Industrial Design Education in the Age of Digital Products

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Abstract: Preparing product design students for the design of digital products provides a challenge for product design educators. This paper reports an experiment in a senior-year product design studio course. Students were assigned three projects with three different strategies based on the management and the structure of the design process. The analysis of observations on students' design processes, semi-structured interviews with students, and the analysis of design solutions revealed that students mentally separate a product's physical form and digital interface. Students reported time management as their biggest challenge for the design of digital products. Even though they experienced problems in their design process, they think interface design skills as a part of their professional requirements. These findings indicate a need to better address the design of digital products in product design curriculum in general and studio education in particular.

Keywords: Digital products, User interface, Scholarship of teaching and learning, Product design, Studio education

1. Introduction

21st century has increasingly been characterized by products involving digital interactions (Goodwin, 2009; Kolko, 2004, 2011; Pink et al., 2015). Built-in user interfaces and/or software applications operated through smart phones have become major components of a growing number of products. While the new discipline of interaction design might be expected to address the design of such digital artifacts, there is also an increasing demand in the job market for product designers who are able to design interactive components such as control panels, graphical user interfaces, mobile and web applications of smart products (Kiernan & Ledwith, 2014; Kolko, 2004). Furthermore, some of recent product design graduates are employed as UX designers, interaction designers, or UI designers (Kiernan & Ledwith, 2014; Ramoğlu & Coşkun, 2017).

While these developments indicate the need for product design graduates to have competence in designing digital products, product design education has not fully embraced this challenge yet. Scholars call for a change and an alignment in the product design education based on the needs of the contemporary praxes (Kiernan & Ledwith, 2014). There are examples of including service design, interaction design and experience design as part of industrial design curriculum. However the

integration of the above subjects has not been fully addressed in the product design studio education (Norman, 2010).

The need for aligning the product design studio education with the skills needed in designing digital products concerns the process models applied in structuring product design studio courses. The design process in the studio is usually structured to mimic the prototypical design process models developed for non-digital products (e.g., Archer, 1984; Cross, 2008; French, 1985). The complexity of digital products calls for a different approach to design process (Wärnestål, 2016), which should also inform the product design studio pedagogy. The study reported in this paper addresses this concern and questions the pedagogical approaches (in relation to design process models) for preparing product design students as designers of digital products.

In what follows, we first review the literature on strategies/methods for educating product design students for the design of digital products. In order to evaluate the impact of different pedagogical approaches on students, we conducted an experiment in a senior year product design studio course. The course involved designing three digital products with three different strategies. We share our findings together with their interpretation and possible implication for product design education. The paper concludes with a brief summary and the indication of possible areas of further research.

2. Product design studio education and digital products

Product design profession has never been limited to giving form to an artifact. This became more clear with the increased complexity of contemporary products. "The old dictum of form follows function is increasingly inappropriate as products become less mechanical and more electronic" (Ingram, 1981, p. 171). With the increased penetration of smart products into every aspect of our lives, designers are now expected to design interactive experiences with products (Moggridge, 2007; Norman, 2011). This involves designing the physical artifact together with its user interface (Kolko, 2011). Consequently, an increasing number of contemporary jobs require digital design competencies from product designers (Kiernan & Ledwith, 2014). Ramoğlu and Coşkun (2017) discussed the requirements from industrial designers in contemporary society and coined the term "scientific craftsmanship" as the new definition of industrial design. They highlight the impact of digitalization (e.g., use of digital tools in the design process, increasing focus on the design of technological artifacts) on society and challenge design educators to consider this change in the education of designers.

The design education is expected to prepare students to the "complexities of professional practice" (Garner, 2005). For this purpose, several scholars (e.g. Aldoy & Evans, 2011; Dorta, Kinayoglu, & Boudhraâ, 2016) reported studies and experiments regarding the application of digital tools (e.g., 3D software, digitizing tablets) into design curriculum or the integration of the contemporary maker culture to design education. For example, Haldrup, Hobye and Padfield (2017) described three projects from Roskilde University's FabLab to illustrate the learning that is taking place in FabLab in relation to hands-on methods, working with materials, and interdisciplinary project development.

While these studies share invaluable information on some aspects of designing digital products, when it comes to the strategies and methods for teaching/educating digital product design to undergraduate product design students, the existing trials come short.[1] The structure of the studio

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[1] We conducted keyword searches in Design Studies, Journal of Engineering Design, Design Issues, The Design Journal, International Journal of Design, Human-Computer Interaction, CoDesign, International Journal of Human-Computer

education in product design is still based on the strategies and methods mostly defined for the design of analog products (e.g., non-digital products). We lack knowledge on the ways of structuring the studio program and the methods of education for the design of digital products (Wärnestål, 2016).

In order to overcome this issue, Wärnestål (2016) proposes a model, to be applied in design education, with the integration of user-centered design process and transformation cycles. However, in his case, the model was developed and applied within an informatics program. While this study provides insights for product design educators, it is not directly applicable in product design.

From the field of product design, Russo and Ferrara (2017) questioned the aesthetics of smart objects. They share their studio experience and their students' work to facilitate discussion on how to design technologies so that the results will be as cozy as (non-digital) iconic products. However, their focus is not on the ways of teaching digital aspects to designers. They recommend that designers cannot focus on a single object anymore; they have to consider context and approach design as a combination of product and system (Russo & Ferrara, 2017). This conclusion also calls for a new approach to product design pedagogy. However, the review of the product design literature indicates a gap and comes short in terms of providing detailed pedagogical insights into the ways of teaching digital product design in the studio.

3. Methodology

In order to test the possible impact of different pedagogical approaches on students' experience of designing digital products, we designed an experiment with a small group of students in a fourth year product design studio in Fall 2017. The course was structured for students to design three digital products with three different strategies defined based on the management and the structure of the design process. Our primary aim was pedagogic. Through the conduct of this scholarship of teaching and learning study, we aimed to advance our tools as instructors and to open up further discussion on the methods/strategies used within studio environment for designing digital products.

This fourth year product design studio was offered at Ozyegin University, Istanbul. The program offers an interaction and service design track for students. Thus, students had taken courses and had prior knowledge on user experience, design research methods, interaction design, and service design.

The course was co-taught by the two authors; one with a background in industrial design and the other one in user experience. There were six students enrolled to the course. The group met twice a week for 14 weeks. Each session lasted 5 hours. The overall objective of this studio course was to help students gain competence on designing digital products.

The first project was the design of an e-book reader. For this project, students were required to start the process with the design of the digital interface. In contrary, the second project (designing a robotic vacuum cleaner) asked students to design the physical product first. For the last project, students were expected to work on the physical product and the interface simultaneously. This last project involved designing a solution for sustainable food consumption. Meeting the requirements of this project included conducting user research on contemporary food consumption for the

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Interaction, International Journal of Art and Design Education, and ACM database, using combinations of education + studio + "product design" or "industrial design" + digital or "interaction design" or interface. We could only find five articles addressing the aspects of digital product design in undergraduate product design education.

development of products that can support healthy eating habits together with better recycling solutions.

The data was collected through two main methods, observation and interview. Observations were made in the studio throughout the semester on students' design process. Field notes were taken during this process. We conducted semi-structured interviews with each student at the end of the semester. Each interview took 30 to 45 minutes. As part of the interview sessions, students were asked to illustrate their design process with a drawing. This provided another layer of visual material for analysis.

Data analysis followed a mixture of inductive and deductive coding in order to describe students' experiences regarding the three processes. In addition to the data coming from observations and interviews, we analysed the students' design solutions for each project based on their content and integrity.

4. Studio evaluation and student feedback

Throughout the semester, we observed students' inability to develop the product as a whole with its physical artifact and user interface. When students were not directed otherwise, they had a tendency to focus on the design of the physical artifact first. This observation is also evident in students' response to one of the interview questions that asked the approximate percentage of time they devoted for the design of the physical artifact and its user interface. On average, students reported spending 71% of their time on the user interface for the e-reader (29% for the physical artifact), 62% on the physical artifact for the robotic vacuum cleaner (38% for the user interface), and 64% on the physical artifact for the sustainable food consumption project (36% for the user interface). Students' higher focus on the physical artifact might be resulting from the product design education they had received so far in the program.

Students' inability to consider the product as a whole with its physical and digital components is also evident in their sketches of their design processes (one of the semi-structured interview questions). All the students' sketches included a mental separation of the physical artifact and the user interface as seen in Figure 1. The circle on the left indicates the starting point of the project. One of the arcs extending from this circle represents the students' research process on the project (e.g., desktop research, benchmarking), while the other illustrates the initial ideas the student develops in the early phases of the project. These two arcs come together as the student tries to combine his research results with the initial design ideas. This process yields to a final concept at the point where the two arcs recombine in the middle of the drawing. After the selection of the concept, the student explained working on the form and the interface of the product. While the top line represents the further form development with iterations, the bottom one represents the interface development. The lines become straight when the student decides on a final form and interface. While the student initially started the form line at the point where the two arcs recombined, he later scratched this line and moved the form line to the top and introduced the interface line to the below. This can also be interpreted as the secondary nature of the user interface for this student.

The form and interface lines in Figure 1 do not end at the same point. The form line extends further. This is also inline with our observations regarding the students' higher focus on the physical artifact. One of the students even commented on his unwillingness to design the user interface for the sustainable food consumption project. He proposed a solution just because it was a requirement of the project.
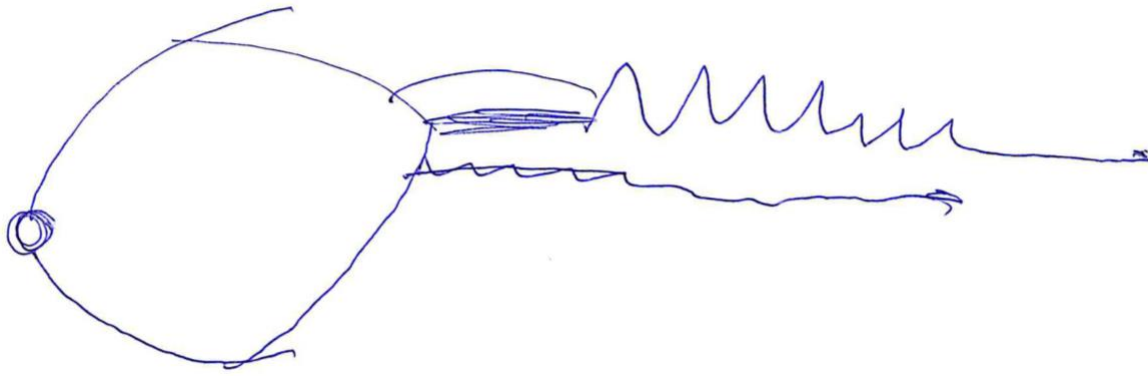
Figure 1. A student's illustration of his design process while designing digital products.

While the students value working on every component of a product simultaneously, working on the artifact and the interface simultaneously is a challenge for them (this is why we preferred to use the same dichotomy in this paper). One student explained: "… designing two different things simultaneously was a challenge; this was like working on two different projects at the same time." Here, he meant the physical body of the product and the user interface. Another student commented: "We either first design the form and try to make the interface match the form or design the interface and try to make the form match it. It is more logical to design these two together." On the other hand, another student noted that each project requires a different approach and the sequence of design depends on the nature of the project. Yet another student suggested shifting the focus between the artifact and the interface several times throughout the process.

The analysis of the design solutions in terms of the integrity of the interface and the physical artifact supported our conclusions from interviews and observations. The interface and the artifact were disconnected for most of the projects. In order to develop a holistic product, students' projects mostly included color (as the robotic vacuum cleaner solution in Figure 2) and/or shape similarities between the physical body and the user interface. There were no student projects questioning the overall concept both with the form and the interface. However, there were concerns regarding the match between the user scenario (i.e., the function list of the product) and the content of the interface.

Figure 2. One of the student's robotic vacuum cleaner and two screenshots from the related product's interface solution operated via smart phones.

All of the students reported time management as their biggest challenge in digital product design projects. Time management had been a concern in the previous years as well, when students were

not designing digital products: "This always happens. The biggest challenge was the project timeline. I somehow cannot mange it. I cannot get things done until it is late in the process." This concern regarding time management became a bigger problem in designing digital products. Students commented on not being able to manage their project schedule, which resulted in projects lacking detailed design solutions on either the physical artifact or the user interface of the products. One student suggested us to have different deadlines for the physical artifact and its user interface in the upcoming years.

One of the students specifically described his frustration regarding his lack of technical information for designing digital products. This includes the type of screens he can use and the newer technologies to be integrated into the products (e.g., projecting the interface on a surface rather than including a display on the product). He also expressed concerns on time management and explained that the project schedules provided little time to conduct research on "digital technologies."

Students also commented on their decreased focus on manufacturing processes when they are required to design digital products. When students were asked to compare their digital product design processes with non-digital product design processes, they made references to giving more attention to issues such as manufacturing, production, engineering and cost for non-digital products. This difference between digital and non-digital products might also be related to students' time management problem. In order to meet the project deadline, students might have ignored some issues related to manufacturing and instead might have allocated their time to the design of the interface.

In addition to analysis of the digital product design process as a whole, we also tried to observe students' user interface design processes, in particular. At the beginning of the semester, students were given a seminar on interface design methods. This seminar provided technical information about relevant tools and techniques for user interface design. This information was reminded to students during critique sessions. For example, we encouraged students to start user interface design with information architecture, decide on the key user flows and then to go into detailed design of screens. We tried to express the significance of the iterative process and specifically explained paper prototyping, wizard of oz technique, wireframing and interactive prototyping tools (i.e. Adobe XD, inVision, UXpin, Balsamiq). Students were encouraged to conduct quick and dirty user tests. While we recommended methods and tools, we do not make these a requirement. Students were expected to present (interactively or as a user interface map) at least two key user flows for each project.

In contrast with the information provided in the initial seminar and the following critique sessions, most of the students designed the interface screen by screen without providing information architecture sketches and/or wireframes. Likewise, only one student used interactive prototyping tools, the rest of the students developed the interfaces with Photoshop or Illustrator. The student who used Adobe Comp in the process described the positive impact on this tool on her process. We also observed one of the student's efforts to follow the recommended user interface design process. This student was not able to manage his time to conduct user testing. Some of the students experimented with paper prototyping. However, the number of such experiments drastically dropped in the last project. We also observed some students' utilization of smart phones and tablets to test their interface solutions. They were importing their graphic solutions to photos folders of these devices and trying different scenarios as if the buttons were working on the screen.

Even though students reported the above listed concerns and struggles regarding the design of digital products, they also commented that they were more satisfied regarding the end results of

their projects. They felt that now they are better equipped for designing products holistically. One student explained: "I now better understand the interface design… I feel as if I grasped the logic of designing interfaces." This student further explained that through the application of interface design in her projects, she became more confident in designing interfaces.

In the beginning of the semester, we were thinking that students had acquired skills in designing interfaces as they previously took classes on interaction design. However, our findings indicate that students fully engaged with interaction design when they were asked to design the interface as a component of their project in the product design studio. Thus, integration of interface design with product design studio course can be interpreted as necessary for students to better develop their competencies on designing digital products. One of the student's comment supports our observation: "Now, I better feel like I can graduate and call myself a designer." This student was not only referring to his user interface design experience. He expressed that he felt an improvement on all his design skills and competencies simultaneously. He also explained that he is now able to better finalize the design projects.

Students' development in terms of competencies was also evident in the quality of their design outcomes. Students were observed to struggle more on the e-book reader project. In this first project, students had more difficulties working on the physical artifact and the user interface together. Mostly, their focus was more on the user interface for this project. On the other hand, we had more students taking feedback both on the artifact and the interface in each critique session for the sustainable food consumption project. The design solutions for the user interface of the sustainable food consumption project were more detailed. This can be interpreted that through experience, students were able to become more competent about designing digital products.

5. Implications for product design education

Our experience within the studio highlights a mental separation of artifact and interface by students. This separation overlaps with what is defined by Kolko (2011) as the interrelation between technology and form in contemporary design praxes. This mental separation becomes a challenge for the development of fully integrated digital products (Goodwin, 2009; Norman, 2011). One reason for this might be related to the fact that this experiment took place in a senior year studio. Senior year might be late for the introduction of digital product studio courses in product design curriculum. Junior year might be a better fit. With the introduction of digital product design studio in the junior year, students can experience higher number of such projects. This experience can help them better address their time management problems as well as mentally bridging the design of interface with the artifact.

The findings show a struggle among design students on ways of handling the design process when they need to design both the product and the user interface of a digital product. In their projects, either one of these components was not well developed or the two were not integrated. In their process, students preferred focusing on a single component (physical artifact or interface) at a time and they mostly preferred starting with the physical artifact. Even though students had had prior classes on interaction design, their feedbacks made it clear that they were not feeling confident about designing interfaces until they did it in the studio. This can be interpreted as the significance of integrating interface design into product design studio projects. Students seem to better understand the design of interaction, as it becomes a part of their product.

While product design discipline is no longer limited to form giving activity (Ingram, 1981), we observed our students' tendency to divide a product into two: form and interface. Their strategy to

develop a harmony between these two seems to be limited to color and/or shape selection. This finding supports Kolko's (2011) and Wärnestål's (2016) arguments and calls for a search for teaching students about better strategies for integrative digital product design, starting from the concept.

While students did not favour any of the project management and/or structure strategies, they seemed to have a tendency for designing the physical parts of the product first. On the other hand, they saw the design of the interface as a duty of product designers and commented on their willingness to become more knowledgeable on the design of digital products. These indicate a need to restructure the product design studio.

6. Conclusion

Contemporary product design practice has increasingly been characterized by the design of digital products interactions (Goodwin, 2009; Kolko, 2004, 2011). It is necessary to restructure the industrial design studio education to prepare industrial design students as digital product designers. This paper aims to discuss this issue and shares findings from a trial in the studio.

The review of the previous work indicates a gap in the literature on the pedagogical approaches to training industrial design students for the digital product design sector. There is a need to conduct systematic research on the topic. Another resource that will advance our understanding on the issue can come from the exchange of pedagogical experiences on digital product design. Our studio experience reported in this paper should be reviewed as one such case and be evaluated as a scholarship of teaching and learning study. Through this trial in the studio, we had the chance to discuss the design of digital products with students. These conversations together with our discussions as instructors helped us evaluate our pedagogical approaches and question ways of advancing the educational environment related to the design of digital products. At the same time, it also provides insights into the students' attitude towards designing digital products.

Among the three design management and design process structures tried in the studio course, we favour the simultaneous design of the physical artifact and user interface. In fact, we believe in the need to overcome form-interface dichotomy as the user experience with digital products involve a blend of these components. It is not possible to easily separate these two while defining one's interaction with products. As a result, we advocate for the need to structure the product design education accordingly.

The experience shared in this paper is based on an experiment in the studio with a limited number of students. While the small number of students served as an advantage in our case to better engage with each student, it is necessary to repeat these trials with larger groups in the future. Furthermore, in the future, it can be more valuable to require students to reflect on their design process during the semester. In this trial, students were not instructed that they were working on three projects based on three different strategies/methods. During our interview sessions, all the students had an "aha" moment as we explained our pedagogical aim with this studio course. We realized that none of the students had questioned the differences between three projects in terms of their design strategy/method until the interview. It could be possible to make the necessary explanations up front in the future for students to self-reflect and self-question their design process while they are working on projects.

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