

Rough prototyping as an effective and efficient means of conveying intent

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Abstract

Working life is increasingly characterized by teamwork and projects. The modern engineer often deals with such complex problems that a broader set of skills is needed than what any one individual can possess. As a result, work is done together with a diverse group of people from different educational, professional, and even cultural backgrounds. Members might have varying perceptions of meanings and their own professional jargon. Furthermore, the team composition can change quite often along with new projects. Combining this all to the fact that abstract ideas can be challenging to understand and represent in the first place, misunderstandings are bound to occur.

One should prepare students to these conditions already during their education and provide them with the tools to function as productive members of their teams. Based on in-depth interviews of product development professionals, we suggest prototyping as an effective and efficient way to establish a common understanding between different parties. Especially rough prototyping is a method that can be utilized easily regardless of educational and professional background. This type of prototyping is often more efficient than building 3D-models and makes evaluating the ideas much easier especially for other stakeholders, such as users, clients and management.

Keywords: prototyping, interdisciplinary teams, project work, communication

1. INTRODUCTION

The problems we face today are becoming too complex for any one individual to master all of the skills and knowledge needed to solve them. Multidisciplinary teams are required to create quality solutions. While diverse educational, professional, and cultural backgrounds offer the best potential for creative work, heterogeneous groups pose a challenge for collaboration. Professional jargon might not be understood by all of the team members, and terms might have a different meaning for everyone. As one interviewed product developer (see next section) remarked, the first thing one should do when a client requests a concept to be created is to ask what the client understands by “concept”.

Furthermore, in for example product development, not only are team members from different backgrounds, the development team also needs to work with and take into account very diverse stakeholders: different departments within the company, outside clients, suppliers, subcontractors, retail, and, perhaps most importantly, users. One needs to be able to present the ideas so that they can be understood by practically anyone. As Leonard-Barton [3] remarks, as the community of stakeholders broaden, the importance of physical objects that can help to bridge the boundaries increases.

The need for communicational skills is by no means a new revelation in engineering education. However, presentation skills and other general communicational abilities are not enough, we need to be able to provide students with concrete tools to aid collaboration. As team composition can change frequently, there is a need to enable efficient working even without the lengthy period of getting to know each other. Our experience with PD6 workshops [4] and the Product Development Project -course at Helsinki University of Technology (TKK) has given a hypothesis that prototyping can help team members to do just this.

Finally, there is a need to concretize and aid the problem solving process itself. For example, one study comparing prototype-driven to specifications driven software design [1] revealed that prototype-driven design lead to more concise code and to a product that was easier to learn and use. Thus we at Future Lab of Product Design (FLPD) suggest that prototyping, especially simple and quick rough prototyping, can be an answer to both communicational and problem solving needs faced by teams. By rough prototypes very simple models are meant, which usually do not utilize the final materials. For example a rough prototype of a joint can be done using cardboard and pins. The model illustrates the basic principle of the joint's movement, but otherwise is not similar to the final product. In this article, if not specified otherwise, this is what is meant by prototypes (portraying some relevant aspect of the idea in a simple fashion), as will be discussed later on, sophisticated full prototypes serve a different purpose.

2. METHODS

2.1 Interviews

Subjects

During Fall 2007, 12 in-depth interviews of professional product developers were conducted. The participants to the study were selected based on nominations from product development managers for especially capable product developers within their department. They represented 4 large industrial and product development companies in Finland. The subjects had from 3 to 36 years of experience in product development and, with one exception, were all Finnish. Their current positions varied from chief developers and project managers to product development managers, but all of them had several years of hands-on experience in development projects.

Interviews

The interviews utilized a simplified variant of the critical incident based technique, critical decision method [2]. The subjects produced a step by step account of one example project that had gone particularly well and of one that had had more challenges than usual. The interviews lasted from 1.5 to 3.5 hours. The focus was on the initial phases of the project, where concepts are created and developed, rather than on the detail design and ramp-up for production. The interviews were transcribed and a number of reoccurring themes were identified and classified from the responses using an affinity diagram approach.

2.2 Questionnaire

A few results will be presented from a general project questionnaire from 2007. The web-based questionnaire was administered to the students of the 2006-2007 Product Development Project -course (PDP) at Helsinki University of Technology (TKK). Out of 95 students on the course, 49 completed the questionnaire.

3. RESULTS

The interviews revealed several challenges in product development projects: clients not understanding what they want (one of the most frequent challenges), design boundaries, managing change, committing stakeholders to the project, consequences of design decisions not understood by all parties, getting along and working together with the people involved in the project, seeing the big picture, communication with different parties, and creating positive competition. Perhaps surprisingly the generation of ideas itself never came up as a challenge, as can be seen from the list, most challenges were related to collaboration and understanding the concept. As the results below will reveal, prototypes can help in at least 5 of the 9 named significant challenges in product development: getting clients to know what they want, committing stakeholders, making consequences understandable to all parties, working together with all of the involved people and collaboration in general.

3.1 Clarifying and sharing ideas

More than half of the interviewees reported that prototypes help to clarify both the problem and the concept. "The purpose of prototypes is to find problems" (quoting one interviewee). Especially dimensions and mechanisms are much better understood from concrete models, the interviewees reported to do paper, cardboard, putty and other very simple models to help them to come up with quality solutions for especially spatial problems. On the other hand, according to the PDP course feedback, out of 49 respondents, 22 thought prototypes had helped very much to create the design solution and 22 that it had helped (totaling in 44 positive

reactions). 34 also felt sketches had helped the design very much and 12 that it had helped, so 46 out of 49 perceived that sketches had had a positive impact on the design solution.

Prototypes also ease design collaboration: the models are then twisted, turned and manipulated in meetings and with the stakeholders as well. Even if no models already exist, calendars, papers etc. objects found in the meeting room can be positioned to mimic for example the principles of a layout. It is often a lot easier to show the problem point than try to explain it (see also [5]). It was reported that showing a model of the solution concept often makes even the original problem itself more understandable to clients.

Clients not knowing what they want was identified as one of the most significant and frequent challenges faced in product development. Many of the product developers reported using prototypes also specifically to get feedback from the client. Many clients are not able to specify exactly what they need, but can react to a shown model – what it is too much and what it is too little. This allows the developer to iterate towards the desired direction. The consequences of design decisions might also be hard to understand for those outside the development team, but when the prototype is seen, they become apparent for all. Showing a prototype was also reported to increase the amount of feedback in general.

3.2 Creating enthusiasm and commitment

Not only did prototypes help to solve the problem and communicate with other parties, they were a source of motivation. Our experiences with PD6 workshops show that hands-on activities help new groups to start working straight away, and according to feedback, “the fun begins when the prototyping begins” [4]. This does not apply only to students: one interviewee commented that meetings become both more productive and more enjoyable with models, “there is an innate playfulness in humans”. It was also reported that the clients typically start to commit to the project on a whole new level after the first prototypes are seen, partly because they clarify the original problems to them. Physical models can also help to create commitment to the project in-house, for example in marketing and product management. (See [5] for more on prototypes creating enthusiasm).

3.3 Rough prototyping versus polished prototypes

Although realistic, full prototypes made out of the final materials, have their uses in product development, we at FLPD suggest rough prototyping should be utilized in the initial phases. As one interviewee said, the aim is to give an optimal representation of the idea with minimal work, and rough prototyping is a tool for just that. By rough prototyping very simple and fast prototypes are meant, typically utilizing paper, cardboard and other “hobby materials”. Rough prototypes can also be taken to include demonstrations of services; there is no need to bind the concept to physical products. According to the interviewed professionals, rough prototypes usually are enough for evaluating the ideas.

Avoiding waste of resources is not the only reason to avoid making the prototypes too sophisticated. If the models are too detailed, they easily guide the conversation to irrelevant aspects of the model – instead of evaluating the overall concept, the developer finds him- or herself answering to questions about why nails are placed at a certain place, why it is exactly this tone chosen, even though they are meant to be just examples. It is better to create the prototype to answer to a certain question or to portray the most important principle and leave the irrelevant rest out, as it avoids distracting attention from the focal issue. The whole concept might be judged unfit or unwanted based on irrelevant, still unplanned side aspects in the visualization.

Having too polished prototypes also risks giving the impression that the product is almost finished already. With this comes several problems according to the interviewees: first of all, there is the risk of disappointment, when the final product does not look like assumed from the prototype. Secondly, the stakeholders can find it hard to understand that they have to wait (and in the case of client, they have to pay) for the finished product much more, as it has already seemed “nearly finished”. However, perhaps most importantly, finished-looking models discourage feedback from users and other “non-professional” stakeholders. It is harder to criticize a final, “thought-through” product than a suggestion, and the whole point of a prototype is to be a tool, helping to develop the concept further. The more feedback the model invokes, the better [5].

3.4 Concrete versus computer models

Like full prototypes, 3D models unquestionably have their part in product development. However, again rough prototyping is better suited to the needs of the initial development phases. Many of the interviewees said that doing by hands is much more fast – in the time that one has created the first protrusion in a 3D model, the whole

structure could already be drawn by hand. One interviewee even recommended not turning on the computer at all at least in the first weeks of the project, it is only a distraction, and what can be done by hand, should be done by hand.

In addition to being time-consuming, 3D models might not be as helpful for further development of the concept. Many problems become apparent only in a concrete prototype. For example, it is much harder to understand space from the computer screen than by building a fast, perhaps a miniature model of the space. The 3D models are also less understandable than physical models to many stakeholders outside the development team, so concrete prototypes can serve communicational purposes better.

Finally, prototypes are needed still even more into the detailed design as well. The interviewees remarked that it is easy to create elegant and convincing 3D models that do not actually work. The danger lies in the fact that mistakes are harder to spot: the computer program might produce a beautiful and convincing result that everyone accepts, but due to one mistake in a parameter somewhere, the results are completely unreliable, which might be immediately revealed by a simple rule-of-thumb. In a CAD-program, the mechanism might function perfectly, but in real life there can be small tolerance deviations that cause problems.

4. CONCLUSIONS

When asked about problems with working with newly graduated engineers, the interviewed experienced product developers highlighted the need for engineering students to learn methods, tools, programs and ways of working, as they help the graduates to become productive members of the teams faster. In fact, while knowledge is continuously transforming and becoming outdated, methods and ways of working last for much longer and can be applied to more diverse contexts.

As team compositions are diverse and might change often, the need for effective communication is highlighted. The results from the interviews of professional product developers have given initial support for the hypothesis that rough prototyping is an effective and efficient tool for both communication and problem solving. Maximal understandability for a wide audience is achieved by minimal input, and unpolished models invite more feedback and keep the discussion on the appropriate level of detail. The prototypes also make both the problem and the concept more apparent and evaluating ideas becomes easier. It is also often easier to show what one means instead of describing it. Finally, the concrete models can help stakeholders to become more committed to the project.

Prototyping also helped in more than half of the significant challenge areas revealed by the interviews: at least clarifying the problem for clients, committing stakeholders to the project, making consequences of design decisions apparent, and communication and collaboration with the involved parties was enhanced by prototypes.

More research is still needed, but there seems to be reason to encourage and teach such a working way to students that concrete models are utilized as much as possible, especially in the context of project and team work.

References

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