Learning through the Hands-on Project: An Introduction to the Freshman Engineering Program

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ABSTRACT

Feng Chia University regularly improves its teaching quality and standards based on student learning outcomes. Improvements have been made in the areas of curriculum planning and management mechanisms in accordance with the needs of relevant industries and students. Through the "conceive, design, implement, operate (CDIO)" educational model, Feng Chia University has innovated its methods of teaching and course design to increase students' interest and motivation while cultivating their interpersonal communications and problem solving capabilities. In addition, FCU works to gain international accreditation so as to bring curricula and educational quality in line with international standards and benchmarks.

This study introduced different kinds of "hands-on" projects for freshman in the Department of Automatic Control Engineering and the Department of Urban Planning and Spatial Information at Feng Chia University in Taiwan. Students and faculty of these two departments have formed inter-discipline research teams. The teams have adopted the CDIO model to design Freshman Project, focusing on the themes of "Smart City" and "Smart life." The projects requires students to brainstorm and integrate their knowledge. Moreover, integrating project-based learning and CDIO educational model has enabled students to experience the Conceive-Design-Implement-Operate process while brainstorming above two issues. In this paper, the freshman project consists of three main parts: a series of lectures and seminars, hands-on project, and a group presentation or competition, in order to develop personal, interpersonal, and problem-solving skills.

KEYWORDS

CDIO approach, hands-on project, Introduction to engineering courses, Standards 4

INTRODUCTION

In view of the shift towards low fertility and aging populations, talent acquisition represents a nation's future competitiveness. Thus, training competitive talent to develop a global vision, as well as multicultural qualities, and the ability to combine theory and application, is the main consideration of higher education in the future. Furthermore, In order to train talent to fulfill

adequately the demands of different sectors amid the development and transformation of industries, both the quality and quantity of talent must be enlarged as well. Therefore, the methods for educating future talent are particularly important.

In this information age, the amount of information can be easily accessed online and university is not the only source for knowledge innovation and cultural explanation. Therefore, it is urgent for university to rethink the role and functions of higher education in order to help students become global citizens.

However, a remarkably hug gap between higher education curriculum and industrial needs in Taiwan has led to dilemma and challenges for teaching and learning in engineering education. Therefore, offering curriculum for engineering students to understand aspects of conceiving, designing, implementing and operating systems for international competitiveness has become an urgent issue to discuss in university engineering education.

Education transition is a continuing activity in all engineering education to meet future technological needs (Lehmann, Christensen, Du, & Thrane, 2008). Therefore, in the academic year of 2016, Feng Chia University launched a freshman project for every first-year student~~s~~, aimed at inspiring his/her imagination, creative thinking skills, and soft skills. The project made use of theme-based learning activities targeting vital employment skills in various professional fields. Students thus have the opportunity to realize their future professional sectors, and experience different learning methods to those previously experienced in senior high schools.

This article illustrates the execution of the freshman project at Feng Chia University. The goal of the program is that, through simple project-based practical learning, students develop an understanding of the learning themes and content within their department, as well as learning to recognize how to distinguish vitally important “gaps” in knowledge needed in their future study. Moreover, it was hoped that by increasing students’ learning motivation and interest, the study methods would be transformed, and the goal of training innovative talent can be achieved.

THE WAY OF PLANNING THE FRESHMAN PROJECT AT FCU

The Center of Teaching and Learning Resources (CTLR) is responsible for the design of the freshman project at Feng Chia University. In addition, a teacher’s research community was organized to facilitate teachers’ unified understanding of the project through interaction, discussion, and peer learning. Also, FCU organized a day referred to as “The Day of Learning Together,” with the purpose of breaking down barriers for planning classes across disciplines, as well as increasing the opportunities for students to develop in a multidisciplinary learning environment. It was therefore decided that FCU would allocate a common available timeslot across all departments and faculties, which is to remain empty, with no departmental classes during the slot. This arrangement allows students and instructors have the opportunity to plan time for discussions and lectures according to their learning and teaching requirements in the project-based learning program.

The implementation of the freshman project can be divided into two categories: (1) intensive course: courses that are held five to ten days prior to the beginning of the semester intensively; (2) course throughout the semester: a six to eight-week course held on each “Day of Learning Together.”

The freshman project is comprised of diverse members, including the course instructor, experts from industrial fields, teaching assistants, and students in their second year of study or above. By using a combination of real-world examples within the industry, and challenges faced in the 21st century, students work in teams throughout the program. At the end of the course, students present their results in various ways, such as written reports, oral presentations, product development, videos, drama performances, contests and so on.

THE CURRICULUM DESIGN OF DEPARTMENT OF AUTOMATIC CONTROL ENGINEERING

This course was divided into three main themes, including self-propelled vehicles, graphene sensors and dye sensitized solar cells. On the first day, teachers introduced the principles and applications of a variety of basic sensors in an oratory manner, followed by introducing the revolutionary material, graphene, and finally is the green energy components. Beginning with the introduction of sensors, graphene and solar cells, teachers summarized application fields with great future potential, leading to the current mainstream industrial sensing method, and the introduction of graphene-related commercialization technology. The second day courses centered on the implementation of the self-propelled vehicles and dye sensitized solar cells, respectively, with the former including design and assembly, where students had to implement vehicle design and creative modification. The course of dye sensitized solar cells required students to try different kinds of dye and observe their performances. The afternoon course content included self-propelled vehicle racing, exterior display, and performance competition, as shown in figure 1.

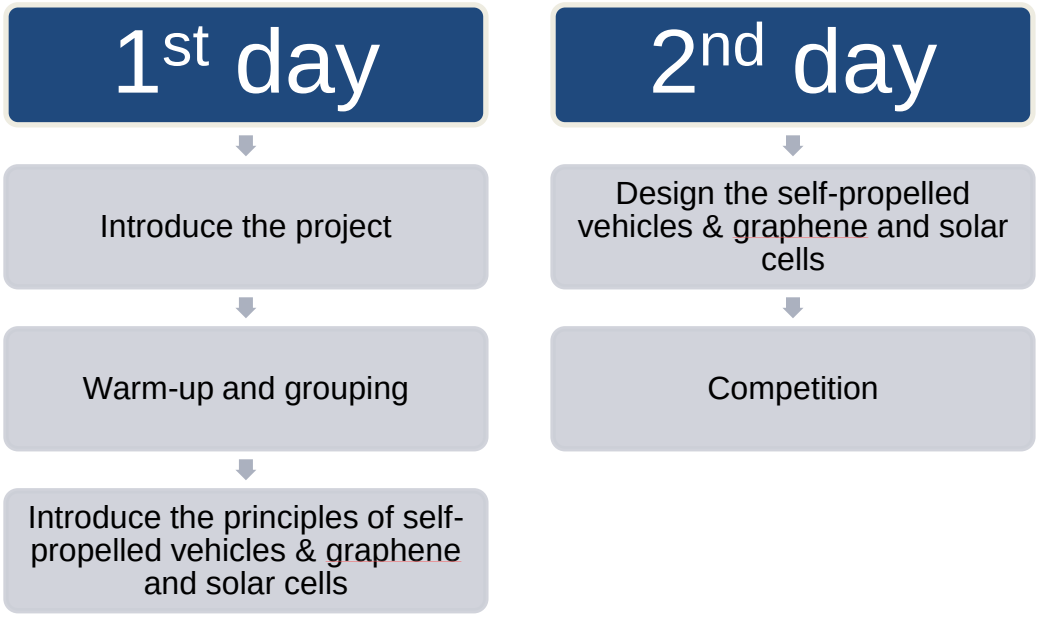

Figure 1. The procedures and contents of freshman project of the department of automatic control engineering

Based on the three main purposes of freshman project: “imagination is infinite”, “value is infinite” and “contributions to human environment is infinite”, creative subjects could be self-defined for discussed by each team. Important issues of current social demands or yet-to-breakthrough science and technology issues could be selected as the discussion subjects by teachers.

Additionally, at the end of the course, innovative prototypes pertaining to the defined subjects were presented via the teaching aids of self-propelled vehicles and solar cells, which marked the most important event.

For self-propelled vehicles, including sensing circuit and motor control circuit design, teachers developed and examine students' circuit design ability and practical welding operation skills; for green energy components and two-dimensional material, including integration of solar cells and emerging material of graphene, teachers enabled students to acquire knowledge on energy, and strengthened their exploration of different science fields. In addition to teaching fundamental circuit and control theory, the teachers also developed and examined students' knowledge on basic electrical science and control, as well as their active cooperation and diligent study attitude through teamwork among students. In addition, teachers also examined the attitude of teamwork and the degree of knowledge absorption via group discussions, and finally surveyed the students' vehicle tuning and practical operation skills through subject competitions on self-propelled vehicles, including individual competition, team relay competition, and external rating, where the self-propelled vehicle-based team relay competition was used as a criterion to examine the effectiveness of students' giving play to their creativity, triggering their learning interest, teamwork spirit and learning attitude.

Taking advantage of the freshman-training period, the department of automatic control engineering required students to perform freshman projects, where the students were grouped to develop teamwork spirit. Meanwhile, a subject-based innovative ideas course was arranged to let them brainstorm and come up with innovative and practical applications, where the prototypes of "self-propelled vehicles" and "graphene-based green energy components" were employed to realize their innovative applications. Finally, the results were presented by each group in a performing manner. With simple operation and assembly procedures, the freshman students not only triggered their interest toward college life, but also developed the attitude of team responsibility and innovation, which is more important.

THE CURRICULUM DESIGN OF the DEPARTMENT OF URBAN PLANNING AND SPATIAL INFORMATION

Using "Exploration of Urban Spatial Imagery" as the main topic, the freshman project for the Department of Urban Planning and Spatial Information has broken away with the core concept of communications. In the past, teaching assistants or teachers communicated with students in a unidirectional manner in the freshman training. This has been changed into a "co-curatorial" approach, where students could understand how to explore the city and construct mind maps to learn the basic concepts of urban design through paper model making and 3D printing. The event took place on September 9th-11th, 2016, and there were three teachers co-guided 110 two group-based students of this department.

Aiming at the students of the two classes in the Department of Urban Planning and Spatial Information, we granted one credit for this course, whose core purpose is to trigger student interests in Urban Spatial Imagery Design. With campus as the implementation site, the course was divided into two phases:

First Phase of This Course

The first phase aimed to construct paper models for the indispensable elements of the urban spatial imagery. First, the teachers explained the paper model making process, and illustrated the relationship and design of the structure elevation required to be investigated in drawing a

paper model, which allowed students to have a clearer concept of the required details such as objects and dimensions for constructing the paper models. Next, the students were required to design the blueprint for the 3D paper building model in person to test their abilities, and to finish constructing the 3D paper models using cut and paste. In this way, the students could understand the spatial imagery components through different orientations (the relationship of objects with different facets, the importance of accurate calculations for the construction process), and through collaboration, the students finished constructing the post-exploration urban spatial environment, which was also aimed to trained the students to improve their concentration and cultivate their patience.

Second Phase of This Course

The second phase course aimed to provide the students with theoretical teaching and practical implementation guidance regarding 3D computer graphics model generation. For 3D printing, with the course provided in the first phase, the students were more familiar with the exploration of the urban spatial imagery. Next, the course was intended to enable the students to more professionally and delicately finish constructing the urban spatial imagery. First, the students were required to be familiar with the operation of computer modeling software through basic procedure, based on which and the deformation and material transformation tools, the student learned how to make spatial imagery elements. Finally, the results of spatial imagery construction were presented. In the process, the students completed finer urban spatial imagery in a manner different from the paper model approach, which made them understand the features of 3D software. Additionally, the students could select an appropriate approach based on their requirement to construct high-quality 3D models. Finally the students were grouped to plan the urban spatial imagery they knew, and were given opportunities to present the results to more clearly convey the planned connotation.

In general, with 3D printing and the manufacturing of the paper models, the students have understood the features of the three-dimensional implementation procedures and the manufacturing skills. In addition to triggering fun for handmade models, they also brought the students closer to the problem of practical modeling design, enhancing the students' conceiving and implementation ability, and making students better understand the components required to be considered in different aspects of spatial imagery as well as understand the spatial imagery step-by-step. Additionally, the students could learn the applications of technology in relevant fields, and complete constructing the urban spatial imagery together through the grouping method. With the models pieced together, a complete campus of FCU was constructed. Finally, the results were presented, where the students could express their opinions and imaginations concerning the exploration of urban spatial imagery after the course study. The course also connects the anchoring course and urban design of this department, serving as the prerequisite course for the anchoring course, and developing students' basic urban design concepts and practical skills. Moreover, this course can assist two groups of students in taking the sophomore and junior-based practicum course. It is expected to diversify the practicum course as practical cases of urban design.

For improving teaching quality, a total of 3 teachers engaged in this course. They divided the courses into two phases, which allowed students to explore the urban spatial imagery with different methods and different aspects, and enabled them to express their conceived imagery. Also, the results were presented to enable the students to clearly express their opinions and imaginations concerning the exploration of urban spatial imagery after the course study.

In the promotion of research on energy, with different auxiliary materials most familiar to the students such as a variety of paper tapes, convenience stickers and paperboard, computer software and 3D printers, the course made the students understand the urban spatial imagery step-by-step, and enabled them to learn the applications of relevant field technology, and complete constructing the urban spatial imagery together through the grouping method, with the final result being a complete FCU campus model, which was constructed by piecing together all models. The course also connected the anchoring course and urban design of this department, serving as the prerequisite course for the anchoring course, and developing students' basic urban design concepts and practical skills. Moreover, this course can assist two groups of students in taking the sophomore and junior-based practicum courses and practical cases of urban design which are expected to diversify the practicum course.

CONCLUSION

More and more industries have involved actively in researching industrial innovation and transformation in recent decades. Thus, it is essential for Taiwanese universities to participate in social enterprise and collaborate with industries to improve students' abilities and knowledge to meet industrial needs. In order to enhance students' interests in engineering education, FCU design freshman project for every freshman student in the academic year of 2016. Using active and experimental learning techniques and hands-on activities help establish integrated curriculum to improve students' personal and interpersonal skills and product, process and system building skills with disciplinary knowledge in those projects. Students have opportunities to directly participate in the conceiving and problem-solving process through experiencing freshman project and learning from Introduction to Engineering curriculum. The notion of this framework is to provide students opportunity to offer an outline of a project and their responsibilities of an engineer and to apply their professional knowledge into execution. Also, in recent decades, there has been an increasing need for interdisciplinary experts in various industries. Thus, it is crucial to add elements of humanities and social sciences into contemporary engineering education. Considering how to equip engineering experts with both basic engineering knowledge, improve ability for innovation and design, and design products without missing elements of art and humanity has become an important topic for engineering education in higher education.

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Ching-Yi Lee is currently an assistant professor in the Center for Teaching and Learning Resource at Feng Chia University. She received her Ph. D. degree in Department of Industrial Education and Technology from National Changhua University of Education, Taiwan. Her current research focuses on engineering education, structural equation modelling, imagination, vocational training and higher education.

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