Collaborative-Interdisciplinary Studio:

Control System and Instrumentation Engineering and Industrial Design Program

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Abstract—**Various ways to create interdisciplinary approaches in product design and engineering studies have been increasingly adopted in higher education. This paper describes how an engineering and industrial design program attempted to develop a new collaborative pedagogy, instead of single-discipline approaches, using a real industry-based project as the vehicle. The co-alignment of teaching and learning processes illustrates the common goals which are rationally beneficial to both programs. In conclusion, the interdisciplinary-learning framework is recapitulated to suggest more opportunities for collaboration between both academy and industry.**

Keywords: interdisciplinarity; engineering education; industrial design; collaborative pedagogy; human-centered design

I. Introduction

Interdisciplinary approaches to engineering and industrial design have become increasingly important with the recognition of the holistic aspects of product design and development. In different circumstances and faced with specific constraints, higher education has elaborated diverse tactical patterns to overcome the traditional-single-disciplined pedagogies. For instance, Rensselaer Polytechnic Institute (U.S.) offers several interdisciplinary programs including PDI, a design studio jointly offered by the schools of (1) engineering, (2) architecture, and (3) humanities, arts, and social sciences [1]. Meanwhile, in Helsinki University of Technology (TKK), the campaign called "Murjottelu" has been coordinated to apprentice multi-disciplined student pairs in participating companies [2]. Until recently, Product design engineering (PDE) at Swinburne University of Technology (Australia) is an interdisciplinary program combining mechanical engineering and industrial design, and also with the similar concept, PDE programs continue spreading internationally [3].

II. Rationale for Interdisciplinary Approach

A. Engineering Program

Previously, the Department of Control System and Instrumentation Engineering at King Mongkut's University of Technology Thonburi (KMUTT) had adopted a lecture-based course, "Application of Electronic and Digital Technologies for Industry", to integrate with the design studio of industrial design program in the School of Architecture and Design, also at KMUTT. The Engineering Faculty's intention was to address weaknesses in their student's learning-outcomes such as curiosity to learn and creative-problem-solving skills. The kick-off interdisciplinary project was launched before the department's formal program revision. Regarding the evidence of learning-outcome improvement, the revised program has offered more project-based courses to allow for collaborative learning. The new series of Electronic and Digital Fundamentals classes in the second year of the program was strategically planned to integrate two theoretical courses with a project-based-learning approach. Later in the second semester, a multidisciplinary workshop is provided to focus on the development of a strong interdisciplinary pedagogy. Students are challenged to apply their knowledge in practice through product design and development projects in which the Industrial Design Program and participating company members collaborate.

B. Industrial Design Program

For the partner of academic stakeholder, Industrial Design, a Human-Centered-Design philosophy is the backbone of the program. Consequently, in every semester the core-course design studio drives student's competency in theory and practice using project-based learning approaches. Creativity and design processes are grounded within the contexts of physical, cognitive, and cultural factors. However, the concept of interdisciplinarity is also essential for apprentice design students. Moreover, in order to prototype and test their product design projects, engineering skills are required to assist design students in experimenting with and evaluating functioning designed products. In fact, they need to understand various disciplinary constraints that generally occur along the design and innovation processes.

III. Collaborative Interdisciplinarity

According to the characteristics of a science and technology university, KMUTT aims for maximum connection with industry, local businesses, and government sectors through our academic services. This includes business incubation units, pilot plants, research works, and even tailor-made curricula to respond to specific industry requirements. The benefits from this kind of networking between academic, private, and government sectors should efficiently gear teaching and learning innovation towards collaborative interdisciplinary study, work-integrated approaches, and so on.

A. Industry-Based Projects

Industry-based projects bring in several beneficial aspects in classrooms. They provide not only access to facilities and know-how in real manufacturing and marketing situations, but also professional viewpoints contributed in class. These are significant jigsaws fulfilling faculty's academic paradigm. Evidently, fine-tuning faculty's paradigm with professionals' perspectives could deliver win-win situations for all stakeholders [4].

B. Co-alignment of Course Structures

In the Engineering Program's first eligible interdisciplinary course, "Application of Industrial Electronics for Multidisciplinary", the product design and development projects are planned among engineering faculty, industrial design faculty, and company staff. The objectives of this course are to challenge and inspire learners by locating their academic work in relation to more professional environments and processes. Moreover, realizing the design process as well as the engineering process is another criterion intentionally set up in this learning scenario. The major change from the traditional-single-disciplinary course is in-class assignment. Instead of fixed-function projects by a course's instructor, the engineering students are confronted with more open-ended briefs. The thinking behind this is to encourage students to review the relevant issues, including existing products and available technologies, before they begin to search for technological solutions. Meanwhile, the basic engineering software training is offered to ensure that engineering students are ready for creative-problem-solving execution (Fig. 1).

Meanwhile, the Design Studio course of the Industrial Design program is currently positioned in its fourth-year studies. The process through which design students are required to work consists of more steps than that of the engineer's, starting from user research and moving to design prototyping. Actually, this design process is the backbone of product design learning and is repeated every semester in the Design Studios. However, the challenge for this course, as already discussed, is how students will cope with projects constrained by real-client conditions and engineering processes. Developing collaborative working teams is the main priority for the learning process. Thus, the key success factors since both-program's students are familiar with different approaches, processes and procedures, are the *shared concepts* developed during new product design. The shared concepts herein imply three stages of the project's milestones which help engineering and design students to fine-tune their understanding of contrasting processes and goals together. These three stages consist of;

- *Understand human, machine, and user need:* This first lesson is essential to fulfill the important aspects in each field. Whilst engineering students tend to merely focus on the machines, design students conversely tend to focus on the human. Consequently, the integrative concept to understand all human, machines and needs is essential for the interdisciplinary mission.
- *Identify problems, ideas, testing results, and final design:* Activities in the second conceptual stage basically involve creative problem solving. Student's team working requires the efficient interaction between disciplines in order to deliver any innovative design solving technical and functional issues appropriately.
- *Implement prototyping and business plan:* To achieve the final shared concept is all about convincing the real clients, which are the company's participants in this case. Good design should provide opportunities to commercialize from the business viewpoint. Eventually, student's efforts should be based on the mindset of challenging real business opportunities, instead of just submitting their academic assignments.

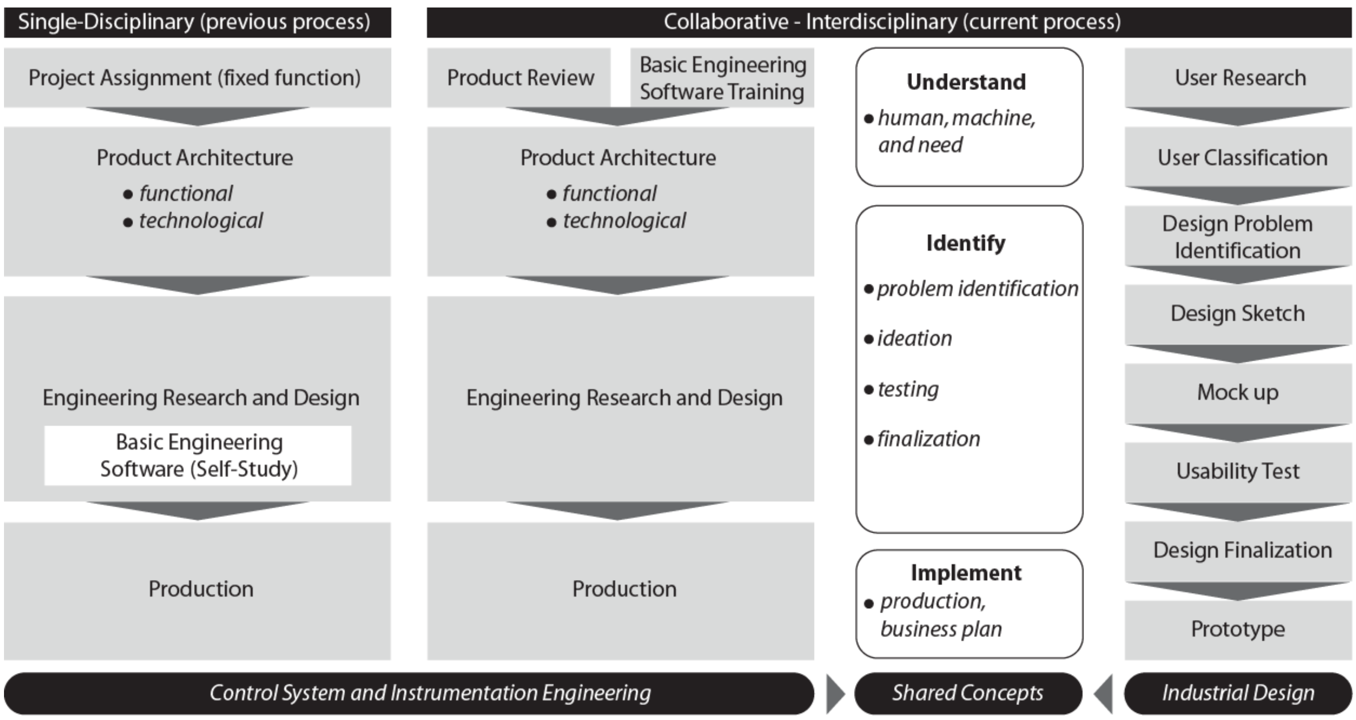

Figure 1. Co-alignment between Control System & Instrumentation Engineering and Industrial Design course structures.

IV. PROJECT OUTCOME

The evidence of our student's final works has been exhibited in campus. This is not only for assessment purposes, but also to provide students with the opportunity to deal with the responses of an anonymous-audience, thereby helping them practice their skills in communication and presentation. Meanwhile, by using open-house activities for the interdisciplinary project, we were also able to promote our teaching and learning approach to the prospective participants from other programs.

A. Product Design Output

Design prototypes from engineering and design students have reached a level of quality sufficient for presentation and demonstration. However, it should be noted that a number of these did not function well due to limitations of acquirable technology in class. Nevertheless, students did compensate for this by demonstrating their abilities in simulation analysis and testing.

B. Student's Learning Outcome

During the interdisciplinary project, the majority of engineering students significantly broadened their perspective of learning. The importance of understanding user's needs was introduced by design students through observational research and brainstorming within groups. As a result, engineering students started to be curious to investigate types of technology available which might possibly serve desirable functions. On the other hand, technical issues and principles were communicated to design students. For both groups, a very positive result was a set of soft skills like communication, problem solving, and team management that had been gained throughout the project.

Design students also gained many valuable experiences from working with engineering students and faculties as the principle of digital and electronics for products was introduced into design studios by engineering faculties. Consequently, design students were able to be more practical and technologically grounded in their creative solutions. In addition, they realized along their team working that to finalize their design depended on not only user requirements and aesthetics but also the technical constraints of products such as manufacturing process and embedded system.

C. Faculty and Company Benefits

Engineering and design faculties in this project reflected the benefits of integration and collaboration by interchanging and sharing knowledge across their disciplines during teaching and guiding students in class. Accordingly, the possibilities for future collaborative projects were positively anticipated. Simultaneously, academically contributed company participants were also educated in the context of interdisciplinary-for-innovation processes. Even though the student's project outputs did not reach a level where they could be transformed into innovations, at least the participating company realized that just engineers, marketing experts, or designers are rarely sufficient enough to create innovation, in contrast to interdisciplinary teamwork.

V. SUGGESTIVE CONCLUSION - INTERDISCIPLINARY LEARNING FRAMEWORK

Based on the outcome of the academic project in this study, the authors conclude that interdisciplinary teaching collaboration between Control System and Instrumentation Engineering and Industrial Design Program, is in alignment with KMUTT's plans to raise the quality of graduates. Also, the program has potential to expand and include framework from other faculties such as the Faculty of Engineering, School of Architecture and Design, Faculty of Science, School of Liberal Arts, School of Energy, Environment, and Materials, and Graduate School of Management and Innovation or even those in other universities.

Teachers can together set up the syllabus to include all the learning outcomes during the foundation years and control the difficulty level of the projects. Industry-oriented projects with real-world constraints can be integrated into the program in advance-level classes.

According to the cross-disciplinary-knowledge trends, setting up teacher and learning clusters can be considered to the foundation of developing knowledge excellence. Meanwhile, the benefits incurred on the industrial side are not only the knowledge and experience arising from academic-industry collaboration but also the future opportunities for product innovation.

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