# A First Implementation of a Design Thinking Workshop During a Mobile App Development Course Project

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## ABSTRACT

Millennials prefer learning-by-doing and social learning, and project-based learning. At the same time, software engineering educators should take into account that software development projects require not only technical skills but also creativity—Design Thinking can help in achieving the latter. We conducted a workshop, following the Design Thinking approach of the *d.school,* to help students generate ideas for a mobile app development project course. In addition to the details for implementing the workshop, we report our observations and lessons learned. Moreover, we provide suggestions for further implementation of Design Thinking in similar courses.

## KEYWORDS

software engineering education, design thinking, project-based learning, team-based learning.

## 1 INTRODUCTION

Millennials—the tech-savvy generation of university students—prefer learning-by-doing, group works, and the social aspects of learning [1]. For them, the roles of consumer and producer of creative work are blending [2]. Software engineering educators should take into account those features and put an emphasis on practice as theory alone is not sufficient to solve real, professional-grade problems [3]. Therefore, software engineering curricula often include project-based courses, in which students have the chance to apply traversal skills (e.g., software development, project management, user experience design) while addressing a complex, possibly real-world problem. Rather than focusing on specific, technical knowledge, software engineering educators should support the students' learning process and help them to deal with complex problems while exploring diverse solutions. This approach is not static and requires creative problem solving [4]. In the last few years, Design Thinking has emerged as a problem-solving approach for "wicked problems,"

settings which are characterized by incomplete, contradictory, ambiguous, and changing requirements [5]. Design Thinking supports the generation of ideas and solutions which are "viable and novel for a particular group of users" [6]. Other disciplines [7], including engineering [8], use Design Thinking as a teaching approach, particularly in combination with project-based learning. In this paper, we describe and report our lessons learned from a design thinking workshop carried out during M-Lab—a project-, team-based course focusing on app development with industry partners, playing the role of real customers at the University of Hamburg, Germany. We implemented the workshop as an intervention for the teams struggling with creating a viable solution for the problems presented by their customers. This scenario was ideal for Design Thinking and for engaging the students in generating creative solutions. In particular, we used the Design Thinking approach proposed by the d.school (Section 2) and followed several of their recommended methods during the workshop (Section 3). We conclude the paper reporting lessons learned and suggesting further improvements (Section 4).

## 2 DESIGN THINKING MATERIAL AND METHODS FROM d.school

In this section, we describe the Design Thinking approach we used during the workshop based on the methods developed by the Hasso Plattner Institute of Design (also known as d.school) founded at *Stanford University* in 2005. We decided to use this specific approach as it has already been tested in an engineering environment. Although there is no accepted definition [9], Design Thinking can be understood as a framework with a *"human-centered approach to problem-solving"* [10]. Depending on the context, Design Thinking can also be interpreted as an innovation method, a working procedure, an attitude towards life, a mindset, or a tool [9]. The d.school defines *Design Thinking* approach as a "constant work-in-progress" framework of working modes (Section 2.1) and mindsets (Section 2.2).[1]

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[1] https://dschool.stanford.edu/resources/the-bootcamp-bootleg

## 2.1 d.school WORKING MODES

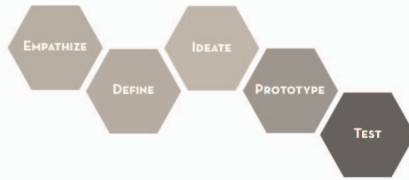The working modes are process phases, which consists of five iterative steps (see Figure 1), described as follows[1]:



**Figure 1: Working Modes from d.school.[1]**

**Empathize.** In this mode, the designers should try to understand their users. The theory is that the actual problems of the users are often not communicated to the designers. Hence, designers need to empathize with the users to design appropriate solutions that fit their needs.

**Define.** In this mode, the designers need a deep understanding of their users to identify their problems. Based on these insights, designers can "scope a specific and meaningful challenge."

**Ideate.** The challenge defined in the previous phase represents the starting point for the designers to look for a solution.
This process supports the designers in generating new ideas; they will have an exact problem to solve and know where to start. Moreover, while searching for a solution, the designers will come up with new ideas.

**Prototype.** A prototype is "anything that takes a physical form."[1] It is useful to test functionalities, deepen the understanding of the user's needs, inspire teammates, and explore more solutions.

**Test.** The testing mode gives the designer the opportunity to get feedback from the users. The latter will improve the idea and lead to new insights.

## 2.2 d.school DESIGN THINKING MINDSETS

In the guide "The Bootcamp Bootleg", the d.school states seven mindsets (see Table 1) representing a toolkit to support the design thinking practice. The mindsets describe the attitude needed by designers to practice Design Thinking.

**Table 1: Mindsets from the d.school "The Bootcamp Bootleg." [1]**

| MINDSET | DESCRIPTION |
|---|---|
| Show, don't tell | Communicate the vision in an impactful and meaningful way by creating experience, using illustrative visuals and telling good stories. |
| Focus on human values | Empathy for the people the designer is designing for and feedback from these users is fundamental to good design. |
| Be mindful of the process | Know where the designer is in the design process, the methods to use in that stage, and what the goals are. |
| Bias towards action | The name Design *Thinking* is a misnomer; it is more about doing than thinking. The designer should be biased toward doing and making over thinking and meeting. |
| Radical collaboration | Bring together innovators with diverse backgrounds and viewpoints. Enable breakthrough insights and solutions to emerge from diversity. |
| Embrace experimentation | Prototyping is not simply a way to validate an idea, but an integral part of the innovation process. Prototypes are built to think and learn. |
| Craft clarity | Produce a coherent vision out of complex problems. The problem needs to be framed to inspire others and fuel ideation. |

# 3 IMPLEMENTING THE d.school DESIGN THINKING DURING M-LAB

In this section, we report the motivation to organize the workshop and the specifics of its implementation.

## 3.1 WORKSHOP MOTIVATION

The d.school Design Thinking approach was implemented as an intervention workshop within *M-Lab*[2]—a semester-long project-based course at the Department of Informatics, University of Hamburg, Germany. During the project, each of the five teams, consisting of five to eleven students, developed a mobile app for a real customer (e.g., the city's largest hospital). According to the syllabus of the project, the students should have generated "innovative" ideas (to be later implemented) two months after the beginning of the course. Two teams were struggling with idea/solution generation. Hence, the teaching staff decided to intervene with a Design Thinking workshop. A mix of 11 Bachelor and Master students (four from the software engineering curricula, five from Information Systems, one from Software System Development, and one from Human-Computer Interaction) attended the workshop. We interviewed the teaching staff before the workshop. They reported that the students had issues coming up with innovative ideas and that rather than trying to create something new or remarkable, they were more concerned with meeting all the formal criteria to pass the course (e.g., writing a problem statement, developing a clickable prototype). According to the teaching staff, the team facing the most difficulties was the one that did not get any specific requirements from their customer, a large telecommunication provider, about how the final app should look. The customer gave the team complete freedom regarding specific functionalities, as long as their solution would improve the communication between the provider and other users in an innovative way. Instead of

being inspired by the possibilities, the students felt overstrained and clueless.

Based on these insights, we wanted to achieve two types of goals, internal (i.e., not communicated to the students) and external (i.e., presented to the students), as listed below:

**Internal Goals**

- Inspire students' creativity.
- Improve their confidence and enable them to come up with ideas in a limited amount of time.
- Help the group struggling the most, without exposing them as "weak" to their peers.
- Provide each team with specific impulses for their progress.

**External Goals**

- Reflect on the current state of their project
- Create new ideas as well as concrete suggestions for their implementation

## 3.2 WORKSHOP IMPLEMENTATION

We summarize the implementation of the workshop in Table 4, focusing on:

- Goals to be achieved by the facilitator and students.
- Activities carried out by the facilitator and the students.
- Corresponding d.school working mode.
- Materials used by the facilitator for the preparation and during the workshop.
- Formation (e.g., grouping) of the students during the different steps.
- Timeframe.

The workshop took place at the University of Hamburg. The environment consisted of a room with space for 30 people (see Figure 2). The materials used were pinboards, a flip chart, Post-It notes, markers, A3 and A0 sheets.



**Figure 2: World Café Round 3.**

The first author of this paper acted as the facilitator and put the workshop into practice. The workshop lasted for two hours and consisted of five modes[3] (see Figure 3).



i) Introduction  ii) Understanding  iii) Definition  iv) Ideation  v) Prototyping

**Figure 3: d.school Working Modes.**

**i) Introduction:**
The facilitator and students introduce themselves and tell each other about their backgrounds.

**ii) Understanding:**
Every team reflects their previous progress with a template (see Figure 4) and should realize if they understood and covered the needs and problems of their users. This phase should be used as a starting point to build up empathy for the users.
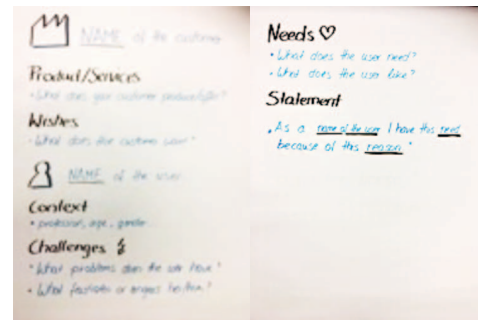


**Figure 4: "Understanding" Template Customer/ Users.**

**Transition** from Understanding to Definition:
The facilitator chooses an app project in agreement with the students. Following the recommendation of the teaching staff, the students will focus on the telecommunications app.

**iii) Definition:**
The facilitator collects the experiences of the students as smartphone users and customers of a telecommunications provider. The facilitator closes this phase with a clear scope focusing on three topics.

**Transition** from Definition to Ideation
The facilitator prepares students to develop an open mindset with an adjusted version of the improvisation game "Yes, but.../Yes, then let's..." (reported in Table 2).

**Table 2: Instructions of Improvisation Game "Yes, but.../ Yes and then let's..."**

| PHASE | ACTION |
|---|---|
| Preparations | • Each student chooses a partner whom he or she never really interacted with before.<br>• The students should get used to working with unknown partners. |
| Round 1: "Yes, but..." | • Student A thinks about a destination, where she or he would like to travel.<br>• Student B has to find arguments against the ideas of Student A and should start her/his sentences with: "Yes, but..."<br>• The dialogue should last about 2-3 minutes.<br>• Example of a dialogue:<br>  - Student A: "Let's travel to Hawaii."<br>  - Student B: "Yes, but it is so far away."<br>  - Student A: "Maybe, but it is sunny and we can relax at the beach."<br>  - Student B: "Yes, but I will probably get a sunburn and have to stay in the shadow for the rest of the journey." |
| Round 2: "Yes, and then let's..." | • Student A starts with the same destination.<br>• Student B has to build on the ideas of Student A, and should start her/his sentence with: "Yes, and then let's..."<br>• The dialogue should last about 2-3 minutes.<br>• Example of a dialogue:<br>  - Student A: "Let's travel to Hawaii."<br>  - Student B: "Yes and then let's spend some time on the beach."<br>  - Student A: "Exactly and go swimming."<br>  - Student B: "Yes and then let's rent a boat to visit all the small islands of Hawaii." |

**iv) Ideation**

The students create ideas using the "World Café" method reported in Table 3. During each round, they fill in the template shown in Figure 5.
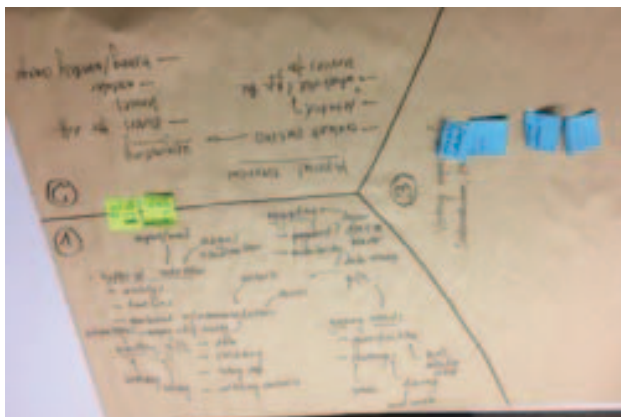


**Figure 5: World Café Template**

**Table 3: World Café Procedure.**

| PHASE | ACTION |
|---|---|
| Preparations | • The students spread equally according to the number of tables. |
| Round 1 | • Each table team creates ideas or solutions based on the topics of the "Definition" phase. |
| Transition to Round 2 | • Each team chooses a "table master."<br>• The "table master" has to stay.<br>• The other students spread individually to a new topic/ table. |
| Round 2 | • The "table master" presents the results of the previous group to the new members.<br>• The new team creates ideas or solutions based on the results of the previous group. |
| Transition to Round 3 | • The first "table master" has to leave the table and the team decides on a new one.<br>• The other students spread individually to a new table again. |
| Round 3 (see Figure 4) | • The new new "table master" presents the previous ideas to the new team.<br>• Last round of ideation based on the ideas of the previous teams. |

**v) Prototyping**
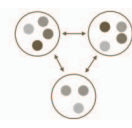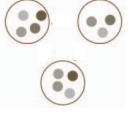
The students transform their theoretical ideas into paper prototypes (see Figure 6) These prototypes should serve as inspiration as well as suggestions on how to implement the ideas.



**Figure 6: Paper Prototypes Round 3.**

After the last mode "Prototype", we had a debriefing session in which we summarized the results of the workshop and gathered feedback from the students.

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**Table 4: Detailed description of the implemented Design Thinking (DT) Workshop.**

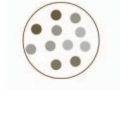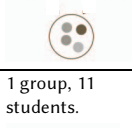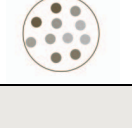| PROCESS | GOALS | MATERIALS | FORMATION | TIME | DT MODE |
|---|---|---|---|---|---|
| **i) Introduction** | | | | | |
| • Facilitator and students introduce themselves (name, background, app-team). <br> • Flipchart presentation of the goals and schedule (displayed during the duration of the entire workshop). | • Creating a trustful atmosphere. <br> • Involve students, so that they are more likely to express their ideas by [11]: <br> - Knowing each other's name and background. <br> - Being transparent about the procedure. | • Tape, name tag for the participant. <br> • Flipchart. | 1 Group, 11 students. | 5 Min. | |
| **ii) Understanding** | | | | | |
| • Facilitator presents a template with questions about their customer and users (see Figure 4). | • The students should recap their current progress and what they might have missed. | • Flipchart. | 5 Groups, divided by app/project. | 10 min. (presentation). | Empha-thize |
| → *TRANSITION TO THE DEFINING PHASE:* | | | | | |
| • In agreement with the students, the facilitator decides to focus on the telecommunication team. | • Focusing on the telecommunication team without putting them in a difficult spot. <br> • Creating a clear scope. | | 1 Group, 11 students. | 5 Min. | Empha-thize → Define |
| **iii) Defining** | | | | | |
| • 1. Elicitation. <br> The facilitator asks the students about their experiences with their telecommunication provider. The facilitator writes down each experience on a Post-It. | • Collecting needs and challenges, which should be inspirations for solutions/new ideas. | • A0 sheets. <br> • Pinboard. <br> • Post-it. | 1 Group, 11 students. | 15 min. (work) | Define |
| • 2. Clustering. <br> The facilitator arranges Post-It in clusters on the board while brainstorming with them. | • Getting an overview of the topics and preparing for the voting. | | | | |
| • 3. Voting. <br> Each student votes for their most interesting topic/cluster. | • Defining a clear goal. | | | | |
| → *TRANSITION TO THE IDEATION PHASE:* | | | | | |
| • Improvisation Game: <br> "Yes, but..." / "Yes and then... "(see Table 2) | • Making students realize how important it is to be open-minded and supportive towards teammates to create new ideas [11]. | None | 6 pairs. | 5 min. | Define → Ideate |

| | | | | | |
|---|---|---|---|---|---|
| **iv) Ideation** | | | | | |
| • World Café [12] (a technique for generating ideas—see Table 3):<br>- Facilitator puts the top three topics on different tables with a template (Figure 5).<br>- Students divide equally (max. four students) onto the tables.<br>- Students rotate topics and teammates three times. | • Creating ideas based on other people ideas.<br>• Collaboration with different people.<br>• Students realize that too much discussion in the ideation phase prevents new ideas. | • A0 sheets.<br>• Tables for 3 A0 sheets. | 3 rotating groups. | 30 min. (each round 10 min.) | Ideate |
| **v) Prototyping** | | | | | |
| • First round of prototyping:<br>- Students stay in their last World Café.<br>- The facilitator hands out a paper with smartphone outlines (see Figure 6).<br>- The students have to sharpen their solutions by building a prototype. | • Creating suggestions and inspiration for concrete implementations. | • A3 Sheets with Smart-phone Outlines. | 3 groups. | 10 min. | Prototype |
| • First feedback with method "I wish/I like":<br>- Teams present their prototypes.<br>- Students comment on prototype what they like/what they wish the prototype would offer or change.<br>- Facilitator writes down the feedback. | • Getting constructive feedback from the other groups. | • Post-It. | 1 group, 11 students. | 15 min., each group 5 min. for presentation and feedback. | Test |
| • Second round of prototyping:<br>- Adapting the feedback.<br>- Presentation. | • Realizing that early feedback is very helpful. | • A3 Sheets with Smart-phone Outlines. | 3 groups. | 10 min. | Prototype |
| • Second round of feedback:<br>- Same as first feedback. | • Getting constructive feedback from the other groups. | • Post-It. | 1 group, 11 students. | 15 min. | |
| → *DEBRIEFING* | | | | | |
| • Facilitator sums up the results of the workshop. | • Building up students' self-confidence by stressing that they accomplished a lot in a short amount of time.<br>• Convincing students that their mindset is important to be creative. | • All the results on Pinboard.<br>• Flipchart. | 1 group, 11 students. | 3-5 min. | |
| • Feedback:<br>• The facilitator gives students a small ball:<br>- The students toss the ball to one another.<br>- The student with the ball should give a feedback. | • Collecting suggestions to improve future workshops. | | | 10 min. | |

# 4 RESULTS

The workshop had the effect of changing the students' perspective towards a human-centered approach. At last, their final ideas were based on potential user's needs.

From the educator perspective, the most significant challenge was deciding on methods in line with:

- The internal and external goals.
- The mindsets of the d.school Design Thinking.
- The available amount of time.

In this section, we reflect on the achievement of our goals and report the lessons learned and suggestions for further improvements based on our observations during the workshop, and at the end of the project.

## 4.1 ACHIEVEMENT OF INTENDED GOALS

We assess the accomplishment of our goals based on the students' feedback and the facilitator's observations.

### Internal Goals

- Inspire creativity – *Achieved.* During the "Prototype" mode the students worked autonomously without any further guidance of the facilitator. They reported a strong feeling of accomplishment.
- Improve students' confidence and enable them to come up with ideas in a limited amount of time – *Partially Achieved.* Students commented that they felt very productive during the workshop, however, the facilitator did not ask upfront whether they gained experiences that will change their way of working.
- Help the group struggling the most, without exposing them as "weak" to their peers – *Achieved.* After the definition phase the students, encouraged by the facilitator, agreed on the telecommunication topic.
- Provide each team with specific impulses for their progress – *Not achieved:* the students felt that mainly the telecommunication group gained suggestions specific to their project.

### External Goals

- Reflect on the current state of their project – *Partially Achieved.* During the *"Understanding phase"* the students should have used the template (see Figure 4) to understand their customers' wishes and their users' problems and needs. However, they focused on filling the template rather than reflecting on whether the customer's wish meets the user's need. Some groups did not give an explanation regarding an apparent mismatch between the identified user's need and their customer's wish.
- Create new ideas as well as concrete suggestions for their implementation – *Partially achieved.* New practical suggestions to implement certain ideas were made. Although, some ideas had in part been created by the team prior to the workshop.

## 4.2 OBSERVATIONS DURING THE WORKSHOP

We divide our observations, lessons learned, and challenges according to the specific steps.

### Understanding phase

*Observation.* The facilitator observed that the description of the template (see Figure 4) was not specific enough. In particular, some students described their users in general; other described a personification of the user. The students were confused by the term "name," which meant for some groups a real name like "Jane" and not the general name of their user group. In fact, the facilitator wanted them to take the perspective of their typical user group rather than making up a persona. The students should look at a group to get a comprehensive overview of needs and problems. A single persona could be too narrow and misleading if the students did not interview their customers and users.

*Lesson learned.* Describing the task as clearly as possible.

*Suggestions.* The template should explicitly state the characterization of the users in the *Understanding template* (see Figure 3). For example, express the naming of the user group as an activity rather than a noun. Therefore, we suggest the template to be tested beforehand—e.g., in a small dry run.

### Defining phase

*Observation.* In the beginning, we were worried that the students would not engage with the workshop and could not develop needs and problems because their academic background was too similar in contrast with the mindset of "*radical collaboration.*" (see Table 1) Although the facilitator asked the group about each student's experiences and background, three did not provide any. Nevertheless, it was a productive phase, mainly due to the input from the students with a more creative education (e.g., in human-computer interaction, user experience) who provided half of the discussion topics.

*Lesson learned.* Not every student is used to openly express his or her ideas nor able to develop them in a group.

*Suggestions.* Before starting the open discussion, every student should get a few minutes to think and develop their ideas individually. Moreover, we suggest asking for background information separately—e.g., in an online form or interview.

### Ideation phase

*Observation.* During the "World Café," some groups took too long to start sketching their ideas. The facilitator had to keep the students from discussing too much by reminding them about the time limit.

*Lesson learned.* It was challenging for the facilitator to keep an eye on every single group, as well as tracking time and to make sure that the groups would not get stuck discussing details. Therefore, the students should do some parts of the group management.

*Suggestion.* At the beginning of each round, the students should assign roles, like "writer" and "timekeeper" to remember themselves of their tasks and focus.

### Debriefing phase

*Observation.* The students were surprised by how productive they were in such limited time. They expressed positive feedback about the strict time-frame of the working sessions which forced them to focus on the essential parts of their ideas. They suggested that the workshop should take place at the beginning of the project rather than half-way through it.

*Lesson learned.* Although the students experienced an unusual approach in comparison to their previous studies, they appreciated the workshop and engaged with the activities.

*Suggestions.* Implementing the Design Thinking workshop not just as an intervention, but as a regular part at the beginning of the course.

### 4.3 OBSERVATIONS AT THE END OF THE PROJECT

In this section, we focus on the feedback obtained by the telecommunications team.

*Observation.* The team had four members. Only two of them participated in the workshop. It became apparent that their teammates did not want to engage with the ideas that emerged during the workshop. They did not perceive the workshop as useful because it did not have an applied goal and it was just about creativity. However, after the customer later expressed dissatisfaction with the team's technically-motivated ideas (e.g., a chatbot to improve customer support), they were then motivated to work on the ideas which had been the output of the workshop.

*Lesson learned.* Acceptance is critical to implement new ideas. The students need to understand and experience the ideation to implement the ideas.

*Suggestion.* All members of a team should be involved in the workshop so that each of them has the chance to contribute with his or her idea(s).

*Observation.* The team did some research afterwards and realized that the customer already implemented most of the ideas generated during the workshop.

*Lesson learned.* While the students were halfway through the project, they were still not able to get an overview of the products/services of their customer due to difficult background research due to the company size.

*Suggestion.* Involve the customer in the workshop and ask them for validation (e.g., *Test mode*) to get faster feedback and to avoid redundant ideas. Planning an "Ice-breaker" session—a game to prevent biased behavior due to the different roles (e.g., customer, student, teacher).

*Observation.* According to the team, the final app idea did not originate from the workshop. However, the facilitator documented an idea which was quite similar during the first prototype phase.

*Lessons learned.* Students can experience difficulties in accepting that their project idea originated from a context in which other teams were also involved. This indicates low acceptance towards shared ownership of ideas.

*Suggestion.* In case of an intervention workshop, the facilitator should ask the students beforehand about their ideas and experiences to avoid redundancy. To that end, the facilitator can prepare an "*Ideation phase*" for every team to increase the acceptance towards shared ownership of ideas. The educators should acknowledge those side effects of project-based learning (e.g., a team crisis) to the students as learning opportunities which can be solved using Design Thinking.

## 5   CONCLUSION

In this paper, we reported our experiences conducting a Design Thinking workshop with teams of students involved in project-based learning. In particular, we used the modes and mindsets proposed by the Stanford d.school to implement Design Thinking activities. From the workshop, the students gained a human-centered perspective towards the generation of innovative solutions. We proposed improvements for further iterations of the workshop based on our lessons learned.

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