

# UNDERSTANDING THE CHARACTERISTICS BETWEEN DESIGN AND NON-DESIGN BACKGROUND STUDENTS IN PRODUCT DEVELOPMENT PROCESS AND ITS IMPLICATIONS

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## Abstract

As only technical advancement in the market is not enough to meet increasingly higher expectations of users, companies have tried to take the initiative through multi-disciplinary approach in the product development process. As their influencing the academia, non-design background students are expected to experience innovation through design. However, there has been a lack of understanding of their characteristics comparing to design background students. Therefore, this study aims to find out the similarities and differences between design and non-design background students in the product development process. Through a design course where both groups of students had taken, distinctive characteristics between groups were identified. The key contribution of this study lays a good foundation for the development of design education for non-design background students. The implications and limitations are discussed as well.

**Keywords:** Design education, Product development, Collaborative design, Design thinking

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# 1 INTRODUCTION

As competition among firms is increasingly intense in the market they have been pressed to dominate the market in advance. Especially, in order to take the initiative in consumer electronics market, companies have led innovation through technology adaptation and user research. In such innovation, design plays a key role because design makes a significant influence on product improvements and brand expression to innovative products and innovative product development process (Highsmith 2009, Dell'Era *et al.* 2010, Wrigley and Bucolo 2011). Since more than a decade, design has been perceived as a tool of contribution not only to product development (Walsh 1996, Bruce and Bessant 2002) but also to business performance (Gemser and Leenders 2001, Formosa and Kroeter 2002, Hertenstein *et al.* 2005). It has been possible because the value that design brings is a different way of thinking and tackling the problems (Wrigley, 2011), which is defined as design thinking.

(Brown 2008) and (Martin 2009) believes that thinking like a designer can transform the way of developing products, services, process and even strategy. Also, design thinking or the creative principles have significant impacts on business management and strategy management to achieve value innovation (Leavy 2010). Especially, design thinking and creativity has strong influence on the product development (Li *et al.* 2007, Verganti 2008). There were several attempts to adopt the creative thinking method into product design process (Dym *et al.* 2005) such as user-centred product design (Kelly *et al.* 2001, Hertenstein *et al.* 2005) and radical changes in the meaning of product (Verganti 2008). These studies describe design thinking as a mixture of convergent and divergent thinking, and the application of design thinking is not limited to the conceptual design stage that industrial designers mainly deliver; it engages in a wide range of product development process.

In the product development process, there are several ways to implement design thinking. Among them, multi-disciplinary collaboration approach that not only designers but also other professionals from various disciplines involve in the product development process ((Ainamo 2007) has been broadly used. Future innovation will require intensive collaboration between stakeholders, and shared understanding of methodologies is crucial (Gardien *et al.* 2014).

However, even though design has become pervasive in many disciplines such as engineering and marketing since multi-disciplinary approaches in product development process are increasingly required, collaborative works of multi-disciplinary teams often have problems and controversial issues (Littler *et al.* 1995, Sethi and Nicholson 2001, Vissers and Dankbaar 2002, Wang *et al.* 2002, Xue *et al.* 2010). In this regards, it is important to understand the differences between stakeholders who participated in the product design process in order to facilitate multi-disciplinary cooperation. Currently, people also realized keenly the necessity of educating design thinking to non-designers. As a result, students having different background than design are expected to have an understanding of design. For instance, design becomes a course required for non-design background students in order to facilitate their creativity in problem solving. However, there has been a lack of understanding of what characteristics they have compared with design-background students in terms of design education. Therefore, the study aims to identify what similarities and differences there are between design background and non-design background students when they are involved in the product development process.

## 2 METHOD

In order to figure out the characteristics of two groups of students, a design course running for junior students, UX Design, was selected, in which both designed major and non-designed major student (e.g. engineering and marketing students) participate and collaborate for redesigning existing products or services from user experience perspectives going through the product development process.

### 2.1 Participants

29 undergraduate students (13 male students & 16 female students) took the course, and the students were separated by their different educational backgrounds. One group consisted of design majored students and the other group was composed of non-design majored students who had not received design-related education before. Within each background group three sub-groups were made, each of which was comprised of four or five students. For the study, three design background groups and three

non-design background groups were made up. All the groups participated in the project without noticing that they were a sample for the study.

## 2.2 Materials

In order to build an experiment situation, three products (alarm clock, digital audio player, and online photo printing service) were chosen. The main reason of the selection was to avoid bias caused by different characteristics between products, and also to understand the way of developing solutions in terms of product type: traditional product (alarm clock), high-tech product (digital audio player) and service product (online photo printing service)

In order to make students' creativity actively involved in the project, three particular products that were popular but to which many consumer complaints were reported at the time of the study were selected among many products: Philips AJ3136, iRiver T7, and SNAPS (Figure 1).



Figure 1. Products and service selected in the course: Philips AJ3136 (left), iRiver T7 (middle), and SNAPS (right)

The alarm clock is a ball-shaped product that makes unique interaction between product and user. Due to the unique structural characteristic, users are able to change alarm sounds or display by rolling the product. It also had the radio function. In addition to the music player function, the digital audio player also features FM radio, voice recorder and USB memory. SNAPS as online platform consists of photo albums and decoration contents such as albums, posters, canvas and calendars with many design templates. Each two groups of design background and non-design background students were provided one subject among three different products and service. Through this we could understand the different characteristics of collaborative work in different context, and it will give suggestion to develop better design education.

## 2.3 Participants

This experiment was conducted for a semester for which the course was run. Each set of two subgroups of design background and non-design background students was given one target product or service among three. Provided with lectures and team coaching by the lecturer, they were asked to redesign the product or service following the product development process. The product development process consists of analysis, synthesis, simulation, and evaluation phase (Roozenburg and Eekels 1995) and specific activities were given in each phase. Outcomes to be delivered were expected at the every end of each task (Table 1).

Table 1. Tasks and outcomes in each phase in the product development process

Phase	Task	Outcome
<b>Analysis</b>	Analyzing the product itself	Product specification
	Competitor and market analysis	Problem definition
	Team's impression	Design goal
	User study 1	Short scientific paper
	UX workshop	Design requirements
<b>Synthesis</b>	Design ideas and selection	Provisional Design
	Design conceptualisation	Concepts
<b>Simulation</b>	Prototyping	Prototype
<b>Evaluation</b>	User study 2	Improved properties
	Final redesign	Final design

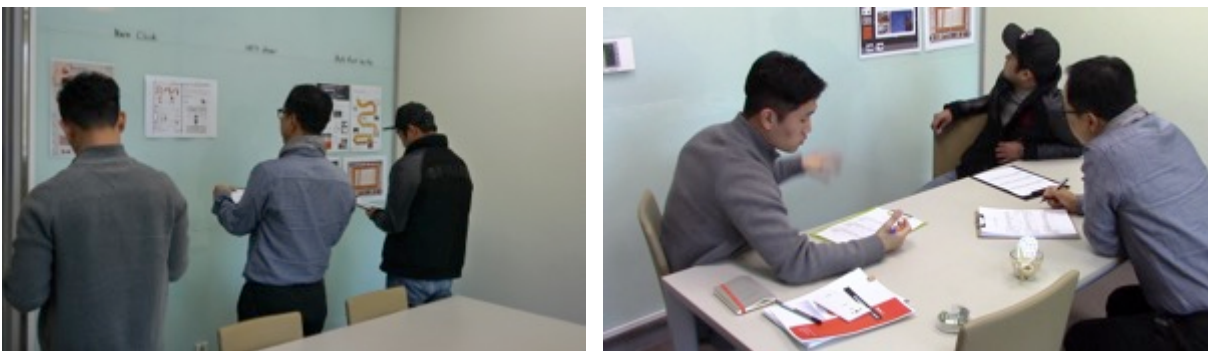
The course consisted of an interim and a final oral presentation session. The interim oral presentation covered redesign plan, data collecting methods, user study for figuring out usability and user experience, UX workshop for design requirements initial ideas and concepts. The final presentation included developed concepts, prototypes, user study for concept evaluation and final redesign. The final deliverables were a final project report in which all the details groups had done were documented and a A1 poster in which their project was present in a concise manner. The two presentations, final report and poster were used as data source to identify similarities and differences between design and non-design background student groups. (Figure 2: a picture of presentation, the other of UX workshop).



*Figure 2. UX workshop (left) and final oral presentation (right)*

## **2.4 Procedure**

After collecting all the data from groups, we split up and coded the data based on the tasks of each product development phase. Then, their works were analysed to investigate the differences and similarities between design and non-design background student groups by following each product development process. The final concepts were then evaluated by the lecturer and two invited reviewers who had taken design education and also had practical experience in product development. First, they were invited to Home Lab, UNIST and the purpose of this research was introduced. Then they evaluated and scored the concepts presented on the six groups' final posters with ten-point scaled concept assessment criteria. The assessment elements consisted of creativity, aesthetics, technical aspects, usability, and business aspects. This category, except usability, was come from (Kees Dorst 2001) scoring category used to evaluate the overall quality of the resulting design concepts produced by designers. If any, the invited reviewers could ask questions as needed for further clarification about projects. Lastly, the reviewers shared their opinions about the scores they had given, and this session was videotaped to further analyze their comments on the concepts (Figure 3).



*Figure 3. Concept evaluation and discussion by the reviewers*

### 3 RESULTS

It was found what similarities and differences exist between design and non-design background student groups in the study. These findings are described in order of product development process.

#### 3.1 Analysis Phase

In the stage of analysis, student groups started their project from understanding their assigned products or service in terms of product specification. Each group conducted activities such as product analysis, market research and competitor analysis where had been assigned in lectures. In those activities, there were few differences between design and non-design background student in the phase. However, a difference was observed in research questions formulated for the first user study. Design background student groups seem slightly more interested in meanings and stories to which the products are related rather than those who have non-design background. For example, one of research questions of design group, which assigned to redesign digital audio player, was about user emotion by possessing music, while the questions of non-designers were majorly about usability problems and addable features.

Table 2. Research questions of digital audio player

<b>Design Group 2</b>	Q1. What are the differences between listening music using smart phone and iPod or any other digital audio player(especially T7) in terms of UI? Q2. What are the differences between listening to music using smart phone and digital audio player in terms of UX? Q3. What is your opinion of the music industry? Q4. What do you think about 'possessing the music'?
<b>Non-design Group 2</b>	Q1. What usability problems are they facing? (In terms of perception problems, cognitive problems, action execution problems, and experienced effort) Q2. Which features can be added? (In terms of function, design, context and so on)

In this phase, student groups also participated in the UX workshop. The purpose of this workshop was to manifest UX targets gained from the first user study. UX target is guidance set in the very early phases of the development, and helps people pinpoint where to focus on redesign most profitably for both research and development. The difference identified was that UX keywords chosen by design background student groups were more emotional and ambiguous while those by non-design background student groups were more specific. These differences are continued until they determined design requirements (see Table 3 as example).

Table 3. Comparison of UX targets and design specifications of Online Photo Printing Service between design and non-design background student groups

	<b>Design background group 3</b>	<b>Non-design background group 3</b>
<b>UX targets</b>	- <i>An escalator</i> : Just by stepping on it, people can reach their desired destination easily and quickly. Also, they can do whatever they want on a moving escalator. They may look around or walk up if they want to arrive earlier.	- <i>User-friendly</i> : Usability and UX can be improved with familiar arrangement and actions. - <i>Explanatory</i> : Kind help and effective information will help the user to interact with site smoothly. - <i>Joyful</i> : Making the process joyful, the memories can be recalled more beautifully
<b>Design specification</b>	- Providing guidance - Improving intuitiveness - Making better use of space.	- <i>Vivid</i> : Visually conspicuous color, size, location of information & function. - <i>Kind</i> : Explain in detail by giving direction to promote understanding of information & how functions work.

- *Flexible*: Functions are customizable, controllable & give various options / movable options.)
- *Familiar*: Matching to mental model of users for natural use
- *Reminiscence* : Functional aspects to stimulate rousing recollection / More amusing process of transforming memories into tangible outcome

### 3.2 Synthesis Phase

In this phase, ideas were first generated on the basis of formulated design specifications. There was many differences in the way of developing ideas between design and non-design background groups. Design background groups tended to use sketching to develop their ideas generating as many ideas as possible. However, non-design background group hardly took sketching as a way of coming up with ideas. Rather, they collected and then combined existing ideas and artifacts to find a final solution (Figure 4).



Figure 4. Examples of Ideas between Design (left) and Non-design Background Groups (right)

Another difference was discovered in the approach to adopt solutions. Idea generation by design background student groups began with understanding and adopting natural behaviors of users. For instance, in the development of alarm clock, the design group adopted light and sound as natural means of waking the user up. On the other hand, the non-design group focused on solving problems without taking natural behavior of the user into account: in their concept the user should throw the alarm clock which has a ball shape several times with elastic covering material until he/she completely wakes up, which is not a natural behavior of wakening (Figure 5).



Figure 5. Examples of Final Concepts between Design (left) and Non-design Background Groups (right)

### 3.3 Analysis Phase

Simulation phase was conducted to build an interactive prototype of the design proposal, which enables the assessment of usability and user experience in a second user study. In this phase, a difference of the depth of solutions was identified between design and non-design background groups. Design groups noticeably showed higher completeness in terms of user interface. Moreover, the ideas of design group were not only functional but also emotional. Design groups considered both hard (quantifiable) and soft (non-quantifiable) design requirements while the non-design groups took only hard requirements into account (Figure 6).



Figure 6. Example of Prototypes between Design (left) and Non-design background groups (right)

### 3.4 Evaluation Phase

In this phase their prototypes were evaluated through the second user study (see Figure 7). After then, design groups seemed to keep tried to improve the final concepts as much as they can, while non-design groups less tried and did not conduct further improvement for their final concepts. After getting user feedback, two design groups redesigned their final concepts based on the results of the second user study. One design team did not conduct additional development for their final concept, but the completeness of their results was already higher than other groups. On the other hands, all of non-design groups did not conduct further development after solving the problems; one non-design group just suggested further development in words.



Figure 7. Evaluating prototypes through second user study

### 3.5 Final concept

The final concepts were evaluated by three design experts. All design groups got higher scores than non-design groups in every aspects except the technical aspects of alarm clock; Design group received 6.7 points while the non-design group received 7 points on average (Table 4).

Table 4. The Results of evaluation done by the reviewers (measured on 1 to 10 Scale)

	Reviewer Group	Alarm Clock				Digital audio player				Online Photo Printing Service			
		A	B	C	Mean	A	B	C	Mean	A	B	C	Mean
<b>Creativity</b>	Design	8	9	9	8.7	8	5	6	6.3	6	5	6	5.7
	Non-design	6	6	8	6.7	7	3	5	5	5	3	5	4.3

<b>Aesthetics</b>	Design	8	9	8	8.3	4	5	9	6	8	5	9	7.3
	Non-design	5	5	6	5.3	5	3	8	5.3	6	3	8	5.7
<b>Technical Aspects</b>	Design	5	9	6	6.7	9	9	9	9	9	9	9	9
	Non-design	6	8	7	7	8	7	7	7.3	7	7	7	7
<b>Usability</b>	Design	8	9	9	8.7	6	8	8	7.3	9	8	8	8.3
	Non-design	7	7	6	7	5	8	8	4	8	5	8	7
<b>Business Aspects</b>	Design	8	7	6	7	8	9	8	8.3	9	9	8	8.7
	Non-design	6	7	7	6.7	8	3	6	5.7	8	3	6	5.7

Table 5 shows the comments given by the three reviewers during the evaluation. As the scores of the design group concepts are higher, the comments on their concepts were also mostly positive while the non-design group concepts received many negative reviews.

*Table 5. Comments on the Final Concepts given by Three Reviewers*

	<b>Design Group</b>	<b>Non-design Group</b>
<b>Alarm Clock</b>	<ul style="list-style-type: none"> <li>• The concepts are understandable without additional explanation. Users don't have to learn how to use the products and service.</li> <li>• There is no serious functional problem.</li> <li>• It seems that the concepts considered natural user behaviors.</li> </ul>	<ul style="list-style-type: none"> <li>• It's not attractive and creative.</li> <li>• It includes donation system, but it's questioned whether the option is positive.</li> <li>• Throwing the alarm clock to turn off is unnatural behavior and seemed dangerous.</li> </ul>
<b>Digital audio Player</b>	<ul style="list-style-type: none"> <li>• It's not strongly attractive, but it gives unique experience in terms of creative aspects.</li> <li>• It's little bit inconvenient to comment to each song that I have.</li> </ul>	<ul style="list-style-type: none"> <li>• The tangible features are creative, but it's not attractive.</li> <li>• Too many functions are included.</li> <li>• Module based concept is already existed.</li> </ul>
<b>Online Photo Printing Service</b>	<ul style="list-style-type: none"> <li>• It's particularly good in terms of aesthetics.</li> <li>• It could be a highly marketable concept because of its aesthetical aspect.</li> <li>• It seems easy to use.</li> </ul>	<ul style="list-style-type: none"> <li>• Its first impression is that I need to learn how to use it.</li> </ul>

## **4 DISCUSSION & CONCLUSIONS**

The study was conducted in order to contribute to the collaborative works within multi-disciplinary teams. Thus, the main goal of this study was to figure out the differences and similarities between design background students and non-design background students in product development process. Through the analysis of each group's product development processes and final results, several findings could be made that provide clues for the research question.

### **4.1 Degree of Completion**

In the early stage of product development process, both design and non-design groups conducted analysis of the assigned products similarly. These groups considered current market of the product, competitors, and the product itself, and they developed UX targets and design specification to guide their final concepts. In this phase, non-designers generated more concrete ideas and it seemed that the progress of non-designers are faster than designers. However, it changes as the project progressed, and the degree of completion of design groups is higher on the final results. This change seems to be occurred because of the different characteristics between design background students and non-design background students. During the whole project, design groups focused on the development of their solutions. However, non-designers focused on problems they found in the analysis phase, and their progress rate is getting slower after solving the problems. It means that design groups' main purpose



of final concepts is creating new products or service while the main final purpose of non-designers are just solving the problems. Design and non-design groups' different completeness level regarding final results also affect on the assessment of three reviewers. The final concepts developed by design groups had higher scores comparing to the final concepts of three non-design groups.

## **4.2 Idea Generation Methods**

In the synthesis phase, we found different methods of idea development. Design groups preferably used sketching as a method of idea generation. On the other hand, non-design groups expressed their ideas by suggesting example products or ideas which already exist. Especially, the appearances of final concepts of non-design groups were developed based on other products or services. Comparing to the final results of non-design groups, the ones of design groups were more unique in terms of both function and form. Moreover, design group generate more ideas through sketching, and the depth of concepts were much deeper than non-design group because they developed their own ideas from the beginning. In addition, as the judges also mentioned the concepts of non-design group are mostly unattractive, and they doubted the originality of the concepts. One of the non-design groups did sketching, but the purpose was different; they used sketching to imagine the appearance of final concept before making prototypes. It was found out that hand sketching in idea generating phase is important to come up with various ideas, which can be distinguished from existing products.

## **4.3 Approach to Product Development**

Generally, the ideas of design groups seemed more intuitive and focused on understanding the behaviors of users. However, non-design groups majorly focused on problem solving less considering what exactly users want to experience. As a result, the concepts were composed of complicated functions and the interaction with unnatural user behaviors. For example, the non-design group 2 suggested a variety of different functions on the digital audio player, but the reviewers were not sure whether the functions are essential. Comparing to non-design background groups, design groups considered usability as well as emotional values of what they are developing in the design process.

## **4.4 Conclusions**

This project aimed at analyzing activities in the product development process and the overall quality of outcomes delivered in each phase such as the resulting design concepts between design groups and non-design groups. Through the analysis of student data, we identified similarities and differences in terms of product development approach and methods. First, the difference was found on the degree of completion of solutions. In the beginning phase of product development process, designers tend to think broadly and generate fuzzy ideas when the non-designers try to develop ideas that closely related in final concepts. However, after solving problems that they figured out through user studies, non-design groups didn't put as much effort as the design groups to improve total quality of the final concepts. Second, the idea generating methods was different. Design groups used sketching as a main tool to generate and develop ideas, but non-design groups did not use sketching frequently preferring instead to adopt existing ideas from other products. Lastly, both design and non-design background students had different approaches to product development. Design groups developed ideas with the aim of creating new concepts with better user experience while the non-design groups majorly focused on solving existing problems.

Previously, similar researches were conducted, but the major difference of this research is that we collected sufficient data from the participating students during a whole semester, so we could closely observe the overall product development process from basic investigation research to final suggestions. The key contribution of this study lays a good foundation for the development of design education for different background students who need to work in a multi-disciplinary product development team and use design thinking. This study was done with a characteristic of explorative study. Therefore, it requires further refinement and validation of the results with statistical data analysis, and more cases with other products to concrete the future research area.

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