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METHODS FOR IDEATION: REVIEWING EARLY PHASE CONCEPT GENERATION AMONG INDUSTRIAL DESIGN ENGINEER STUDENTS

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ABSTRACT
Developing and teaching method design remain an important component of many product design and engineering courses. Several scholars have shown that the use of ideation methods may result in better concepts. Yet students do not actively use many methods. In order to understand which ideation methods are used by students during the early phases of concept generation, we examined student journals kept during the length of a practice-based course where students worked on tangible interfaces. Students were not specifically instructed to use any specific method. Our study reveals that students use a limited assortment of ideation methods as part of the early phases of concept generation, often restricting themselves to unstructured brainstorms, finding inspiration from existing products and services. Our study raises questions about method use and education.

Keywords: Design methods, brainstorming, education, conceptual design, ideation.

1 INTRODUCTION

Method design remains an important focus of design and engineering researchers [1], with researchers continuously developing or adapting existing methods. Especially for young designers, methods may offer a systematic way of ideation or product development that leads to better design outcomes [2]. Among such systematic approaches, we find an assortment of tools aimed at finding (design-) inspiration and solutions through various ideation techniques [3]. Yet, while many developed methods may not be used extensively by students or practitioners [4], students still rely on certain tactics to help them create design solutions and education on methods is nonetheless taught widely.
To understand which tools design students use, we examined the chosen ideation methods of master level industrial design engineering students during a 12-week course where student teams developed tangible interfaces that go “beyond the desktop” [5]. Project examples include augmented reality prototypes in the kitchen, an installation for a public library, a nurse call system or improving an e-bike for postmen. Projects typically involve industrial design, and human computer interaction. Students are already familiar with a variety of existing design tools and techniques, having completed earlier courses on methods in design. Students were not specifically asked to apply any particular method during their design process and were thus free to use methods as they saw fit. Student-teams were asked to keep an online journal during the course. Each team catalogued all design decisions, benchmarks, meetings and design iterations. Our focus was specifically on ideation methods. Priority was thus given to the early phase of the development process where opportunities are identified [6], and the methods used to help refine the design task and lead to a choosing a final design focus.

2 BACKGROUND

2.1 Methods in higher education

Cross frames the rise of methods as object of inquiry as an attempt to make design more scientific [7]. Since the 1970’s design methods has garnered much attention from scholars as a way to systematize design decisions, and many have proposed their own particular design methods. From the start of their

education, students also get into contact with a wide variety of methods that should aid them during the design of products. Seminal texts introduce and review a variety of methods for "Finding and Evaluating Solutions", ranging between brainstorms, literature searching, or analysis of technical systems [3, Ch. 4]. Other relevant scholars in this domain include Cross [8, p. IX], who "offers a strategic approach and a number of tactics as aids for designing successful products". Efforts may also focus on better understanding the target audience or the context of use [9]. Similarly, Jones presents various techniques such as brainstorms, or morphological charts [10, Sec. 4].
These texts illustrate the emphasis on methods in design higher education. However, the focus on methods is not without criticism. For example, Dorst [11] remarks that surprisingly few methods are actually used by students, emphasising the importance of studying design practice. Rogers [12] also states that, while many theoretical approaches have been helpful in the scope of human computer interaction practice, uptake among practitioners remain low.

2.2 Related Studies

There have been various efforts at studying method use among design students. We provide a brief overview, first looking at selected comparative studies that highlight difference in - and value of - method use. Following this, we introduce studies that provide overviews of method use among students and practitioners.
Daalhuizen, Person and Gattol [4] compared the effect between systematic and heuristic methods on students experience. Significant differences were found between the two approaches, with systematic methods resulting in higher experienced time pressures and effort, and lower feelings of motivation. Yilmaz and Seifert [13] also looked at the use of heuristics by an expert designer, stating that through the application of heuristics, the designer expands his creative thinking.
Weaver et al. [14] compared two specific methods, the Transformation Design method and the WordTree Design-by-Analogy, showing that the Transformation Design method increased the quantity of ideas. The authors refrain from analysing the quality of the concepts generated by each of these methods. Also relevant is Lai, Honda and Yang's [15] study into user involvement, examining how involving users impacts design outcomes, concluding that iterative evaluation of concepts can be particularly valuable. This study contributes to these earlier efforts through reviewing the actual ideation method usage among students. In an additional comparative study, Genco, Hölttä-Otto, and Seepersad [16], conclude that method use by freshmen students, specifically, the 6-3-5/C-Sketch method (see [17] and [18]) yields results significantly higher than those by senior design students, suggesting that this particular method can be valuable in design practice.
While these studies offer comparative analysis of method use among students, others provide a review of tools and methods usually used by designers. For example, Stolterman et al's [19] provides a review of "designerly tools". While tools may not always equal to methods, the authors took a similar approach by cataloguing the variety of design tools used by master or PhD level design students. Examples include whiteboards, interviews, personas or brainstorming. Similarly, Biskjaer, Dalsgaard, and Halskov [20] provides an overview of tools often used by interaction design students. These studies highlight the value that method use may have and the uptake among students. We further contribute to this work by providing insight into the actual use of methods among master students.

3 METHOD

3.1 About the course

As part of their master education, students at our department were tasked with the development of tangible interfaces that go "beyond the desktop" (see [5]). These projects typically involve a certain degree of interaction and interactivity. Students were presented with cases, some of which proposed by local industry, and others linked to on-going research. Students could choose three cases in order of preference. Following this, students were assigned a case. Groups are limited to 4 students, with most containing 3. They are asked to keep a journal of their process, meetings, technical issues, ideation processes and early prototypes. Results are finally documented in a short paper. Students are all in their 4th year and have thus already finished their graduate (Bachelor) degree and are currently enrolled as Master Design Engineering students. None of the participating students were international. The education in the Bachelor program offers courses on ideation and creativity techniques, user involvement and problems solving.

3.2 Data collection

We focussed on the online journals of each team (n=15). Their journal was analysed for mentions and descriptions of ideation methods and techniques. The emphasis was on the first weeks of the course, when there is a strong emphasis on ideation. However, in some cases (#5 and #15), ideation extended beyond early phases and here, analysis was continued until the final concept was identified. We focus on the journal and paper, since this documents their design process and captures the various methods they themselves feel are most valuable. Results are categorised into explorative and generative phases, following Finke et al.'s [21] creative process categorization. Finke et al.'s [21] model is widely cited in studies on creativity and problem solving [13], [22]. Additionally, we included ranking solutions, as this frequently assists students to narrow down the scope of their ideation.

4 RESULTS

4.1 Explorative phase

A common exploratory strategy was exploration into similar solutions, using both visuals and videos, presented as a collage. These serve both as inspiration (on form and function) and as benchmarks to strive towards. Additionally, technical reviews were conducted to explore the limits and possibilities of various sensors or electronics platforms. The results from the technical review may be used to frame a brainstorm or result in the rejection of ideas. For example, team 10 rejected their initial concepts after realizing their technical complexity, and restarting ideation, limiting their scope.

Table 1. Overview of method used

	Explorative				**Generative**				**Choosing**
Team	Solution Ranking	Related Works	Technical review	Field research	Brainstorm	Scenario's	Sketching	Digital Images	Solution Ranking
1		X		X	X		X		
2	X				X			X	X
3	X	X			X		X		X
4					X	X	X		
5	X		X				X		X
6		X	X				X	X	
7	X	X			X		X		X
8		X	X		X		X	X	
9			X		X		X		
10		X		X	X	X			
11					X				
12		X		X					
13	X	X	X		X				X
14		X			X				
15	X			X	X		X		X

Figure 1. Overview of some of the ideation methods by students

In later phases not covered in this paper, students involved external stakeholders to test prototypes, but in the early phases external collaboration through field research was limited. An exception was team 15, who extensively involved their target audience (postmen) in their ideation phase, both through observational studies, interviews and film. Team 1, whose assignment was to make in interactive installation for a library, also performed research on location, while team 10 and 12 visited their client to better understand context of use, prior to ideation.

4.2 Generative

A common initial method for idea generation is a brainstorm, captured as mindmap. These brainstorms are loosely structured: they do not follow any script. Ideas are rapidly generated, or word associations written down. To narrow the scope of the brainstorm, students sometimes focus their efforts within particular themes. Later phases may see brainstorms narrowed down, by specifying particular criteria that new ideas must fulfil. Criteria may be derived from technical specifications or based on lecturer feedback.

Throughout this ideation process, students rely on sketches, most commonly after documentation of their textual brainstorm. They are limited to rough drawings, quickly drawn to work out a particular idea, while others could be more complex and include text to illustrate use scenarios. In later phases

(week 4-5) digital representations were also made to show particular concepts in detail, including 3d renders, often as a way to communicate ideas to others.
Because the projects all involve a degree of interactivity, some teams created scenarios that capture typical use cases. Sketches are supplemented with stories and descriptions of task. They are a linear description of the interactions users may expect with the proposed system.

4.3 Overall process

While sketches, brainstorms, and looking for related works feature prominently in our review of used methods, they do not structurally occur in any particular order. For example, a brainstorm captured as a mindmap may be preceded by sketches and followed by a review of related products, after which a new cycle of ideation may start with the newly gathered information. Notably, students do not start first by questioning the initial assignment as presented by the briefing, but start generating ideas as almost as soon as the assignment is known. At most, they will request clarification on the briefing. In this review, we also include tools that allow students to narrow down their concept ideas. Typically, a list of criteria is developed (i.e.: fun, feasible, utility, cost), and concepts rated according to these criteria using radar plots or colour-coding. These efforts help the team to focus and provide a rationale behind rejecting certain concepts.

5 DISCUSSION AND FUTURE WORK

There are some limitations to this study. Firstly, it is not always possible to understand why a particular method was used. While the journals reveal various types of methods, students mostly refrain from expanding the reasoning behind the choice of a certain method. This study also does not show the effects these methods may have on final results. Additionally, the journals only indicate the various methods voluntarily reported by students in their journals and papers: they do not reveal methods implicitly used but not documented. Furthermore, it is not clear from this particular overview whether students benefited from the use of a specific method for their design problem, as opposed to another problem. Additionally, the reasons why students prefer one particular method remain unclear.
Most crucially, this overview shows that a very limited range of methods are used by students, with most staying with loosely structured brainstorms and sketches to illustrate ideas. This stands in contrast with the wide availability of ideation methods available in literature. Furthermore, students are reluctant to involve end-users in their early phase concepts. In one particular case (#15) students extensively involved end users, but found themselves struggling to implement their findings efficiently into their design. This study underscores what other authors have previously discussed: methods are only used in a limited fashion. Among the methods indexed, none are highly specialized or novel and are used in an unstructured way.
However, the fact that students have used these methods (conscious or not) and have documented it and posted it in their journal, illustrates that they found the outcome or the application valuable in their process. Even when results of a method show that the chosen direction was wrong and the query should be aborted, it may still be useful.
As previously shown (see for example [14]–[18]), certain ideation methods can result in better concepts. Given that some methods may be valuable to students, uptake of such methods remains low, how do students experience the use of methods as part of their design process? Furthermore, what is the rationale between rejecting particular methods in favour of others? Finally, if the use of certain methods are shown to be valuable, how can the use of these methods be facilitated?

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