Advances in Intelligent Systems and Computing 585

WonJoon Chung
Cliff Sungsoo Shin *Editors*

Advances in Affective and Pleasurable Design

Proceedings of the AHFE 2017 International Conference on Affective and Pleasurable Design, July 17–21, 2017, The Westin Bonaventure Hotel, Los Angeles, California, USA

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Editors
WonJoon Chung
School of Industrial Design
Carleton University
Ottawa, ON
Canada

Cliff Sungsoo Shin
Department of Industrial Design
University of Illinois at Urbana Champaign
Champaign, IL
USA

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8th International Conference on Applied Human Factors and Ergonomics and the Affiliated Conferences

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Preface

This book focuses on a positive emotional approach in product, service, and system design and emphasizes aesthetics and enjoyment in user experience. This book provides dissemination and exchange of scientific information on the theoretical and practical areas of affective and pleasurable design for research experts and industry practitioners from multidisciplinary backgrounds, including industrial designers, emotion designer, ethnographers, human–computer interaction researchers, human factors engineers, interaction designers, mobile product designers, and vehicle system designers.

This book is organized into ten sections which focus on the following subjects:

1. Product Development and Design Process
2. Emotional Engineering
3. Emotion and the Qualitative Side of Experience
4. Material and Texture Exploration
5. Designing Affective and Pleasurable Design Interactions
6. Affective Value and Kawaii Engineering
7. Kansei Engineering
8. Integrated Design
9. Implication of User Behavior in Design Process
10. Affective and Emotional Aspects of Design

Sections 1 through 3 of this book cover new approaches in affective and pleasurable design with emphasis on product development and emotional engineering. Sections 4 through 7 focus on material and design issues in product, service, and system development, human interface, emotional aspect in UX, and methodological issues in design and development. Sections 8 through 10 cover Kansei engineering and user behavior in design process. Overall structure of this book is organized to move from special interests in design, design and development issues, to novel approaches for emotional design.

All papers in this book were either reviewed or contributed by the members of editorial board. For this, I would like to appreciate the board members listed below:

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This book is the first step in covering diverse topics including design and development of practices in affective and pleasurable design. I hope this book is informative and helpful for the researchers and practitioners in developing more emotional products, services, and systems.

July 2017

WonJoon Chung
Cliff Sungsoo Shin

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Designing Affective and Pleasurable Design Interactions

Affective Value and Kawaii Engineering

Product Development and Design Process

Exploring Two Design Processes: Slow and Fast

Cliff Shin(✉) and Joyce Thomas

University of Illinois at Urbana-Champaign,
408 E. Peabody Dr., Champaign, IL, USA
{thecliff, jkthomas}@illinois.edu

Abstract. Responding to changes in industry that are driven by improving processes that cause the product development cycle to be compressed, design educators integrate new technology tools and techniques of product development to ensure that students will keep pace with professional practice. Two approaches for Slow and Fast product innovation projects and the student and faculty takeaways are discussed here - ‘Kickstand’ based on crowdfunding and self-manufacturing concepts in a fourth year industrial design studio (14 weeks), and ‘Design Sprint’ in a business/engineering studio (4 weeks).

Keywords: Design thinking · Collaboration · Innovation · Manufacturing

1 Introduction

Design educators continually integrate new technology tools and techniques of product development to ensure that students will keep pace with professional practice in industry. Two approaches, Slow and Fast, for product innovation and the students’ emotional responses are discussed here - ‘Kickstand’ based on crowdfunding and self-manufacturing concepts in a fourth-year industrial design (ID) studio (Slow - 14 weeks), and ‘Design Sprint’ in a business/engineering studio (Fast - 4 weeks).

ID student teams, who have already been versed in traditional design processes, were charged with developing a product and manufacturing 15 units to be sold in a ‘Kickstand’ pop-up shop in the school gallery. They had full responsibility for design concept, execution, manufacturing, finance and marketing, providing these students with experience in real world design and decision-making processes.

Third year engineering and business students who are new to product development participated in a housewares product ‘Design Sprint’ meant to help them understand innovation, design thinking, and answer critical business questions through design, prototyping, and testing ideas with customers.

Student design projects can vary based on product complexity, outcome, and goals for learning. The student experience, how they perform brainstorming, and in fact, the entire design process can change dramatically depending on the project. ‘Kickstand’ and ‘Design Sprint’ were created to help students develop their problem-finding skills and to get past the obstacles of getting stuck, decision-making and falling in love with your own idea. Collaboration, trust, problem finding/solving, articulating ideas, and shared vision were some of the student takeaways from both of these projects.

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Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_1

2 Kickstand

Entrepreneurship has been a big topic in design industries as well as design education. Crowdfunding websites, "an open call… for the provision of financial resources either in form of donation or in exchange for some form of reward" [1], have become a good source for people who have ideas but have limited budget to take their products to market. Because of the easy access crowdfunding structure, many design students have started dreaming of having their own business.

There is another aspect to adopting the crowdfunding structure for a new product into the classroom. Traditionally, the final outcome of ID students was to produce final appearance models. This practice can potentially mislead design students to focus only on the product's appearance, ignoring how the manufacturing process can influence the final design. This project causes the ID students to understand the product development process from concept generation, through manufacturing, as well as marketing and sales and how these aspects impact the final design of the product.

2.1 Kickstand in an Education Setting

Kickstand utilizes the concept of a crowdfunding structure where innovators design, develop, manufacture, launch and sell their products online, usually with the intent to create market desire and funding for mass-production.

Project Constraints

- Length = 14 weeks.
- Each team will have to manufacture 15 units of the product they design.
- Products can only be sold at campus 'Pop-up Shop' (no online or phone sales allowed to prevent their parents/family from making bulk purchases).
- All 15 products must be sold.

Project Outline

1. Companies are formed by random selection of 4–5 students. Each company, to promote a professional atmosphere, creates titles such as Head of Research, Director of Design, etc.
2. Each company performs brainstorming to find product opportunities based on their target audience of college students, faculty members and staff.
3. A business model canvas is constructed to understand their business components; key partners, key activities, key resources, value propositions, customer relationships, channels, customer segments, cost structure, and revenue stream.
4. Market research and surveys are conducted to validate their value propositions.
5. Sketch models are created for evaluation of design, manufacturing feasibility and product performance.
6. Based on their research and evaluation of concepts, companies explore:
    a. Design/form/material.
    b. Method of manufacture and materials required.

7. Multiple iterations of products are evaluated in the process of design and manufacturing.
8. Marketing plans are developed that include social media, email, and posters around campus.
9. Each company completes manufacturing a run of 15 units of their final product.
10. All products are sold in a 'Pop-up Shop' on a university campus.

2.2 Kickstand – Educational Values

The Kickstand project aims to teach design, manufacturing, and business including project planning. The company members were assigned randomly, which means their teammates might not be their best friends resulting in students having to learn how to work with a variety of people.

2.3 Project Planning

The goal of the planning phase of a project is to prepare the structure for project execution and control. Planning is an important factor for project success [2–4] and as such is recognized as one of the critical success factors of project management [5–8]. Students often don't realize that there are differences between the planning and execution stages of a project. During studio projects, students often discover through errors, unforeseen accidents, and other uncontrollable outside factors that they have failed to plan adequately. This project was in part designed to help the students learn that many errors and accidents can be prevented from carefully calculated project planning.

2.4 Design Process

Traditional outcomes for ID studio projects are 3D renderings, physical prototypes, a presentation and a process book. In many cases, students have researched new technologies, materials, and science to come up with concepts. Students frequently choose to focus (or are directed to focus) on blue-sky concepts 'of the future'. This leads to solutions that are 'could be' concepts that give students limited hands-on product development experience.

The Kickstand project was focused on developing products that solve current needs in our lives. Because the end goal was to produce 15 identical units, the students' design research processes needed to be more hands-on, collecting meaningful and relevant data rather than just browsing the Internet for cool ideas. This encouraged the students to go out into the marketplace to see what their 'competitors' were doing and to observe consumers' behavior to set appropriate target segments for their products.

2.5 Manufacturing

Students entering ID programs often don't recognize the role that manufacturing processes will have on the ways products are designed, perhaps even believing the old paradigm ‘the factories will figure things out.’ However, it is critically important for them to learn that to carry their designers’ intent from concept through production, they must have essential knowledge about manufacturing processes.

The requirement for making 15 copies of their product in the Kickstarter project meant student ‘companies’ needed a sustainable way to manufacture their products, as opposed to making one single final appearance model. This challenged them to be consistent across the manufacturing processes and meet the quality levels people expect for products they purchase, leading each company to perform its own quality control. Previous to this project, mass-production and quality were topics outside their perspective; however, in Kickstarter students realized that they were critical components to their success and this caused them to be more creative and innovative to meet the deadline as well as product quality.

2.6 Business

It is suggested that successful business strategy should create and deliver value to the customer [9]. While ID students are taught to use a human-centered approach to their designs, they are not used to thinking about delivering value to the customers. Zott and Amit define a business model as “the content, structure, and governance of transactions designed so as to create value through the exploitation of business opportunities” [10]. With the introduction of the crowdfunding structure in the design industry, ‘business plan’ has become an important keyword for designers. This influences design education as more design students take business classes or minor in business. Industrial designers in industry frequently take on roles beyond ‘design’ as multi-players and cross-pollinators (Fig. 1).

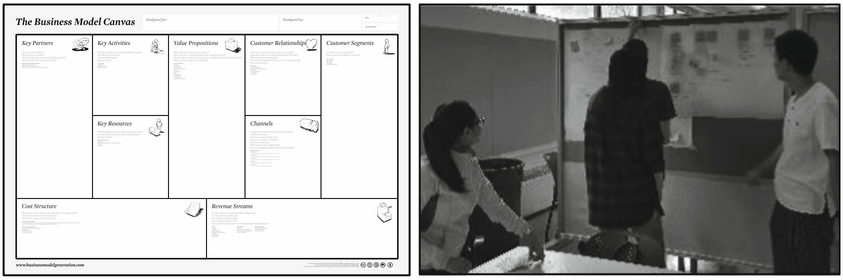

Fig. 1. Student ‘company’ developing their business model canvas.

Constructing the business model canvas [11] (0) was new for the ID students, but they were able to quickly grasp the concept because many components of the canvas are already covered in the design process (e.g. value proposition, customers). This became an effective and valuable tool for ID students to understand the connection between the design process and the overall business structures.

2.7 Kickstand - Result

Kickstand comprised 8 total companies, each with 4 members. Seven companies were able to sell everything they had during the 'Pop-up Shop' day (some taking orders for a future run of their products). Only one company could not sell all 15 units.

This project was an opportunity for students to think about design as a big picture and the overall student experience was very positive. The instructor's goal for 'companies' to choose their own titles was to create a professional environment and provide students with better motivation to perform. In fact, these students tended to take more ownership of their projects and be more responsible for the tasks assigned. However, one side effect of this 'company' structure was that some students tended not to help in areas for which they were not responsible.

Observing student progress across the 14 weeks of this project, it was interesting to see how collegiality among the teammates (or lack thereof) affected several companies' overall performance. In the beginning of this project, most companies didn't seem to have any issues between teammates; however, 6 out of 8 teams started having problems when there was lack of participation or responsibility taken by the team members. The peak of this discord occurred about the 10th week.

In the follow-up survey, students indicated that going through full spectrum from a product planning, through manufacturing, to sales was impactful. They reported the biggest challenge was managing their time well and working with team members. Over the course of this 14-week project, they collaborated with their teammates for a longer time frame than they were used to (typical team projects run 5–6 weeks).

Experience analysis gives an interesting insight (Fig. 2). All student companies had issues with both team and personal progress when they approached to 7–8 weeks where all students were stressed out, and many students also had emotional issues with teammates. Once they resolved the issues (with some counseling assistance from the instructor), both team and personal progress improved. During the 11th and 12th weeks,

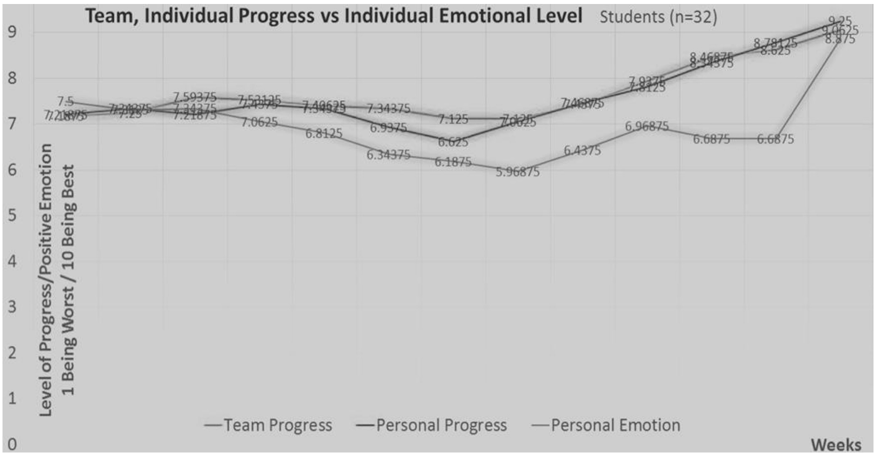

Fig. 2. Team, individual progress vs. individual emotional level based on survey (1: Worst/10: Best)

exams for other classes caused additional stress. As the deadline approached, team and personal progress improved and the instructor noted team members started being more collegial and helping each other. Students reported improving personal emotion that hit the peak during the 'Pop-up Shop' day where the students presented their products to public and had interchanges with actual customers (Fig. 2).

The other distinction from typical studio projects was that the final requirement to personally manufacture 15 units caused the product planning stage, including brainstorming, to be significantly different. It led the companies to come up with realistic product opportunities based on team members' capabilities of manufacturing and access to technologies. All companies went through several iterations for their manufacturing method to find a sustainable way to create 15 identical units. Ultimately, 7 companies made craft-like products and one company used several manufacturing processes including sewing to make 15 backpacks, see (Fig. 3).

Fig. 3. Each 'Company' created 15 units of their product and sold them in a 'Pop-up Shop'.

3 Design Sprint

Teaching New Product Development in an educational setting is an iterative process. Students must learn the elements of design thinking while they develop skills to communicate in both two- and three-dimensions (drawing, physical modeling, computer modeling). They need an understanding of users, learning empathic research strategies [12] to uncover unmet needs. At the same time they are acquiring knowledge of manufacturing processes and an understanding of how design, manufacturing and marketing can influence a product's success or failure. Decision-making at critical points is difficult for students who are just beginning to understand the design process. Faculty have found that these 'lost' time frames slow down student progress and can even completely sidetrack their development. Students are able to gather interesting data using solid research methods and can work through an effective summary process in order to reach engaging conclusions. However, when it comes to converting those conclusions into "insight" (a level of understanding that motivates towards action), many students seem to hit a brick wall" [13].

Although project deliverable dates are defined around the faculty's reasonable expectations of time required to complete each aspect, workload for other courses that students are involved with is a factor in when and how they decide to proceed with a project. Lack of effective time management skills frequently causes students to start and complete projects 'just-in-time' or perhaps even without enough time allotted to complete the task well.

For inexperienced students, the tendency to fall in love with their ideas can be a very difficult hurdle and can cause them to make poor decisions early or even stunts their ability to explore other ideas or solutions. The act of designing forces the designer to understand user needs; however, students are frequently reluctant to speak with real users and tend to fall back on their own perceptions or those of their roommates, classmates or parents [14], especially in design education where typically there is no real client [15]. 'Millennials' born between 1980 and mid-2000 value active learning; to sit just listening is not their style [16].

The design sprint project was conceived in the fall of 2014 to help students get past these obstacles and to develop their *problem-finding* skills along with their already developing *problem-solving* skills. The authors developed the project briefs, deliverables and methods for selection of ideas, modeling this sprint exercise from their professional and academic expertise.

3.1 Design Sprint - Professional Background

A search of literature following the first iteration of this fast paced educational project shows there are similar concepts used in professional practice, both in developing digital computer technology/programs and in physical forms of new products.

On the digital front, one example is Google Ventures Design Sprint, which they describe as a method for teams to prototype innovations in a fast-paced implementation of the design process in five days using a process that includes Unpack, Sketch, Decide, Prototype, and Test [17]. The foundation of a design sprint is built upon design thinking that "combines empathy, creativity and rationality to solve human-centered problems" [18]. Rapid product development in object technology (an umbrella term for object-oriented programming, databases and design methodologies) [19] also relies on what Meyer describes as "User-interface Design Principle: Do not pretend to know the user; you don't." He professes that assumptions made for a specific group "simply do not hold for a larger audience" [20, p. 12]. Imposing constraints such as time in a design project can lead to great design decisions, forcing you to view things from a new perspective. This can stimulate the design process rather than debilitating it [21].

In the 2015 book Design Sprint: A Practical Guidebook for Building Great Digital Products, the authors describe a design sprint in five phases that are similar to Google Venture: Understand, Diverge (empathy, ideation) Converge (decision), Prototype, Test. This design sprint process echoes early design charrettes (collaborative meetings to share design ideas), as well as the 'deep dives' that design firm IDEO 'pioneered' in the 1990s for physical products (think shopping cart). Designers collapsed the time frame in order to come up with better solutions in a shorter time [22]. These authors individually and collectively have experience running design sprints with clients from Fortune 500 companies as well as venture capital startup companies.

3.2 Design Sprint in an Educational Setting

A design sprint project has been implemented in 5 different studio courses over the course of 3 years – three cohorts of Technology Management (TM) students in their

3rd year of study at the University (TM studios are roughly equal cohorts business and engineering majors with no previous new product development experience) and two cohorts of ID students in their capstone year.

Each project starts with one overarching product *'category'* for which teams of 4 to 5 students are provided with thought provoking *'areas of focus'* to encourage problem-finding in the initial days of the project. (Categories = bathroom, tractor cab, housewares; Areas of Focus = technology or waste management, social connectedness, cleanliness, storage, relaxation, entertainment…) The tight time constraints require students to work inside and outside the classroom with deliverables each class period. A rapid exploration and mapping of the product space and analogous products provides a jumping-off place for the group's brainstorming, mind mapping and divergent thinking. To better understand that they are NOT their user and push them out of their comforts zones, students personally use empathic modeling to simulate having a disability [23]. Team members individually create rough concepts that are then funneled through a stage-gate (peer review) decision-making process. Students practice convergent thinking as new ideas are developed and iterated through sketching, modeling, and prototyping. Two additional peer reviews funnel the concepts to a final direction to be developed and delivered (Fig. 4).

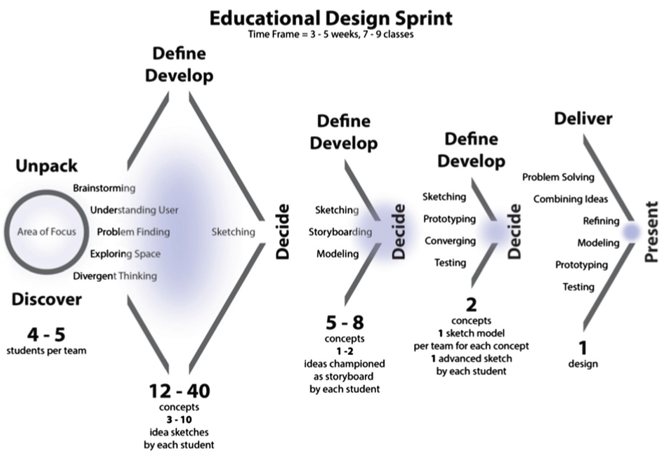

Fig. 4. Overview of the educational design sprint process. Source: Thomas 2017

3.3 Project Plan [24]

1. Class Day One: product category introduction and brainstorming areas of focus—Problem Finding, Discovering, Unpacking
2. Class Day Two: preliminary product research—Discover, Unpack
3. Class Day Three: understanding the user and sketch ideation—Define, Develop, Sketch, Decide
4. Class Day Four: progressing the idea through storyboards—Define, Sketch, Decide

5. Class Day Five: advancing the ideas through low fidelity prototypes and sketches—Define, Sketch, Prototype, Decide, Problem Solving
6. Class Day Six (Plus Seven and Eight Depending on the Overall Length of Project): Develop, Prototype, Test, Problem Solving
7. Class Day Seven (or Nine Depending on the Overall Length of Project): Deliver/Present

This project plan was designed to help students think and work quickly, providing them with an example of real world design and decision-making processes. Might suggest that single segments of the sprint may be a linear process; however, the overall design process is quite iterative with each step potentially moving the project forward, or sending it back for more discovery or definition. "Inside stages, there is much looping, and back-and-forth play as the project proceeds; some activities are undertaken sequentially, others in parallel, and others overlapping" [25] (Fig. 5).

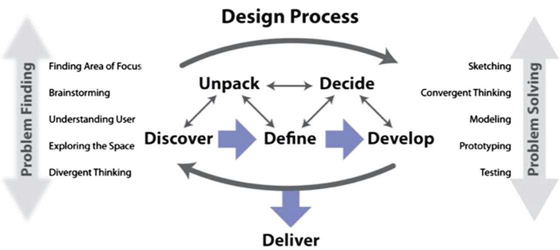

Fig. 5. Iterative design process [25]

3.4 Design Sprint in a Business/Engineering Studio

This business/engineering studio is the introduction to new product development for a cohort of TM students who are very focused on their professional futures and excelling in their majors. This course timeframe is scheduled as a lecture and thus has half the hours in class than a normal ID studio. Students in their third year of college majoring in business (e.g. finance, accountancy, supply chain management) and engineering (e.g. chemical, computer science, mechanical) were rapidly immersed in this project using design thinking, drawing, and modeling tools that were mostly unfamiliar to them at the start of the course. Nearly every activity forced most of this group outside of their comfort zones and required physical deliverables and visual communications that were new to them (Figs. 6, 7, 8 and 9).

Considering only the images in Fig. 6 through Fig. 9 one might suggest that the work from the business/engineering cohort could not be of the same quality level as students at a comparable level in an ID program. While their visual representations (e.g. sketches, final models, graphic design) exhibit low skill level compared to the designers, the quality of the ideas developed overall was quite equivalent to the work created by design students. Perhaps due to their better time management skills, the business/engineering cohort actually delivered their work on time and followed directions. For example, for the initial design concepts 3 design and 2 TM cohorts were

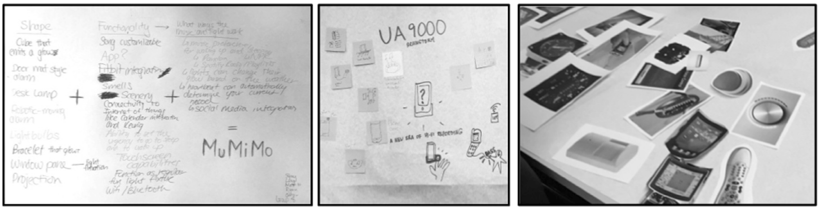

Fig. 6. The first phases involved teams brainstorming areas of focus and mapping existing and analogous products to discover unmet user needs and product opportunities.

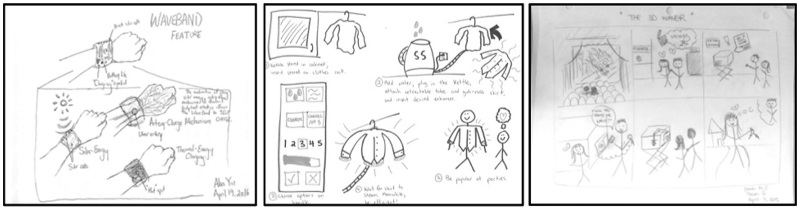

Fig. 7. Initial concept sketches (3–5) by each student were presented to 'Management' (other teams) who selected the 5–8 ideas to continue. This was rapidly followed by storyboards advancing each of the chosen concepts. 'Management' funneled this phase to 2 ideas to pursue.

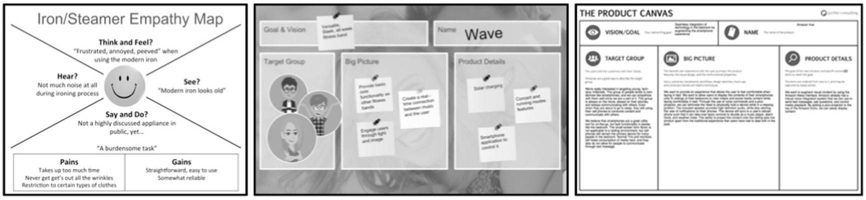

Fig. 8. Teams use 'tools' of empathy maps [26] and 'product model canvas' [27] to discover and describe product opportunities.

Fig. 9. Teams advanced their ideas through sketch models (low fidelity prototypes) with one final selection by 'Management' to pursue. In the final phase, more advanced models and drawings were created to describe the 'final' concept.

directed to deliver one concept per page: illustrated with a main diagram with callouts and notes; include an evocative title and state the problem; identify key stakeholders; and include their name. The technology and management students were more successful in meeting these requirements than the design students even when both cohorts were delivering their work 'just-in-time'. Similar to the design cohorts, some of the team projects in the business/engineering studio were more successful in innovation than others.

Reflecting on their experience in this design sprint several TM students suggested that they found the 'Management' decisions to be arbitrary and not taken seriously. However, the better teams seemed to push beyond these decisions and incorporate ideas that had been discarded along with their 'Management' direction to complete their new product development successfully. Comments from each of the students were pulled into a presentation to have an in-class discussion, which further explored the success and failures of the project. Some selected comments (positive and negative) follow:

"Having different ways of displaying the idea through sketches, storyboards, and models gave different criticism to help the product improve…"

"Many times [we] as designers fall into the trap of thinking that we understand the way in which other people think and operate, but that is clearly not true."

"The biggest strength of our team was our diverse backgrounds."

"… it was obvious there was a clear disconnect between what our ideas were and what people understood."

4 Learning Experience - Pros and Cons

See Tables 1 and 2.

Table 1. Industrial design

ID/Slow - Pros	ID/Slow - Cons
Initial motivation and passion high	Limitation of product concept
Full spectrum of product development	Limitation of brain storming
Conversations with real target users	Plan modified due to lack of experience
In-depth design research	Struggle with manufacturing
Iterative prototyping	Lack of business/marketing knowledge
Sustainable manufacturing research	Random selection of team members
Interaction with real customers	Final products tend to be craft-like
Solving issues rather than avoiding them and focus on products	Personal issues influenced team progress
Learning what went good/bad after review of sales	Customer tended to be college students – they were designing for themselves

Table 2. Technology management

TM/Fast - Pros	TM/Fast - Cons
Highly motivated business/engineering students	1 h 20 min. lecture class timeframe compressed all in-class activities
Teams assigned by instructor to equalize business and engineering members	Heavy core course loads made team meetings outside classroom difficult
Rapid immersion and ideation	No depth to initial idea development
Focus on a real user group	Limited opportunity to talk to real users - they were designing for themselves
Making sketch models to proof concept was completely new to this cohort	Making sketch models to proof concept was completely new to this cohort
'Management' evaluates concepts and determines course of development	Some students didn't take the activity seriously and made careless decisions
Good collaboration and pooling expertise helps teams to refine ideas to concepts	Human-centered design/form development design is rudimentary compared to ID students
High technical/engineering skills resulted in a few working prototypes	Some teams still fell in love with their idea, or alternately had no passion and both then missed the mark.

5 Conclusion

The experience of the faculty in the 'Kickstand' and 'Design Sprint' projects has been an increase in student collaboration and enhanced design thinking. Students explored many different ideas and used tools new to them (business model canvas, product canvas, empathy mapping) that encouraged innovation. 'Kickstand' in its first iteration engaged 35 students in the 'slow' design, manufacture, marketing and sales of a product. The highlight of Kickstand was to experience a full spectrum of design that the students particularly enjoyed. In the past two years over the course of the five studio courses 235 students have embraced the 'fast' sprint concept and produced high quality work in a very short period. Both projects succeeded in engaging students who were excited about the work they were producing. The students were able to conduct research, explore many design concepts and follow through an iterative design process rather than producing the final outcome in hurry without significant exploration. The faculty sees these 'fast' and 'slow' projects as valuable educational tools that they will continue to utilize in future educational settings.

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Rematerializing the User Interface of a Digitized Toy Through Tokens: A Comparative User Study with Children Aged Five to Six

Marieke Van Camp(✉), Lukas Van Campenhout, and Guido De Bruyne

Product Development, Faculty of Design Sciences, University of Antwerp, Ambtmanstraat 1, 2000 Antwerp, Belgium
{mariek.vancamp, lukas.vancampenhout, guido.debruyne}@uantwerpen.be

Abstract. This research aims to measure and empirically validate the effect of tangible interaction on children's play experience. During this study a Research Through Design approach was followed. A prototype of a programmable toy train with a Tangible User Interface based on tokens, was build. Afterwards a comparative user test with 34 children aged five to six, was carried out to verify the prototype. The prototype was compared to two similar established toys, one with a Physical User Interface and one with a Graphical User Interface. After the user tests, the participants were questioned to gain insight in which type of user interface is preferred and why. Preference was asked with the use of the This-or-That method. Insight into the reasons of preference towards a user interface was gained through a Laddering method.

Keywords: Empirical validation · Research Through Design · Tangible interaction · Children · Laddering · Comparative user test

1 Introduction

Now that microcontrollers have found their way into almost every consumer product, among which also toys, interactive technologies are increasingly pervading children's lives [1]. There is very little dispute that interactive technologies can have great potential for children's play experience. By digitizing play more interactive, engaging and challenging toys can be created [2]. Yet, the use of interactive technologies by children have raised fears about the perils of exposing children to them [3]. After all, by adding digital functionality to a toy, not only the User eXperience (UX) increases, but the interaction with the toy transforms entirely. The physical toy dematerializes and shifts towards a screen based interface with push buttons. These type of interfaces present data and information in a graphical manner, and are referred to as *Graphical User Interfaces* (GUI). While the specific physical shape of traditional toys offered affordances [4] that appealed to the bodily skills of the child, the interaction with GUI's is limited to button-pushing or a set of standardized gestures on a display [5]. As a

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result of dematerialization [6], physical play decreases. Movements become very precise and take place at finger level rather than at hand, arm or body level [7]. Piaget states that the cognitive and psychomotor development of young children roots on physical manipulation and handling of objects [8]. For this reason, toys with a GUI are not appropriate for young children [9, 10]. An alternative for the GUI which doesn't feel computer-like, but instead stimulates physical play, should be used when designing digital toys for children.

Lately, a number of alternative interaction styles among which *tangible interaction* have emerged. These new interaction styles aim at leveraging human skills in interaction with technology [11]. In particular, a *Tangible User Interface* (TUI) can be seen as a promising alternative for the GUI, when designing digitized toys for children. Tangible interaction is an interaction paradigm that integrates the digital world and the physical environment. It strives for interaction with digital information in a non-digital, physical way by giving computational resources and data material form [12]. Tangible interaction strives towards more matter instead of less. In that way, it makes a move towards *rematerialization* [13] and thus physical play. It is argued that tangible interaction can offer several benefits for children's play experience. Not surprisingly many research studies regarding tangibility and children have been carried out in the past. Yet, the results from these studies are often contradictory [14]. These contradictions are partly caused by poor empirical validation on whether it's really the tangibility that is causing the positive effect [15]. An enhanced play experience can also be caused by brand awareness, previous experiences with the product, usability and various other reasons. Furthermore, a thorough description of the research method is often missing [16].

This research aims to measure and empirically validate the effect of tangible interaction on children's play experience. In order to measure the effect, a prototype of a digitized toy with a TUI was build and tested. For this, a *Research Through Design* approach [17], wherein knowledge is gained through the process of designing, building and testing, was followed. First, a prototype of a programmable toy train with a TUI based on tokens [18] was build. Secondly, the prototype was compared to two established counterparts, one with a merely physical interface and one with a GUI. Multiple *comparative user tests* with children aged five to six were carried out. Finally, after the user tests, the participants were questioned to gain insight in which type of user interface is preferred and why. Preference was asked with the use of the *This-or-That* method [19]. Insight into the reasons of preference towards a user interface was gained through a *Laddering* method [20].

2 Methods and Materials

2.1 Construction of the Prototype

A programmable toy train with a TUI based on tokens was developed and prototyped. The prototype consists of three different type of game elements.

The first type of elements are *non-interactive construction elements* or traditional building blocks. Two different train tracks – a turn and a straight track – with which one