Design for the Under-privileged

The case study on Multidisciplinary Approach in Design Process

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Introduction

Design Innovation

According to Kumar (2009), to stay competitive and innovative, "design innovation" especially which focusing on users' desires and needs has been increasingly adopted by organizations to replace their old-time efficiency-orientated innovation. Apple and Nike are good examples of companies who no longer focus on shoes or technological devices but instead their innovation focus is on the user experience of using their products. As the scope of design innovation become complex, various disciplines with a variety of competence are needed to build up a multidisciplinary team who work together pragmatically and appropriately to ensure successful innovations (Cleland, 1996; Kumar, 2009).

Multidisciplinary Approach in Design Process

Many studies stated that multidisciplinary courses have advantages over single disciplinary courses for instance: realizing a need for various skill areas to meet the project goal successfully, recognizing importance of other disciplines, and introducing to a real working situation (Gruenther, Bailey, Wilson, Plucker, & Hashmi, 2009; Carrion & Thorn, 2005). At the School of Architecture and Design (SOAD), King Mongkut's University of Technology and Design (KMUTT), industrial design program had conducted a multidisciplinary approach courses for its undergraduate level with affiliated engineering school. The collaboration usually brings industrial design students working hand in hand with the engineering students within the explorative scope given by the local Electronic Appliances Company to search for new innovative concepts. It is more or less considered as an 'exercise' for students practicing their design and engineering skills with professional input and feedback. Even though the benefit of the collaboration has been seen in total great opportunities but it is still not in the context of real world practice.

This paper aims to explore the mechanism and benefits of multidisciplinary approach in design process between the two complement organizations between KMUTT and the National Electronics and Computer Technology Center of Thailand (NECTEC). Through a platform of a studio course focusing on cognitive human factor and industrial design skills, the entire project was a collaborative work between Industrial Design students of KMUTT and 2 complement organizations - the National Electronics and Computer Technology Center of Thailand (NECTEC) and the School of Control System and Instrumentation Engineering (CSIE) of KMUTT. Apart from the professionals, mostly engineers from these two science-and-technology based

institutes, there is also an involvement of specialists who are physician, physiotherapist, linguistic experts, and psychologist to co-develop a series of technology-embedded daily-aiding products: home electrical appliance controller system and communicative devices for underprivileged in Thailand, the real world project. The NECTEC and CSIE's anticipation towards industrial design students' contribution is an archetypical product designer's expertise, an ability to 'humanize' those bare-skin mechanics by adding more ergonomic concerns and styling it with some senses of aesthetics. Apparently, the project concept in terms of mechanism was then handed in at the beginning of the course by the head of Rehabilitative Engineering and Assistive Technology Institute (REAT), NECTEC and CSIE researcher. For us, this collaboration can be considered not only as an opportunity for students to practice their industrial design skills, by which the final design outcomes are subjected to make their way to the real production, but also a chance to see how creative thinking could be stimulated through the collaborative process among us and all the stakeholders.

Research Objectives and Methods

The study proposed to compare the two groups of students, pursuing different design approaches: *"single-disciplinary approach"* and *"multidisciplinary approach"* through their 15-week design processes. The main objective of this study is to investigate the notion of how 'Multidisciplinary Approach in Design' provides design constraints, and to what extent that the same approach enhances creativity, practicality and feasibility in archetypal design process and outcomes of collaborative project.

In this study the authors as design studio mentors followed two groups of students working with single-disciplinary approach and multidisciplinary approach under the same project theme from the beginning to the end. Through observation, class tutorial session and discussion, the data from both groups were collected and after the course finished, they were compared in terms of design brief, design process and design outcomes. Conclusions were made by the authors based on accumulated data gained from group discussion among mentors, engineers, students and ended-users throughout the study as well as lesson-learned reports by students at the end of the course.

Design Project for the Underprivileged

Design project for the Underprivileged in this study were part of the Industrial Design course in junior year. The study focuses on 2 groups of students in charge to design daily-aiding devices for underprivileged in Thailand. While the first group of students conducted their project through "Single-Disciplinary Approach" by exploiting a regular user-centered design framework, the students in the second group had taken over the regular course with the collaboration between NECTEC, CSIE and SOAD, "Multidisciplinary Approach".

Since the Industrial Design course at KMUTT has focused on Human-Centered Design principle, either with or without the multidisciplinary approach, both of student groups had then started their design project by conducting a series of user research such as user observations and in-depth interviews to gain design insight in order to outline their project focus and assure the design success. It was clear that in terms of design brief, the single-disciplinary approach's research questions were more open-ended (such as 'How can the underprivileged's quality of lives be elevated through design?') and exploratory in order to search for new product concepts, similarly to so-called 'Blue Sky Project', while the multidisciplinary approach had been assigned with specific task to explore design opportunities in improving NECTEC home electrical appliance controller system and communicative devices for the underprivileged.

In the single-disciplinary group, students were solely guided through user-centered design process. They conducted user field research including user observation and in-depth interview to gain insights directly from their end-users, the blind. They were then steered through creative

design process to design communicative devices according to the needs of the blinds' different lifestyles. Their specific project topic has not been identified at the beginning of the project since they were required to "discover" how the blind prioritize their needs to pursue their daily routine. (see fig.1)

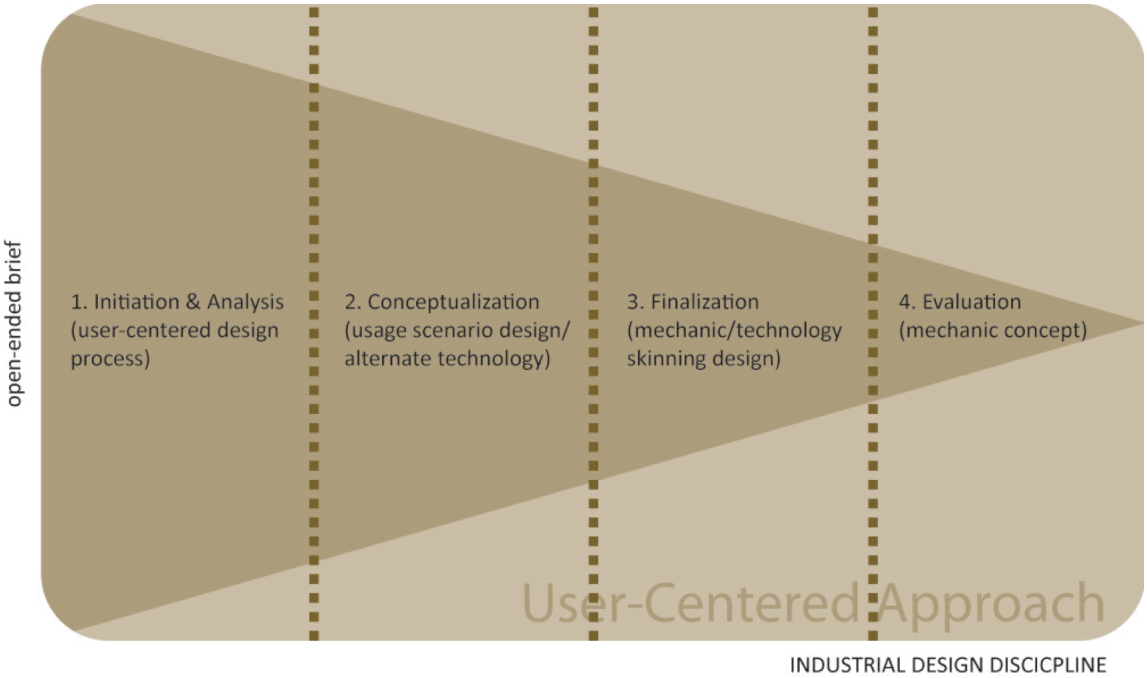

fig1. Design Process of Group I with Single Disciplinary Involvement

In the multidisciplinary group, students were also guided through the same user-centered design process except that they worked with other disciplines instead of working alone. Throughout the project, students had to integrate secondary research data and requirement advised from all the experts including engineers, physiotherapists, psychologists and doctors with their firsthand knowledge acquired directly from end users: paraplegics and a quadriplegic from spinal cord injury patients, to design home electrical appliance controller system and communicative devices. This compromise between the design constraints and the real world needs was made to ensure creative, functional and desirable, yet practical and feasible. (see fig.2)

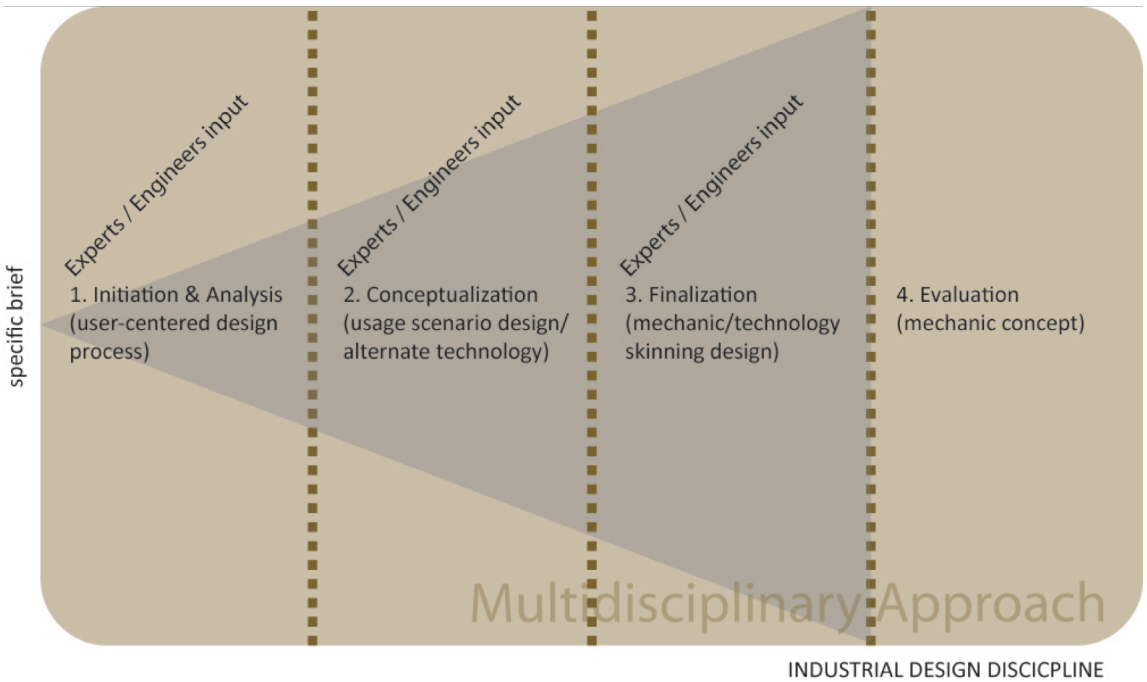

Fig2. Design Process of Group II with Multidisciplinary Approach

By exploiting archetypal design process, both groups of students were guided through four design stages of (1) Initiation & Analysis, (2) Conceptualization, (3) Finalization and (4) Evaluation. In the first stage, Initiation & Analysis, all students employed user-centered design process to collect data, analyze, synthesize and conclude it in order to come up with their individual design brief. Except for the students in multidisciplinary design approach group, students had more opportunities to gain additional essential knowledge of physical treatment principle for each patient condition and psychological therapy from the doctors and experts' viewpoints, as well as the information of how provided technology system worked in the real home-used devices done by the NECTEC engineers. In brief, the first group of students searched out a more open-ended project brief while the second group of students received a specific project brief.

During the second stage of Conceptualization, the students of user-centered design group explored their project concepts by looking at various usage scenario and technology possibilities as well as performing concept feasibility by mock-ups testing with their ended-users. The students in multidisciplinary approach group had their explorations within the NECTEC requirements, since NECTEC researcher head had envisioned the outcome of the design project to be economically produce-able and innovative. Similar to the other group, they also performed concept feasibility by mock-ups testing with all the therapists, doctors, ended-users and proving with engineers for whether what they were doing was feasible enough for usage and production.

Finalization stage was to some extent occurred similarly for both groups of students. While students in the user-centered design approach group had no access to "experts" to prove their designs with so their stage of finalization occurred unconcernedly like other typical studio project. Whereas students in the multidisciplinary group needed to fine tune and negotiate with all the stakeholders involved in the project. Some students also tested out their final design with the real users to verify some usage scenarios and details in their final design. At the last stage of Evaluation, all students had their final design prototypes. The first group students could hardly validate them with the real users, only the simulation while the second groups had more chance to conduct users' validation, allowing users' to try on and collecting their feedback. The second group consequently had more opportunity to improve their design before completing their final design proposal.

Fig.3 The Initiation and Evaluation stages conducted during the project.

Results
Design outcomes

Group1: Single-Multidisciplinary Approach Group
With user-centered design framework, students in Single-Disciplinary Approach group identified their design brief themselves by conducting user observation and interview as well as carry out a literature review in communication device technology for the blind. Design outcomes of this group of students were quite innovative in the terms of adapting inexpensive technology to use in their design scenario (see fig.4). For instance, “Space Indication Assisting Tool for the Blind” by Mr.Chaipat Intawong (a in fig.4), the student utilized sonar technology technique to let the blind generate the click of tongue to indicate the distance between the blind and the obstacles. The aiding device can assist the blind through the unfamiliar surroundings yet still relying on the remaining superior sense of hearing. During the project, the student explored different possible contexts where his selected technology could be used. His working approach was quite similar to the multidisciplinary group. The only difference is that the student did everything alone without any technical support from other disciplines. Other interesting project of this group was “Color Perception Tools for the Blind” by Ms. Tanyathip Boonamnuayvitaya (b in fig.4). The designer tried to fulfill the need of the blind, especially in terms of ability to see colors. The ring-like object guides the users through the cloth shopping context without intrusive physicality. By embedding Bluetooth, the ring transmits the code of color frequency into meaningful sound delivered to the user through indistinguishable ear phone. This conceptual design was developed first from users' physical and psychological needs and then the student searched for appropriate technology that can fulfill her design functions and features. However, without technical support form other disciplines, her design is very conceptual and cannot be produced with today's affordable technology.

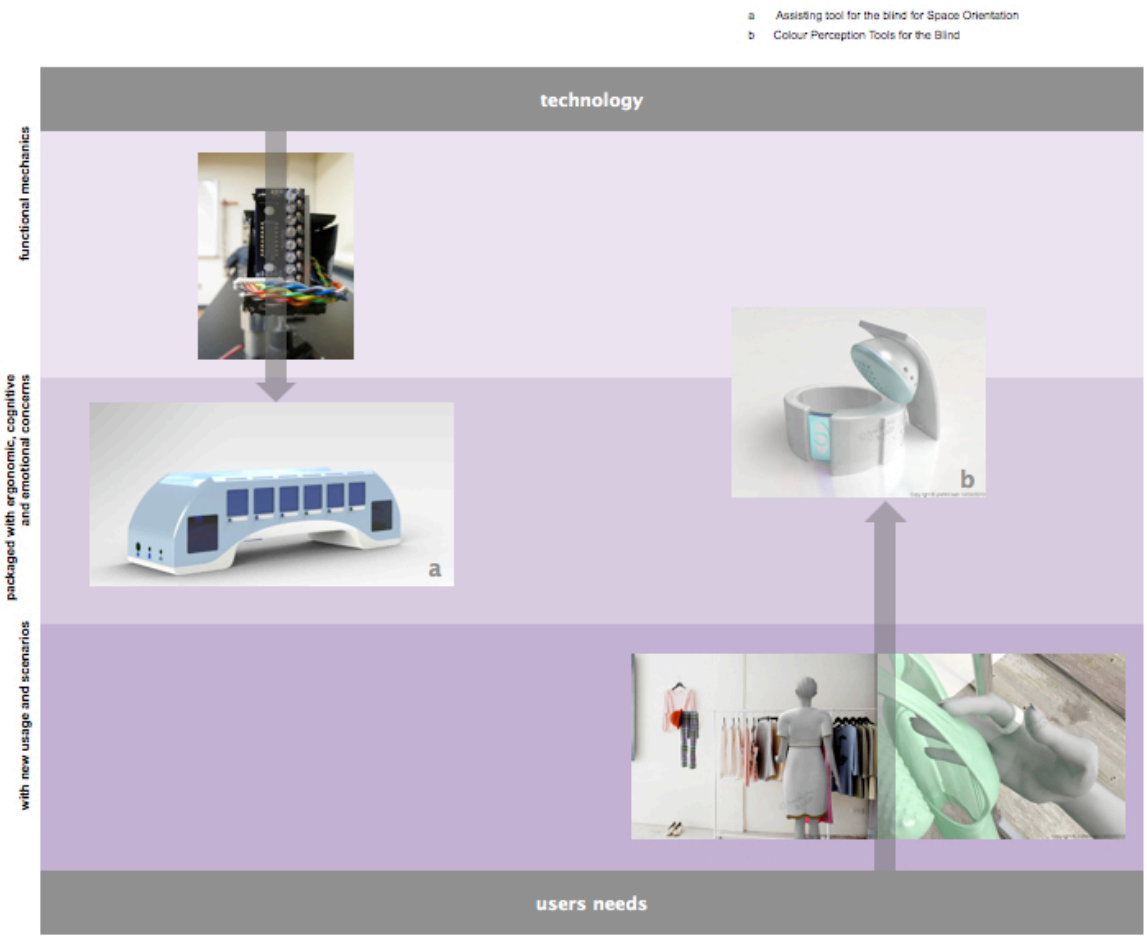

Fig.4 Design outcomes from Group I -Single Disciplinary Approach group

Group2: Multidisciplinary Approach Group

Through multidisciplinary approach framework, students of this group had been assigned with a more specific design brief of developing: 1) a home electrical appliance controller system and 2) home telephone for paraplegic and quadriplegic with provided technology by NECTEC, “scan mode” technology (c in fig.5) and product concept. The set of home electrical appliance controller included 3 main parts of an individual electrical appliance input box, an 8-channel remote controller, and a wall-attached receiver, while the home phone set used the mobile Sim-card technology as the platform, operating with detachable big soft button for activating. Students have generated various different levels of solution as seen in fig. 5, but to some extend, during the Conceptualization stage, students of this group were struggle to come up with the new typology of the devices’ form since they encountered a preconception of the device they are designing which lead to other problems in finding new “creative” usage details. Though during the Finalization stage, this student group had more chance in testing out their usage details with the real users. With feedback and faster process of “being assigned with provided technology”, they could elaborate their design further. “The Compact 8-Channel Remote Controller with Detachable Emergency Button“ by Mr. Korakit Silathapanasakul and Mr. Visarut Taweevorasuwan (f in fig.5) was one of the work mentioned above. Their device generally was designed as a typical remote controller over home electrical appliances. The supplementary functions – the nurse calling and the emergency alarm activator – were added as well as the devices controlling tasks in terms of ergonomics and cognitive understanding. This design was seen as a minor change for NECTEC's existing solution improvement.

Fig.5 Design outcomes from Group II - Multidisciplinary Approach group

Other students also had to expand their project scope to cover more user groups to differentiate their work from the original product as seen in the work of Ms.Chidawan Kimawongdachai and Ms.Wiriya Mana-anantakul, “Home Phone for All” (d and e in fig.5). With the Tilt-able Screen”, the design can serve various viewing angles of different laying/sitting positions. Patients activate each command through the dialed number by hitting the red pad during the moving signal light scanning all the buttons. The main concept developed according to NECTEC's existing telephone and technology was then further explored for wider range of underprivileged of the blind and the deaf, as well as people around them such as their family and assistants. By allowing users to plug-in different input and output devices, for instance, voice command input and vibration feedback for the blind made the device suitable for different type of users and can be produced with today's affordable technology.

The most distinguish project in this multidisciplinary approach group were “the Voice Activated Home Electrical Appliance Controller for Quadriplegic” by Ms.Prangthip Visarnkij and Mr. Chaya Hantaweewongsa (g in fig.5), and “the Photo-Sensor Home Electrical Appliance Controller for Paraplegic and Elderly” by Mr. Kittikorn Worawitayakran and Mr. Naroot Pitisongswat (h and i in fig.5). Both group of students explored with alternative input technology for users who suffered from weak limbs. In order to aid paraplegic to perceive the choices of the device they would like to activate/deactivate, the Voice Activated Home Electrical Appliance Controller enabled users’ sense of hearing and sight by emitting the descriptive sound calling the plug-in electrical appliance names together with illuminant base when identifying the devices. The devices are not only efficient in terms of users' cognitive perception and ergonomically practicality, but also well blended with the environment as if they belong to the surrounding. The design also can be produced to fit with NECTEC's provided mechanics and today's affordable technology.

For the “Photo-Sensor Home Electrical Appliance Controller for Paraplegic and Elderly”, the remote controller allowed the use of users’ wrist to handle the device through rotating and pressing movement, the efficient postures for common error reduction among such patients. They also expand their project scope to cover the elderly whom also suffered with weak limbs problem. Users can easily move their arms across the motion-sensor base for browsing the choices of electrical devices with no need to stare at the controller panel. Instead, the visual feedback of the movement can be seen on the display located in the noticeable area such as at the top of the television. This design was not developed based on technology NECTEC had given; instead it was developed based on user needs and today's technology.

Discussion

1) Open-Ended Versus Specific Design Brief

The comparison between the design outcomes of two groups of students indicates the following: at the beginning of the project, both groups of the students encountered different problems. Students in the single-disciplinary group receiving an open-ended design brief – “A communicative device for the blind” – had difficulties in scoping their project brief because the given design brief was extremely broad and apparently needed longer time to elaborate those new information they acquired during user observation and interview. Without strong analysis and synthesis skills, students may turn out their design brief, design criteria, product’s function and feature inadequately which can be leaded to failure of the project.

Whereas students in the multidisciplinary approach group receiving a specific design brief – “Improving NECTEC home electrical appliance controller system and communicative devices for underprivileged” – were overwhelmed by unfamiliar given information related to needs and limitations of the disables as well as NECTEC’s provided technology such as “scan mode” and original printed circuit board (PCB). During the design and development phase, most students in multidisciplinary approach group used given project requirement to guide them what to do and where to go. For this reason, most students in this group, to some extend, during the

Conceptualization stage, were struggle to come up with the new typology of device's form since they had preconception of the device they are designing which lead to other problem in finding new "creative" usage details of the Finalization stage.

2) Single Discipline Versus Multidiscipline

Design Outcomes
The design outcomes of both groups were remarkably different. Most of the final design of the single disciplinary group is considered as conceptual and futuristic when comparing to the multidisciplinary group's final design that is practical and feasible. Working alone on such a complex project was rather difficult for the students in the single-disciplinary group to come up with thorough design solution while collaborating with other disciplines gave the students in the second group enough support to master their project. The single-disciplinary design outcomes are apparently fairly conceptual due to the lack of technology knowledge input as seen in the project "Color Perception Tools for the Blind". Based on this finding, it becomes clear that students actually needed assistance from other disciplines to develop their design outcomes to be realistic.

Design Constraints
Based on the design outcomes, multidisciplinary teamwork were very accommodating for most students in the multidisciplinary group. Nevertheless, from the authors' the observation and discussion with students of this group as well as their design outcomes implied that some students had difficulty to work with other disciplines and encountered with frustration because they perceived the "given engineer's technical requirements" as "design constraints". It was seen, by students of this group, as "creativity constraints" as well as their confidence reduced, from time to time, for their lack of technological understanding. Though design constraint also enhance students' creativity in terms of attempting to differentiate their design with the original design as students had expand their project scope to cover more target users, more universal. Students receiving specific design brief were strained in the search for "creativity" in the next design stages. The pivoting point in each stage of the design process then acted as "a creative arena" for the students to quest for the new design solution.

Design Innovation
From the viewpoint of experts from NECTEC and KMUTT, user-centered design approach was viewed as one of the keys to new opportunities for innovation that their engineering-orientated approach hardly provided. Instead of focusing on the products – the Voice Activated and Photo-Sensor Home Electrical Appliance Controller System for underprivileged and the "Color Perception Tools for the Blind" – all of these design teams had employed user-focused design – the same approach recommended by Kumar (2009) – to explore new promising design that meet the users' needs. Furthermore, the multidisciplinary approach, particularly among designers and engineers in this study, takes a great role of bridging the gap between technology and the users' need to complete the whole process of design innovation. Without one another, the technological-based design solution could be ended up either as alienated functional object to its users, or exclusive conceptual gadget which will never been made for the mass.

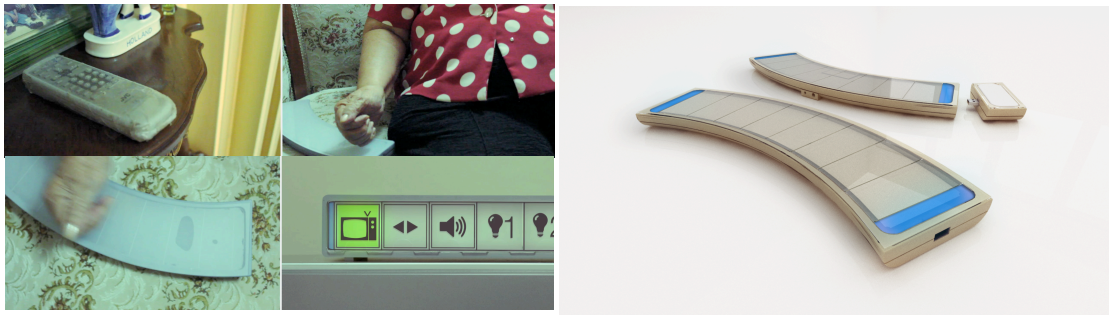

Fig.6 The usage scenario of Photo-Sensor Home Electrical Appliances Controller System

3) Appropriate Collaboration

Project Management
The collaborative project started with each project partner's enthusiasm for each discipline's contribution that could complement one another. At the beginning of the project, all partners planned the project together however a role and workload of each discipline was never been defined clearly. During the project, each discipline mainly worked based on their own expertise but when it came to the decision making stage, the course instructors needed to act as a "decision maker" and "moderator" to compromise between NECTEC's requirements and encouraging student's creativity. In addition, instructors' role were altered to be as "a facilitator", to set up questions for students to inquire, to assimilate complex "knowledge" acquired from experts to the students, to finding tune between professional engineers and design students.

Stage of Intervention
For multidisciplinary approach design process, apart from occasionally check point, there was a specific "intervention" from other disciplines for instance engineers, during the Conceptualization stage, when the design direction was shaped. While for the single-disciplinary approach, there was none of the intervention. In this study, such an intervention did not bring the interruption for the design improvement, nor scope down to only the practical design process. It rather generated opportunity to creatively consolidate the design for the optimal, yet realistic scenarios. Taking the project "Home Phone for All" by Ms.Chidawan Kimawongdachai's and Ms.Wiriya Mana-anantakul's case as an example, the design direction initially was geared specifically towards NECTEC's original telephone model specifically for the Paraplegic and Quadriplegic. After the discussion among engineers and product designers has been made, all had agreed on developing the design based on the same technical platform but added more functions to become universal design, serving broader group of users including the elderly, the blind, the deaf as well as the others around them.

Facilitation
During the multidisciplinary project, other disciplines including engineers, therapists, doctors, and others were very willing and helpful to facilitate the design students' work to some certain extent. Their supports had guided the students, shortened the students' time for mastering the project, as well as ensured the usability, practicality and feasibility of the design outcomes. Nevertheless since the collaboration agreement was never made officially, many supports such as PCB programming and prototyping, which had been offered and agreed on at the beginning, finally were not contributed by other disciplines due to "no-promise agreement" and "time constraint". As a result of this, the students ended up making prototypes by themselves. Furthermore, because they did not have skills to write the workable programming, they only managed to use Adobe Flash program to simulate their design at the final design review session.

Equality
Unlike other multidisciplinary design process occurred in other courses, the collaboration employed an unequal role in the partnership. As there is high cultural hierarchy in Thailand, when negotiating how to develop design with other disciplines, who are professional and older, students were not bold enough to insist on their design. Even though cultural hierarchy seems to hold back the collaboration, in some extent, it has also given students some "second thoughts" during their decision making stage. Not only the hierarchy of age and profession but the hierarchy of ranking in an organization also had some effects on the design outcomes. Good examples of this included there were only NECTEC's junior engineers participating in the design concept selection session and they were moderately hesitated of making a decision on the behalf of their senior engineer. Nevertheless, NECTEC's junior engineers were given a very supportive input during the Initiation and Analysis stage for the students. With their hands-on demonstration and detailed explanation, they had given both instructors and students the great understanding of the "unknown-knowledge". And during the Finalization stage, they were very accommodating in assisting students in probing the production feasibility part.

Conclusion

The research result has proven that multidisciplinary approach has several advantages over single disciplinary. With the appropriate collaboration, the multidisciplinary cooperation not only shapes the design outcomes to be more realistic, practical and feasible, but also can enhance the level of creativity and innovation rather than created constraints.

The multidisciplinary collaboration project was extremely beneficial to the students and had raising their awareness of the capabilities and limitations of their discipline as well as the other disciplines. Furthermore the design outcomes ranging from good-looking skinning design, usable and feasible product design, to design innovation was another sign of success. After the course ended, some projects have been selected for real production while some have been encouraged to take part in the International Convention on Rehabilitation Engineering and Assistive Technology (i-CREATe) 2011 competition. Because of the success of this collaborative project, the projects partners including SOAD's Industrial Design Program, KMUTT's Control System and Instrumentation Engineering Department as well as NECTEC's Rehabilitative Engineering and Assistive Technology Institute have decided to continue their collaboration in other projects.

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