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INTERDISCIPLINARY PRODUCT DESIGN AND EAST-ASIAN COLLABORATIVE DESIGN EDUCATION PROGRAM

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ABSTRACT
This paper discusses the interdisciplinary product design course aimed at teaching consumer-centered design methods for novel products and services using interdisciplinary design teams. The project-based learning is applied and each design team is required to define its own design problems based on the analysis of consumers and trends. The course teaches general design process, consumer and trend analysis methods, creative and rational methods, teamwork and design skills with the combinations of lectures, projects and hand-on workshops. The interdisciplinary product design course also includes the East-Asian Collaborative Design Program, in which the students from China, Japan and Taiwan participate, and as a result, global view for developing products and services could be fostered. The effects of the interdisciplinary product design course are discussed with the project-based case study. It could be found that the students are more flexible to other disciplines and cultures, and more sensitive to consumers and trends to find their potential needs.

Keywords: Interdisciplinary product design course, Consumer-centered design, Project-based learning, Problem-finding design education, East-Asian Collaborative Design Program

1 INTRODUCTION
Recently, professionals who are equipped with the interdisciplinary experience have been increasingly in demand to produce innovative products and services. In order for these professionals to apply the interdisciplinary ability for the production of novel products and services, the critical skills – creativity, business, technology, teamwork and human-centered design – should be properly combined [1, 2, 3].

According to the report of the NSF strategic planning for engineering design in 2030, three mega trends in design can be emphasized: (1) Foundations for Innovation, (2) Human & Social Influence on Design and (3) Design Informatics [4]. Among those mega trends, human and social influence on design can be highly related to interdisciplinary approach in design education. With this view in mind, design education requires human, socio-cultural and technological aspects.

The UK has been a leading country for the interdisciplinary design education. The design council in the UK have launched the program of 'High-Level Skills for Higher Value', and emphasized the fusion of creativity, technology and business in design education [5]. In addition, teamwork, multidisciplinary learning and education linked with industry have been stressed. The program of 'Design London' is another representative example for interdisciplinary design education [6]. The collaboration between Royal College of Art and Imperial College London can drive the fusion of design, engineering/technology and business in the education of innovation, entrepreneurship and design. This program also targets the transformation of the value through design.

Delft University of Technology in Netherlands has been another leading university to offer interdisciplinary design education through the industrial design engineering [7]. Industrial design and design engineering are combined together to provide the multidisciplinary design education for the product innovation and management. The Stanford Institute of Design (D-school) also offers interdisciplinary design education with the linkage among design, engineering, business, social science, informatics, education and medicine [8]. The design science program in the University of Michigan is

another example to provide the multidisciplinary dimension in the design education based on the collaboration among engineering, design, business, psychology, sociology and architecture [9].

The Creative Design Institute (CDI) has been another leading organization offering interdisciplinary design education at Sungkyunkwan University in South Korea [10]. It consisted of 12 professors having various backgrounds including mechanical engineering, industrial engineering, information, architecture, consumer science, psychology, education and business. CDI has played a significant role in creating advanced design education program based on the interdisciplinary approach. In 2004, the pilot program of interdisciplinary design reflecting socio-cultural issues had been firstly launched and successfully finished. Since then, the East-Asian Collaborative Design Program, which was international and interdisciplinary, had been started and seven professors in CDI have been participating in the program. In 2006, CDI have started the interdisciplinary product design course and offered multidisciplinary design education in a more systematic and organized way. CDI has conducted substantial amount of design research, and this research could serve as a good foundation for developing an advanced design education program.

Generally, in the design education, design thinking ability, project-based learning, teamwork-based learning and hands-on education can be considered as key elements to be embedded in the curriculum [11, 12, 13]. The multidisciplinary, multicultural and multinational issues should be harmoniously mingled with those critical elements in design education to maximize synergism [14].

The objective of this paper is to address the overview and education effects of the interdisciplinary design education program which has been conducted in the Sungkyunkwan University with the active involvement of CDI. The descriptions on interdisciplinary product design course are given with course details in section 2. In section 3, the East-Asian Collaborative Design Program, which is a part of interdisciplinary product design course, is introduced by describing its international and interdisciplinary nature. The case study on successful student design projects is given in section 4. Finally, the final remarks and reflections are given in section 5.

2 INTERDISCIPLINARY PRODUCT DESIGN COURSE

2.1 Course Overview

The interdisciplinary product design course has been offered since 2006 in the school of mechanical engineering at Sungkyunkwan University. In this course, the students from mechanical engineering, industrial engineering, design and consumer science have participated and worked as teams to conduct the interdisciplinary design projects. This course is one of major subjects not only in the mechanical engineering, but also in industrial engineering, design and consumer science.

The focus of the interdisciplinary product design course was to learn the consumer-centered process for designing products and services with interdisciplinary approaches based on project-based learning. Therefore, the course could achieve a multidisciplinary dimension through the participation of students from different departments of Sungkyunkwan University as described above.

In the course, each team should find their own design problems for their projects. The team members were asked to observe consumers' behaviors and associated products/services, and to uncover any hidden needs or requirements of consumers. The discovered consumer needs and requirements can be strongly linked to the design problems of each team. The diverse backgrounds of team members can be used to form more interesting and interdisciplinary design problems.

The team composition is based on personal creativity modes to diversify the personal characteristics of team members [15]. In addition, the diversity of majors, gender and age is considered when composing teams. Among students who take the course, a number of students also participate in the East-Asian Collaborative Design Program, which has been run by three East-Asian countries: Korea, China and Japan. Those who attend the East-Asian Collaborative Design Program form their own teams. The detailed description on the East-Asian Collaborative Design Program will be followed in next section.

Personal creativity modes represent the different creativity aspects of individuals, which are intrinsically related to the personal cognitive preferences based on the cognitive theory of Jung [16]. According to cognitive theory of Jung, personal cognitive preferences can be identified based on four aspects, perceiving/judging preference, factual/conceptual perception, thinking/feeling judgment, and introverted/extroverted cognitive motivation. With these cognitive preferences, eight different modes of creativity can be identified. Those eight creativity modes are synthesizing, transforming, experiential, knowledge-based, organizing, analyzing, teamwork and evaluating creativity modes, as shown in Table 1 [15].

Personal creativity mode information can be categorized in four areas of Introverted/Extroverted (I/E), iNtuitive/Sensing (N/S), Feeling/Thinking (F/T), and Perceiving/Judging (P/J), and can be shown in a graphical way, which is given in Figure 1. In addition, as can be seen in Figure 1, 18 design team roles have been determined by further partitioning each personal creativity mode into two and including two central ones: observer and mediator.

Table 1 The eight personal creativity modes [15]

	PERCEPTUAL MODES		RESPONSIVE MODES	
	Conceptual (Intuitive)	Factual (Sensing)	Objective (Thinking)	Subjective (Feeling)
Extroverted Modes	Synthesizing	Experiential	Organizing	Teamwork
Introverted Modes	Transforming	Knowledge -based	Analyzing	Evaluating

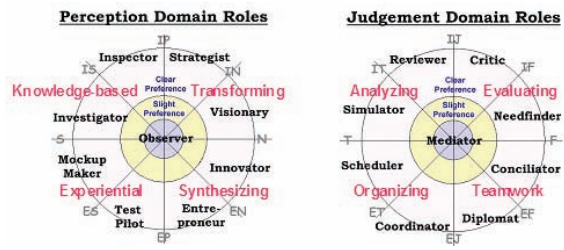


Figure 1 Personal Creativity Modes and Design Team Roles [15]

The course is taught by two instructors: the one from mechanical engineering department and the other from consumer science department. The instructor who majored in design engineering leads the course with teaching general product design and development processes, idea generation and rational design methods. The secondary instructor supports the course with teaching consumer trend and needs analysis. The workshops for promoting teamwork and industrial design skills are also parts of the course, which are led by course assistant who majored in product design. A series of presentations of conceptual designs and fabricated prototypes are conducted in final six weeks of the semester.

The Sungkyunkwan University has two main campuses: humanity and social sciences campus in which design and consumer science departments are located, and natural sciences campus in which mechanical and industrial engineering departments are located, and their locations are geographically separated. Therefore, the video conferencing system is adopted for the interdisciplinary product design course for providing the lectures to the students.

2.2 Course Format and Description

The interdisciplinary product design course starts in March and lasts for the 16 week semester. There are basically 5 phases of the course: General design process and team composition, Consumer needs and wants analysis, Creative and rational design methods, Workshops and Conceptual design and Prototype fabrication. The weekly overview on the course is given in Figure 2.

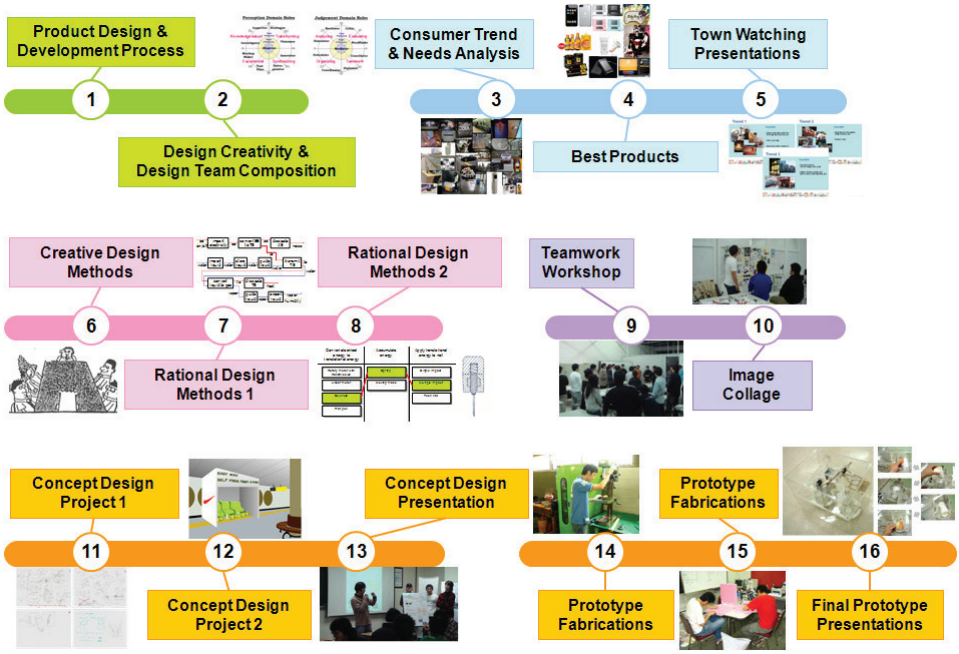


Figure 2 Weekly overview of interdisciplinary product design course

- Phase 1 (Lead instructor)

• Week 1: Product Design & Development Processes
The overall introduction on the course and the lectures on general product design and development processes are given by the instructor. The introduction on what design is and various models of design process are addressed in the lecture. In addition, each student is asked to take the Personal Creativity Mode Test (PCMT) to have the information on individual's personal creativity modes.

• Week 2: Design Creativity & Design Team Composition
The general introduction on design creativity from the view of the personal creativity modes is given to enhance students' understanding on traditional and current notions of creativity in design domain. In addition, design teams are formed based on individuals' profiles: personal creativity modes, majors, gender, and so on.

- Phase 2 (Secondary instructor)

• Week 3: Consumer Trend & Needs Analysis
The lecture on consumers and their relationship with products and services is given to appropriately understand the consumer behaviors. In addition, the lecture on the methods for consumer trend and behavior analysis is provided, and they are used by the teams to expose potential needs and wants. Such methods include questionnaire, interviews, focus group interviews (FGI) and town watching. After the lecture, the town watching assignments are given to each team.

• Week 4: Best Products
The students are asked to examine the best hit products in the market. They also have to investigate and extract the success factors of each product. The best products could be not only physical objects, but also intangible service, contents, and so forth. After the analysis, each team should make a presentation on their findings.

• Week 5: Town Watching Presentations
The results of the town watching assignments are presented in the class. In the assignment, each team is required to observe and record the notable products, stores and customer behaviors. The recorded materials should be analyzed by each team member and later by group discussions. Then, the hidden common dominant trends and consumer needs should be extracted and presented. Those discovered consumer needs should be later linked with the design problems of each team.

- Phase 3 (Lead instructor)

• Week 6: Creative Design Methods
The lecture on various creative design methods is given in this week. Those are idea generation methods including brainstorming, brain-writing (6-3-5 method), synectics, SCAMPER, and so on. After the lecture, each student conducts the brain-writing exercise to better understand the methods.

• Week 7-8: Rational Design Methods
During these weeks, a variety of rational design methods are covered in the lectures. Those are systematic approaches to solve the design problems, and includes Quality Function Deployment (QFD), Objectives Tree, Function Decomposition, Concept Generation Methods (ex. Morphological Chart Method), Concept Evaluation Methods (ex. Pugh's Method), and so on. After the lecture of week 8, the conceptual design assignments are given to each team.

- Phase 4 (Course Assistant)

• Week 9: Teamwork Workshop
The workshops promoting the teamwork of each team are given in week 9. Those workshops were originally designed by the professor majoring in psychology of CDI. The teamwork workshops are composed of two different ones. First one aims to understand the elements threatening the teamwork, and all students participate in the workshop as individuals. On the other hand, second one aims to promote the performances of teams, and is a team-based workshop. Those two hands-on workshops could be useful for each team to understand and promote its teamwork.

• Week 10: Image Collage
The activity of an image collage is conducted in the class of week 10. The course assistant, who majored in the product design, leads the class by providing the lecture on general introduction of an image collage. Then, each team practices the image collage exercise to promote their idea generation.

- Phase 5 (Lead instructor, Secondary instructor, Course Assistant)

• Week 11-13: Conceptual Design Projects and Presentations
There are no classes on the weeks of 11 and 12, and the teams conduct the conceptual design projects to solve their design problems. Each team should follow the creative and rational design methods to produce design solutions, and prepare written reports and presentation material. In week 13, each team is required to make a presentation on their conceptual design projects. In addition, each team should also submit the hardcopy and softcopy of their reports, and the presentation files.

• Week 14-16: Prototype Fabrications and Final Presentations
There are no classes on the weeks of 14 and 15, and the teams are supposed to spend some time to fabricate their prototypes. Those prototypes could be quick-and-dirty ones for the proof of their design concepts. The financial supports were given to each design team for their expenses of materials, and they could use design studios for the fabrications. In week 16, each team is required to make a final presentation with their prototypes. In addition, all teams should submit the final reports. All course instructors and assistant attend the final presentations, and evaluate each team's performances based on the presentations and final reports.

2.3 Supporting Environments

To support diverse activities associated with the interdisciplinary product design course, the design studio equipped with various design support tools was prepared at Sungkyunkwan University. Figure 3 shows the photos of the design studio which the students can use for their design activities. In addition, the workshops in the course can be held in the design studio.

As can be seen in Fig. 3(a), the reconfigurable brainstorming board can support the team activities in the design project, and the space can be reconfigured based on each team's needs and purposes. The design activity monitoring facility, which is shown in Fig. 3(b), was equipped with a couple of video cameras and a video file processing system. It can also be used to monitor team activities and to investigate their characteristics. The results could be used later to evaluate the team performances and to provide possible guidelines for design activities of teams.

(a) Reconfigurable brainstorming board

(b) Design activity monitoring facility

Figure 3 Photos of Design Studio at Sungkyunkwan University

To overcome the geographical separation of the students in the course, another design studio equipped with a video conferencing unit was also prepared. Figure 4 shows the photos of the usage of video conferencing unit by students in the design studio.

Figure 4 Photos of usage of video conferencing unit in the design studio

3 EAST-ASIAN COLLABORATIVE DESIGN PROGRAM

The East-Asian Collaborative Design Program has been launched at Sungkyunkwan University since 2005. The slogan of this program is 'Globality over Difference', and it aims to establish a special partnership among major three East-Asian countries – Korea, Japan and China – in order to build an effective and collaborative engineering design education network. This network can realize the education of next-generation design professionals who are able to develop successful global products and services in the highly competitive world market.

The basic philosophy of the East-Asian Collaborative Design Program is the international and interdisciplinary collaboration for the innovation of products and services on the basis of fundamental understanding on global business and cultural aspects as well as global technology trends. Through the collaborative design and development by the students of participating countries, new product and service values are expected to be generated, which otherwise would not be possible. The pedagogical

goals of the East-Asian Collaborative Design Program are as follows; (1) Cultivating the global collaboration ability, (2) Understating cultural differences and their synergism, and (3) Being able to develop competitive next generation global products and services.

3.1 Historical Overview

Students, professors and design coaches from universities of three East-Asian countries – Korea, Japan and China – have been participating in the collaborative design projects. In the first year (2005), Sungkyunkwan University (SKKU) from Korea, Tokyo Metropolitan Institute of Technology (TMIT) from Japan and Shanghai Jiaotong University (SJTU) from China have participated in the program. Since then, Japanese partners have been changing and two other universities (SKKU and SJTU) from Korea and China continued participations. From year 2007, the program has been run by SKKU, SJTU, and Kobe University and Japan Advanced Institute of Science & Technology (JAIST). In the fourth year (2008), the program has been extended to Taiwan, and the National Tsing Hua University (NTHU) has also participated in the program.

The students participating in the East-Asian Collaborative Design Program had a various backgrounds including mechanical engineering, industrial engineering, design, and consumer science for Korean students, general engineering, information, mechanical engineering and design for Japanese students, electrical engineering and computer science for Chinese students, and industrial engineering for Taiwanese students. The participating students formed the international and interdisciplinary teams to conduct the collaborative design projects.

3.2 Program Operations

• Team Composition

From early to mid February, the recruiting and selection of the participating students from all East-Asian countries are usually settled. The international and interdisciplinary design teams are formed based on the similar team composition rule given in section 2.1 to maximize the diversity of personal characteristics and backgrounds of each team member. Figure 5 shows sample picture of the team composition results illustrated in the personal creativity mode diagram. In Fig. 5, the billiard ball with red and blue means Korean, the red one with yellow stars does Chinese and the red one does Japanese. In this particular case (year 2006), there are three Korean students, two Chinese students and one Japanese student in each team. The participating professors are assigned to the design teams for the guidance and advices.

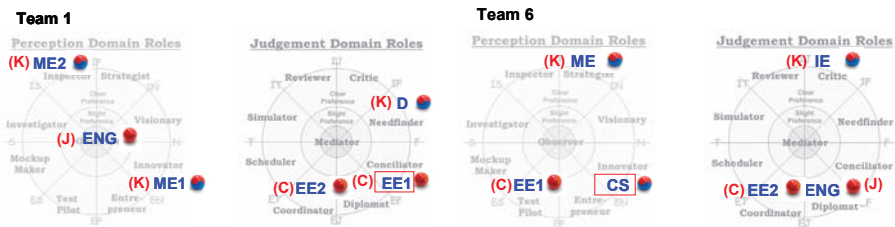


Figure 5 Sample picture of team composition results
(ME: Mechanical Engineering, EE: Electrical Engineering, IE: Industrial Engineering, ENG: Engineering, CS: Consumer Science, D: Design; Red rectangle: Female, (K): Korea, (C): China, (J): Japan)

• Assignments: Best Products and Town Watching

After completing the team formation, the assignments on best products and town watching are given to each team around the end of February. The team members of each team are required to search and study the best products of their own countries, and to conduct town watching analysis to dig out notable trends and cultures of each country. After carrying out individual studies on best products and town watching, the team members should conduct network-based communications with each other to

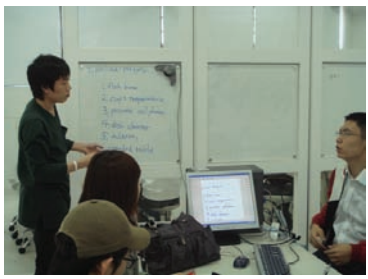
share and discuss their findings, and then come up with common and unique cultures among East-Asian countries. This assignment is a month-long work for each team, and they are required to make a presentation on the results in the face-to-face workshop, which is usually held in Korea around end of March.

• East-Asian Collaborative Design Workshop in Korea

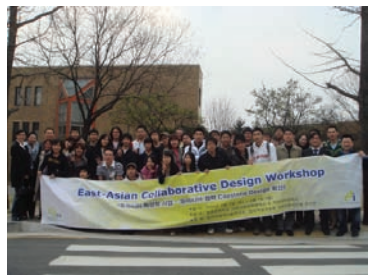
The face-to-face workshop, referred to as East-Asian Collaborative Design Workshop, is held at Sungkyunkwan University in Korea around end of March. All participating students and professors from the East-Asian countries attend this workshop. The workshop program consists of a few special seminars on interdisciplinary design issues, presentations on best products and town watching analysis, group discussions to come up with possible design problems, hands-on workshops for teamwork promotion, and so on. Sample photos of workshop scenes are given in Fig. 6. In the workshop, each design team is required to obtain preliminary ideas on their design project through a series of design ideation group sessions. Then, their preliminary ideas are presented in the final presentation of the workshop and evaluated by professors.

(a) Presentations on best products

(b) Teamwork promotion workshop



(c) Design ideation



(d) Group photo

Figure 6 Sample photos of workshop scenes in Korea

• East-Asian Collaborative Design Workshop in China/Japan/Taiwan

About a month after the workshop in Korea, another face-to-face workshop is held outside Korea. For example, in 2008, two East-Asian Collaborative Design Workshops are held in China and Taiwan at the same time. The participating Korean and Japanese students were separated into two groups according to the design teams to attend the workshops in China and Taiwan. In these workshops, each team is required to continue the group discussions and to finalize the idea for their design projects. Their ideas for the design projects are presented and evaluated by professors in the workshops.

• Continuation of Design Projects

After the face-to-face workshop in Korea and other East-Asian countries, each team should continue their design projects based on online communication. The video conferencing system and various network-based design support tools such as WebEX, TeamCenter Community and E-beams can be used to share, discuss and develop the ideas. The timeline of design projects follows the schedule of the interdisciplinary product design course.

• Linkage with Interdisciplinary Product Design Course
All students participating in the East-Asian Collaborative Design Program are required to register the Interdisciplinary Product Design course. Those students should follow the course schedule of the interdisciplinary product design in addition to carrying out the activities of the East-Asian Collaborative Design Program.

4 CASE STUDY – 'WALKING COOL'

4.1 Design Team
The design team was composed of eight students in an international and interdisciplinary way. There were five Korean students from mechanical engineering, design and consumer science, two Taiwanese students from industrial engineering and one Japanese student from design. In addition, three female students were in the design team out of eight team members. This design team participated in the East-Asian Collaborative Design Program along with the interdisciplinary product design course.

4.2 Trend and Consumer Behavior Analysis
The design team found its own design problem based on the observation and analysis on trend and consumer behavior. It was observed that many women in the street wore high-heeled shoes. The reason to wear the high-heels could be diverse. For instance, it is believed that the high heels can make the body line slimmer. In addition, the high-heels could make her outlook more confident. However, there exist health problems in a foot when wearing the high-heels for a long time. They causes foot ache, easy tiredness, deformation of foot shape, and so on. Those problems are showed in the sample photos in Figure 7.

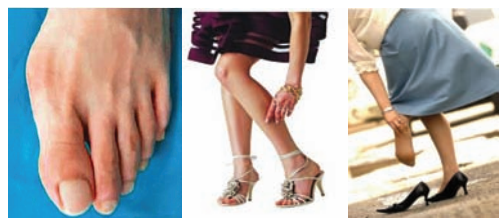


Figure 7 Sample photos of high-heel user problems

Meanwhile, women in a modern society walk a lot due to their increased amount of various activities so that they could feel some pains and heat in their feet in public areas. However, there exist no places in the city areas to make their feet relaxed for the moment. When benchmarking current products and services to provide the foot care, a foot massager could only be used indoors and there are no foot care services for users to easily use within a short time period. Therefore, the design team noticed the absence of total care solution for feet in public area, and came up with a following design problem.

4.3 Design Problem
Based on above observations and analysis, the design team has come up with the design problem as follows:

There is no total foot care solution in the public area, which people can easily access and simply receive the service within a short period of time. Designers should design a total foot care solution that people can easily use in the public areas. Designers should consider that the total foot care solution should be easily accessible, provide refreshment and relax and do no harm to users. In addition, many people should be able to use at the same time and provide social fellowship among users. Besides, installation must be easy and it can be placed in public areas.

4.4 Conceptual Design
The design team has followed the creative and rational methods which were taught in the course and come up with several alternative conceptual designs. Sample sketches on conceptual designs are shown in Fig. 8. The sketches shown in Fig. 8 describe the operational principle to provide the

refreshment to the feet. The fan could be used to provide cool air to the feet for refreshment. In addition, the structure with prominence and depression could provide the massage effect to the feet for relax.

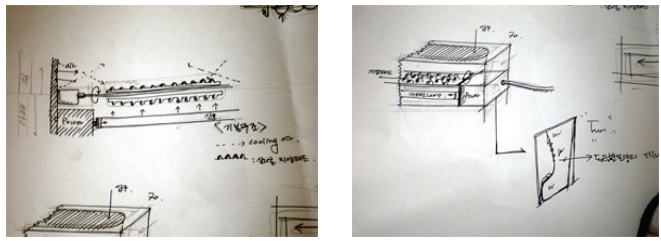


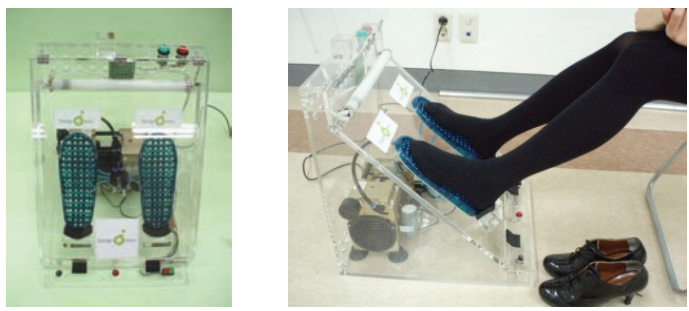
Figure 8 Sample sketches of conceptual design

The concept of the foot care station was also devised and its computer-based sketch is given in Fig. 9. As can be seen in Fig. 9, the multiple units providing the cooling air and massage are equipped in the booth so that users can have social fellowship with others. This booth can be easily installed in the public areas such as subway station, bus station, and so on. In addition, the devised foot care solution was named as 'Walking-Cool'.

Figure 9 Sketch of conceptual design of 'Walking-Cool' foot care booth

4.5 Prototyping

The prototype of the 'Walking-Cool' has been fabricated for the proof of the proposed design solution. The high pressurized air flows were provided through small holes in the foot locating plates with the air compressor. These air flows could provide relax and refreshment to the user's feet. The prominence and depression structure of the foot locating plates could also provide massaging effect to the feet. Figure 10 shows the photos of the prototype and the usage scene.



(a) Prototype *(b) Usage scene*

Figure 10 Photos of the prototype of 'Walking-Cool' and its usage scene

4.6 Discussions

After the design presentations, the feedbacks from the students of the interdisciplinary design product course and the East-Asian Collaborative Design Program were collected. According to them, the students could learn how to work with team members having different backgrounds and interests. It has also been reported that team diversity could be helpful to find design problems from various points of views.

Another benefit which the students could obtain from the course was the capability to find design problems, according to the students' reflections. They should spend considerable amount of time to uncover critical socio-cultural and human issues to be linked to their design problems, and they could obtain problem sensitivity, which is one of the major elements of creativity.

The experiences working with foreign students could be another asset for the East-Asian Collaborative Design Program. They could learn how to communicate with other people having different cultures, nationalities and languages in their design projects. Those experiences could make students more confident and flexible in global collaborating environment.

5 FINAL REMARKS AND CONCLUSIONS

In this paper, the descriptions on the interdisciplinary product design course and the East-Asian Collaborative Design Program were given, which have been offered in Sungkyunkwan University for interdisciplinary design education. The interdisciplinary product design course aimed at teaching consumer/user-centered design methods for developing a new products and services based on project-based learning. In addition, each team was required to find and define own design problems. The course teaches general design process, consumer and trend analysis methods, creative and rational methods, teamwork and design skills with the combinations of lectures, projects and hand-on workshops.

The East-Asian Collaborative Design Program has been a part of the interdisciplinary product design course, in which students and professors from East-Asian countries participated. With this program, the scope of the course could be extended to consider global trends and cultures for developing a novel products and services. In addition, participating students could learn different cultures as well as different disciplines, and as a result, the collaboration ability with ones from different disciplines, countries and cultures.

After evaluating design team's projects and assignments, students had basic understanding on the design process and techniques addressed by the course. Some of the projects produced promising results, which could be further developed to a new product. Overall, it could be found that the students are more flexible to other disciplines, and more sensitive to consumers, trends and cultures to find their potential needs, which would be later reflected in the design projects. Therefore, their problem-finding ability in the design of a new products and services could be enhanced.

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