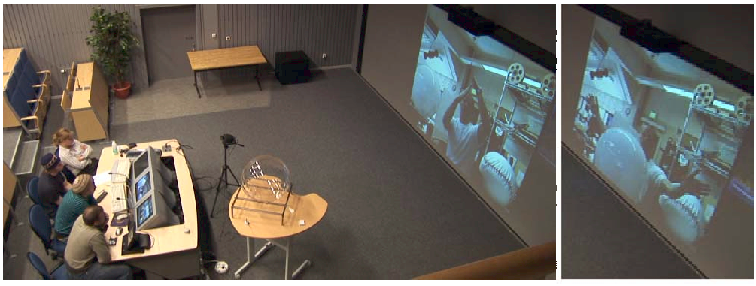

**Figure 5.** The USA student (on the screen) explains a problem.

The communication style in face-to-face meetings (two previous sessions) and in distributed meetings (this session) shows a major difference. Naturally, the dialogue is more dynamic in a group that are gathered in the same room and interacting with a common prototype. In these meetings the teams acted like one team. In the distributed meeting the turn-taking changes (you first and we later) and the sense of two teams emerge. In this study the development of two prototypes might contribute to this, but it also seemed like the technology 'by default' set the students into that mode.

The team members suggested the use of their body as a reference for assessing the size of the ball and other objects. But, the use of the body was sometimes constrained by the technology. For example, there were some problems when the students forgot to hold their hands in front of the camera, the other participants remarked that they did not see, and the student that was explaining was interrupted and seemed inconvenient. In such cases, the focus moved from the prototyping to the adjustment of technology.

## 5. PROTOTYPING — THINKING TOGETHER

A shared design vision or a shared understanding for what to design and how it should meet the identified needs is important, but a challenge for collaborative teams. The use of rough prototypes in early stages support design team to communicate ideas and drives the process towards a product concept. In radical innovation projects, there is, early on, usually no or very limited insights of the product at hand. Hence, it is not the prototype as such that is of interest but rather the prototyping experience, especially the negotiation, the sharing of knowledge and the creation of a shared understanding.

The use of every day items and the body makes it swift to put forward numerous of ideas, thus, not constraining the dialogue to focus on one solution. Since the prototype looks far from finished the team members are encouraged to provide feedback to evolve the ideas. In a prototyping process like this, experiences and implicit knowledge becomes visible and can be discussed. The rough prototypes and the body language becomes means for this transformation, and the invested effort for the prototyping is just as much as necessary to trigger a dialogue. However, the items are *given* other meanings during the sessions, after the sessions and for people outside the team they are still just things, in this case, e.g., a Pilates ball, not a Nösphere product. The prototype thus exists only when the designers are communicating their ideas by using it. The knowledge sharing with members of another project or into the organisation becomes problematic, calling for consideration of how to document the prototyping process. Also, to gain experiences and learn from rough prototypes a designer has to take active part in the dialogues, following the turn-taking by listening, sum up, explain and add new ideas and so forth.

This is a highly flexible process and any technology that aims to support the prototyping process has to take this into consideration. Further, in a distributed and technology supported setting, how to supply for useful items? Is a 'gadget-box' containing similar items enough? And, if so, what items should be included into that box? Such a box might even hamper creativity spurred out of the moment? And, finally, to simultaneous support designers that are working in dispersed teams to *experiencing* the design as in a prototyping process where embodied representations are used, it seems like science fiction has to be the inspiration.

## 6. CONCLUSIONS

In this paper the work within a global student team has been observed for the purpose to describe the prototyping process and the use of rough prototypes in a team based innovation project. This is done to get insights into prototyping in radical innovation projects. The starting position in innovation projects is vague, yet a shared design vision is vital for the subsequent design activities. The focus here has been the use of rough prototypes, e.g., every day items, body language and simple physical prototypes. In this study it became apparent that the prototyping process provided for a shared design vision or shared understanding to evolve within the team. That is, the *process of doing* rough prototypes enabled the students to experience design and to make their implicit understandings visible. A conclusion from this study is that prototyping, including the use of embodied representations, support the team members to widen the design space by building on each others ideas.

In this study we have focused our efforts on the prototyping process in the team. However, we have noticed that the environment, for example the conference room, did not always support the creative and flexible workflow. The table and the chairs was not used, the students was gathered in front of a small whiteboard in a corner of the room. Here, an interesting research question emerged; what kinds of environments support a prototyping process? Of interest for our future work is to perform a quantitative study on the effects of place and space on creative work. Also, for future research the interaction between sketches and embodied representations is an interesting aspect to elaborate on.

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