Prototyping - Is It a More Creative Way For Shaping Ideas

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Abstract
Prototyping is an important phase during development of innovative solutions. Iterative design process and testing prototypes with users may highly improve the final result. Design Thinking methodology developed in Silicon Valley is widely recognized and used in many successful companies as a method to foster creativity and innovation. The paper presents selected case studies from Polish universities, where Design Thinking and prototyping have been introduced.

Author Keywords
Design thinking; prototyping; creativity; innovative teaching techniques.

ACM Classification Keywords
Design; experimentation; human factors.

1. Introduction

Are we able to assess the potential of an idea just after coming up with it? We feel it is great and has a huge potential, but... is that really so? Building a prototype to show it around, talking about the concept to friends and potential customers are actions meant to help to shape the idea at the initial stage into a powerful concept. Moreover, in many cases they give an answer about the idea validity. Design Thinking approach, coined and developed at Stanford University, has been implemented at a few Polish universities by alumni of Top 500 Innovators Program [6]. In this paper, we present selected case studies, events and classes organized to familiarize students and academic teachers with prototyping techniques. The paper is organized as follows: in Section 2 we give a brief overview of the Design Thinking methodology. Sections 3-5 presents selected case studies from universities in Gdansk, Krakow and Poznan, with descriptions of events, observations and conclusions.

2. Background

Design thinking has been defined as *"an approach to problem solving"* which combines: empathy (seeking to best understand the end-users of our innovation), collaboration (aiming in maximizing creative output through team's high diversity) and iteration (based on rapid prototyping, repeated implementation and improvement of the idea) [7] [8]. Design thinking is as well considered as a rational synthesis approach since it *uses the designer's sensibility and methods to match people's needs with what is technologically feasible and what a viable business strategy can convert into customer value and market opportunity* [4].

The methodology used for cases described in this article included five stages of the process proposed by Stanford University Hasso Plattner Institute of Design [9]:

1. Empathize – observe or talk to the end-user to understand his or her way of thinking. Also take into account thought leaders' opinions. Try to review the history of the issue and take into consideration all possible obstacles which happened in the past or may happen in the future.

2. Define – realize the problem of the end-user's unmet needs and expectations. Decide with yourself or your team exactly what issue you are trying to resolve. Prioritize your work in terms of urgency and try to determine what will be the success factor of this project.

3. Ideate – generate ideas and maximize the number of possible (or impossible) solutions. Use different variations of brainstorming techniques and remember not to debate or judge one's ideas. Combine, expand and refine ideas, to make something bigger and valuable. If it is possible create multiple drafts with solutions.

4. Prototype – create simple physical representations of rough and imperfect solutions to investigate their strengths and weaknesses. This step is important because it is the way to translate metaphor or "virtual" idea to a sketch, diagram, drawing or concrete physical object. Rapid prototyping techniques

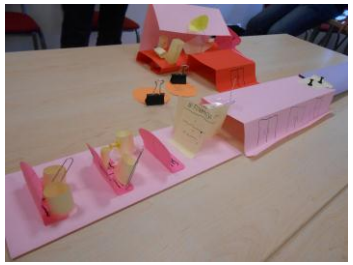

Figure 1. The students decided to modernize Polish trains.

Figure 2. The effect of user needs analysis.

Figure 3. Brainstorming session for solutions generation.

are used to reduce product development cycles, by checking user-friendly functionality, usefulness to end-users and eventually relevance of production. This technique is a powerful tool in almost all branches of production industry. Prototyping techniques are not only limited to the products, but it is also possible to prototype human experiences (e.g. What should we change in emergency room in the hospital to make people feel secure and comfortable?) or customer services (e.g. How to solve customer's product claim to make her or him satisfied with the service?).

5. Test – introduce the prototype to its end-user, but also to a diverse group of people. Collect feedback to improve the product and start the process all over again. Selecting powerful ideas is also an important step. The best or most practical solution, in our opinion, is not always the one valued the most by end-users!

For most outstanding results, design thinking process must stimulate participants' creativity (ability to generate novel ideas [5]) through various methods, tools and arrangements. The most often mentioned ones are: interdisciplinarity, varied tasks realization, work tools and spaces full of colors and unusual shapes, open minded approach and safe organization climate, humor and friendly atmosphere.

Besides creativity stimulation, employing design thinking in the everyday teaching curriculum develops students' empathy, integrative thinking, optimism, experimentalism and collaboration [4].

3. Prototyping class at Gdansk University of Technology

Two prototyping classes have been held for graduate students of Electronics, Telecommunications and Informatics Faculty at Gdansk University of Technology. The idea was to stimulate students' creativity; show them new, "manual" way of thinking; and instantly, fully engage them in an unexpected group work in the class.

Aiming in participants' fast introduction with the rules of this unusual class, we have applied kind of a shock therapy by totally rearranging the classroom space. Instead of regular, school-like tables set in rows, after passing through the door students surprisingly found O-, T-, U-, X- shaped table arrangements. A few seconds later, choosing a place for group work was the first (unrealized by participants) task stimulating their brains to follow the inspiration and think alike.

After short self-presentation, we proposed a team building exercise of participants setting up in a chronological order due to their birthday dates, without using any verbal communication. This quickly made a foundation for the next step: work in 3 to 5 people teams randomly selected by the facilitators. Due to the need for interdisciplinarity and various techniques of group creativity stimulation, we wanted to introduce to the workshop as much unexpected heterogeneity as possible.

The class was planned due to the design thinking process and split into five stages of a certain length which was later adjusted to the whole group working pace.

Figure 4. The prototype of a Dream Customer Service at the Dean's Office.

Figure 5. The warm&cold bottle presentation and testing experience.

Figure 6. Creativity Lab at AGH University of Science and Technology.

1. Product/service selection (ca. 15 min) - the students were asked to choose a product or service that in some ways disappointed them. They were encouraged to come up with more than one idea and choose the most attractive one in the next stage of work (Figure 1).

2. User needs analysis (ca. 30 min) – the feeling of disappointment was analyzed in the means of unmet user's needs and expectations. Working in unusual teams, brought into the light different perspectives, stimulated empathy and opinions exchange. A few questions inviting to define particular needs, product/service deficiencies, drawbacks, etc., made a basis for this fundamental stage of the design thinking process (Figure 2).

3. Solution generation (ca. 25 min) – the participants went through a short brainstorming session in their working groups. The task was to propose as many solutions as possible to each of the inconveniences listed in the previous phase without any criticism or idea selection. A2 sheets of paper, colorful markers and postITs were provided to write each new thought on a separate sticky note. This gave a possibility to prioritize, mix and match them in the second phase to choose the best overall solution and formulate new or better version of the analyzed product or service (Figure 3).

4. Prototyping (ca. 65 min) – it was the time to approach the table full of colorful papers, pens, markers, clips of various sizes, ribbons, plastic cups and packages, and more. Students willingly engaged in building prototypes of their new, ideal products and services. Of course, facilitators' continuous observation and motivating conversations with participants were needed to help them understand the process and its purposefulness (Figure 4).

5. Testing & development (ca. 40 min) – the last part of the class was the most enjoyable: the students presented their prototypes in front of the whole group and asked for comments. No criticism was allowed but explanation of own feelings, needs, experience and day to day observations related to the each piece of work.

The last stage confirmed the value and reasonableness of the whole process of design thinking. One of the prototypes was a bottle to warm up or cool drink due to the needs of its owner (Figure 5). Students proposed a bottle design made of alternating horizontal strips of two different materials: cooling and warming ones. One of the participants noticed that horizontal design would make the drink alternately cold and warm which was not the effect users were looking for. As a result new solution of vertical aligning of the strips was proposed.

During this class participants experienced the effectiveness of rapid prototyping. They learnt the basics of design thinking approach and personally tested the tools used for its facilitation and creativity stimulation. Prototyping combines the advantages of ideas' early stage testing with a great value opportunity of experimental learning on own successes and mistakes. They say *the best way to learn is by doing*. The students' active involvement in teaching process

Figure 7. Prototypes developed by students in Krakow.

Figure 8. Prototypes developed by students in Krakow.

Figure 9. Prototypes developed by students in Krakow.

that is offered during prototyping classes has been met by students with great enthusiasm. This success motivates facilitators to continue introducing design thinking methods into teaching curricula for creativity and success stimulation.

4. Creativity Workshop at AGH University of Science and Technology and Jagiellonian University

Creativity Workshop is a 1-semester experimental course introduced in the academic year 2012/13 simultaneously at 2 universities in Krakow: AGH University of Science and Technology and Jagiellonian University (see the course website: [2]). The former is a 15-hours program available for graduate students in the field of Applied Computer Science (within "Engineering of Intelligent Systems" track) at the Faculty of Electrical Engineering, Automatics, Computer Science and Biomedical Engineering [3]. Extended version (30-hours) available at Jagiellonian University is as a facultative course for cognitive science and philosophy students (mixed group of graduate/undergraduate students) at the Institute of Philosophy. Within the course, students learn various methods improving and stimulating their creativity while working on their own or in a team (Figure 6). The program is strongly inspired by the methods taught at Stanford University and learned in Silicon Valley within the Top 500 Innovators program [1].

One of the classes, devoted to Design Thinking, is a 90 minutes fast-pace "Wallet Project". It leads the participants through all the stages of the Design Thinking process (see Section 2) in a rapid and condensed way. The main goal of the project is to show the students *the value of engaging with real people to help them ground their design decisions, that low-resolutions prototypes are useful to learn from (take an iterative approach), and to bias toward action (you can make a lot of progress in a little bit of time if you start Doing).* [10]

The students worked in pairs, in which they designed a product for each other. They had to conduct two interviews with their partners in order to learn about their needs and values. Starting from a very well defined problem of designing a wallet, they were then asked to re-framed the challenge and to design something "meaningful and useful" for their partner. Depending on the conversations, discovered needs and insights, the final product might have been an answer to an utterly different problem than set at the beginning. An important step in the process was iterative prototyping, in a form of sketches, notes and – finally – tangible prototypes made from cardboard, blocks, paper, drawing pins, paper clips, rubber bands, plasticine, clothes and objects typically found in a workshop or a garage.

After the experience, the students were asked to reflect on the process and answer the questions about particular phases, including empathizing, prototyping and feedback. Although the students showed much enthusiasm doing the prototypes, and seemed proud, satisfied and amused during the demonstration of the results, their opinions varied a lot when it came to evaluating how the prototyping contributed to the final design. Some of the participants stated that this phase helped them while others denied it. Most of the students built really creative and impressive prototypes, although some participants stated that available materials were insufficient to realize their

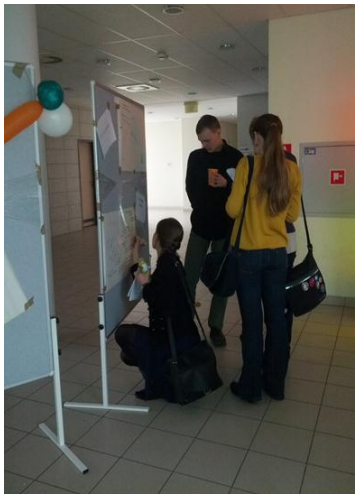

Figure 10. Creativity Day at Adam Mickiewicz University.

Figure 11. Prototyping stand.

idea. Most of the students emphasized the feedback phase which helped them better understand the user's needs and in some cases re-define the problem (Figure 7) (Figure 8) (Figure 9). A few participants stated that prototyping really helped them think and only until they build the prototype, they refined their idea. Almost all participants admitted that the idea changed and evolved during the iterative process.

Two groups at AGH University of Science and Technology and one group at Jagiellonian University took part in this class. It is too little to draw far-reaching conclusions about differences between engineering and humanities students. It stood out, however, that engineering students were more impressed by the interviews and valued the conversation time, claiming that this phase had too little attention. They also highly appreciated the feedback phase and seemed more willing to modify their design. With respect to the definition of the design challenge (problem statement), female participants seemed to frame them wider, including relations with other people and context within the challenge, while male participants were more focused on the functionality of the final product, however influenced by their values and personalities.

Observation of these and consequent classes leads to some more conclusions. First, it seems that prototyping may by challenging for some people, not used to this specific kind of stretching imagination (they did not know how to use available resources). Nevertheless, no participant opted out of this phase, even if they preferred not to draw attention to their work, so it seemed to be an interesting experiment for all students. It could be observed that for some people the prototyping was a sort of revelation, and the next time, when prototyping was optional, they immediately used the possibility to do it. Moreover, some participants who enjoyed the prototyping, became more daring, and the tangible things inspired them to act more spontaneously, elicited their acting abilities and a sense of humor.

5. Creativity Day at Adam Mickiewicz University

This was one of those ideas you have right before falling asleep. It comes to your mind without a reason and with no shape. First Creativity day was a pilotage event which took place at Biology Department at Adam Mickiewicz University.

Creativity Day is meant to be an open platform to create and exchange ideas. This is also a way to acquaint students and academic teachers with new techniques and approaches for generating ideas. It was also designed to check people reaction and to test if the idea is good or bad. There were no expectations towards this project, only a general thought of introducing new creative techniques in place like university where people should be creative or at least could learn how to be creative.

For this reason 4 to 6 stands with empty paper sheets and colorful markers were left in a certain open space in the building only for one day. Perfect place is where people like to hang out and spend their free time between classes. Such friendly atmosphere and creative environment increase the amount of open-minded ideas. Every Creativity Day has its main topic (e.g. “Our Department”, “Biotechnologist, how society

Figure 12. Campus map prepared during Creativity Day by many different people.

sees you") and few additional questions facilitating the main topic (e.g. "What do you like about this place?").

The first Pilotage Creativity Day proceeded very rapidly. Stands were located in the morning and for the first two hours nothing happened. Students tend to wonder what it is all about and what should they do with this. There was also a table serving as a prototyping stand (Figure 11) so that people could easily prototype their ideas. It drew attention of many students mainly because of provided gadgets (scissors, colourful paper, glue, balloons, colourful PostITs, etc.). Yet, its outcome was poor. Students are not familiar with this method and need a facilitator to moderate prototyping activity.

Fortunately, just after first brave opinion was put on the paper an avalanche happened. Paper filled with thoughts and ideas. Some of them were interesting, some crazy, some were comments of reality, some were complaints. This event was a great opportunity to gather very honest opinions (also those cruel ones which in era of Internet forums seem typical for young people). At the end of the day stands were covered with different thoughts, ideas and simple prototypes.

Important observation is also that when the time passed students put their ideas on the paper and in some cases build complicated stories. Different people were adding their thoughts to create one consistent picture for a solution. This means that subconsciously we are able to build creative solutions based on someone's ideas.

6. Discussion

The presented cases illustrate how introducing prototyping into university environment is received by different groups and in various settings (see Table 1):

Gdansk University of Technology	AGH University of Science and Technology	Adam Mickiewicz University
2 single classes	1 class x 3 (part of a semester-long course)	Single open event
Interdisciplinary teams	Individual work or work in pairs	Ad-hoc teams or individual work
Warm-up, team-building activity	Tight schedule (no warm-up at this time)	No warm-up, no tight schedule
Facilitators	Facilitator	Facilitators
Product selection and emphatize phase done collaboratively	Topic given, emphatize phase done in pairs, collaborative re-framing problem	A few topics to choose from, no explicit emphatize phase
Brainstorming	Reduced brainstorming – individual work and work in pairs	A visible tendency to build on others' ideas, yet not explicitly guided
Prototyping: great fun and engagement, new experience for students, enthusiasm and contentment	Varied opinions on the influence of prototyping on the final design, enthusiasm and interest, diversified engagement	Initial apprehension, gradual improvement of the process (encouragement by other people prototyping)

Table 1. Comparison of prototyping activities introduced to three different Polish universities.

In all setting, people showed great interest and curiosity for the prototyping as something new and unusual. Moreover, it turned out that facilitation is very important, because people are not used to this way of working and need guidance. In all cases, prototyping resulted in developing really innovative and interesting solutions. Most important lessons learned are: the need for conscious introduction of the new techniques into the academia, need for relaxed and comfortable environment, friendly atmosphere, to defeat the apprehension of being silly and risking, and warm-up and team building activities, especially when new people work together.

7. Conclusion

It may be concluded that there is an enormous potential of creative thinking in Poland, but there is a need to build an environment supporting it and promoting in Polish universities. We are a creative nation, but we do not know how to manage this creativity or how to use it to develop innovations. We should introduce new techniques known and used for years at world top universities into the education. These include brainstorming for new ideas, implementing ideas by prototyping of products or services based on customer's needs, team building, working in interdisciplinary teams etc. With access to knowledge and with help of experienced mentors facilitating processes of design thinking we can achieve long-term goals supporting and stimulating innovation in society. Some of us are born creative, some of us need to learn to be creative, but it is worth the effort.

Experiences described in this paper demonstrate that introducing innovative methods, such as Design Thinking and prototyping into curricula or university open spaces, is well-received by the academic community. The results are promising no matter if we consider design schools (where it is obvious) or faculties of computer science, electronics, biology or philosophy. What is more important, it is a great fun and never-ending journey!

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