Coupling Engineering and Entrepreneurship Education through Fuel Cell Product Development

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Abstract

This paper presents an overview of the entrepreneurship curriculum at Yuan Ze University. In this curriculum, thirteen courses are identified as required courses for students that intend to apply fuel cell as the key component for starting a new company. The thirteen courses include fuel cell design, fuel cell experiments, manufacturing process, mechatronics, international business and entrepreneurship. These courses are offered by different departments from the engineering and business schools. Students with different backgrounds are required to complete two to three courses in the curriculum depending on his/her interest. Upon completion, they are formed into several teams from different disciplines to work together as a virtual company in creating a new product that could be used to solicit funding for future commercial purposes. The final evaluation is then based on the feasibility of the business plan and the merits of the product.

Starting from February of 2003, 52 students joined this virtual company and 31 students fulfilled all the requirements at the end of September 2003. Two products were developed, a fuel cell scooter and fuel cell education kit. An important result from the curriculum was that both the engineering and business students developed an understanding of the technical and business challenges in starting a new company. This required development of effective cross-disciplinary communication skills and learning to function in a setting similar to one that might be found in industry.

I. Introduction

Yuan Ze University is a fully accredited private university offering standard

degrees in liberal arts, education, management, science and engineering. The Mechanical Engineering Department at Yuan Ze University was established in 1989. Currently there are 19 faculty members, more than 700 students（including undergraduate, master, and doctoral students）and more than 1300 alumni. The department seeks to combine excellence in education and research with service to society. The goal of our academic program in Mechanical Engineering is to provide students with a balance of intellectual and practical experiences that enable them to address a variety of societal needs. Our program at the undergraduate level emphasizes on creativity, hands-on practice, internationalization, and the ability to adapt to rapid changing technologies. Our mission is to prepare for practice or for graduate studying engineering or other fields where a broad, fundamental engineering background is desirable. A solid grounding in the principles and practices of mechanical engineering enables graduates to acquire innovative concepts, technologies and methodologies throughout their lives, and to address a variety of societal needs.

Combining engineering and business students in a company environment is an effective method of entrepreneurship education. It provides a more realistic environment for developing business plans and exposes both engineering and business students to the challenge faced by many actual companies. The objective of this paper is aimed to give an overview of the project which intends to design a cross discipline curriculum to enhance the knowledge innovation capability of our student under the impact of knowledge economics. The design of this new curriculum is based on the review of the educational goal of Yuan Ze University and the characteristics of the students we like to cultivate are as below：

（1）creative problem solving
（2）ability to practice engineering
（3）apply advanced technology
（4）function multidisciplinary teams
（5）communicate effectively
（6）understand global impact and societal context
（7）entrepreneurship

This new curriculum consists of two parts, lecture based courses and a capstone design project. The lecture based courses are grouped into four categories: fuel cell, mechatronics, smart system and entrepreneurship. Each category is composed of two to five courses taught by participating professors from mechanical engineering, chemical engineering, electrical engineering, industrial engineering, international

business and business administration. The fuel cell scooter and educational kit powered by fuel cell were used as capstone design projects to integrate the knowledge taught in the modular courses. To facilitate these capstone projects and provide a close link to the business environment, the design projects were implemented as a virtual company. In doing this, we believe that students will be more effectively prepared to meet the challenges in the future job market.

II. Modular Courses

Sophomore and junior students are qualified to join these modular courses. All involved courses are classified in Fig.1. Students must join one of the modular courses and fulfill all of the requirements specified in that module. In addition to the requirements stated in each module, students are asked to take obligatory courses offered in different modules. Students from the engineering school must take Management of Technology from the Entrepreneurship module. Students from the business school must take 3D Visual Simulation and Virtual Reality as their obligatory courses. When all required courses are completed, students are qualified to join the virtual company and start their capstone design project.

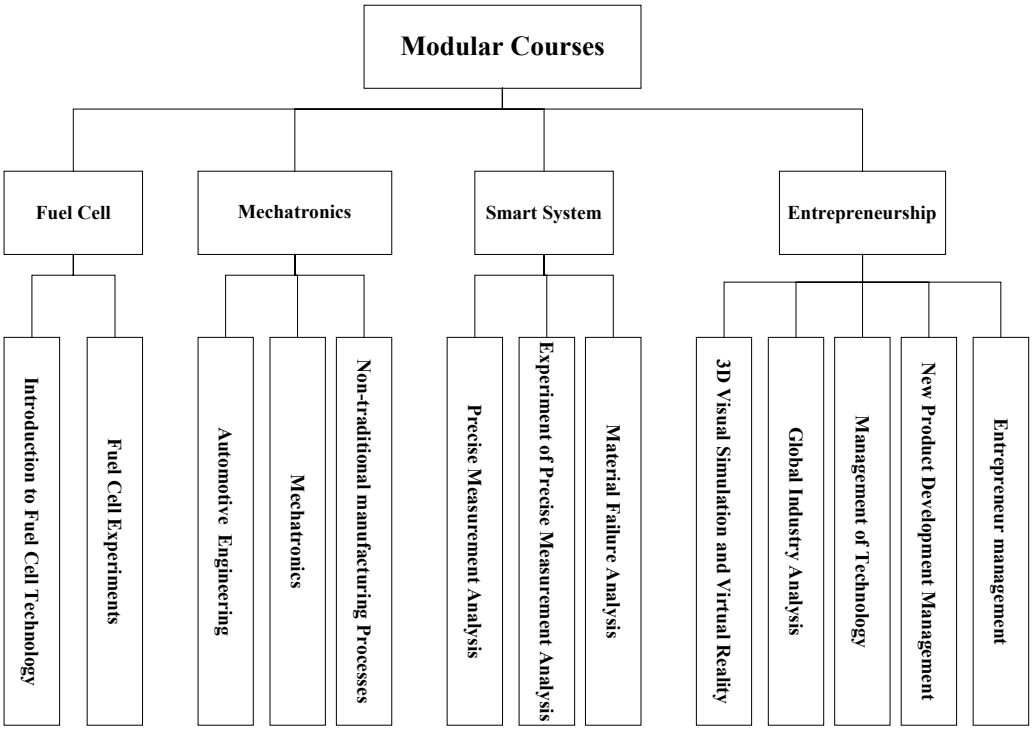

Fig.1 Modular Courses

III. Virtual Company

Starting from February of 2002, more than three hundreds students took these courses with 52 students completing all of the requirements of each module and were willing to join the virtual company at the end of the February 2003. After completing the capstone design project at the end of September 2003, 31 students fulfilled the obligation as members of the virtual company and obtained the certificate of the curriculum. The organization chart of the virtual company is shown in Fig.2.

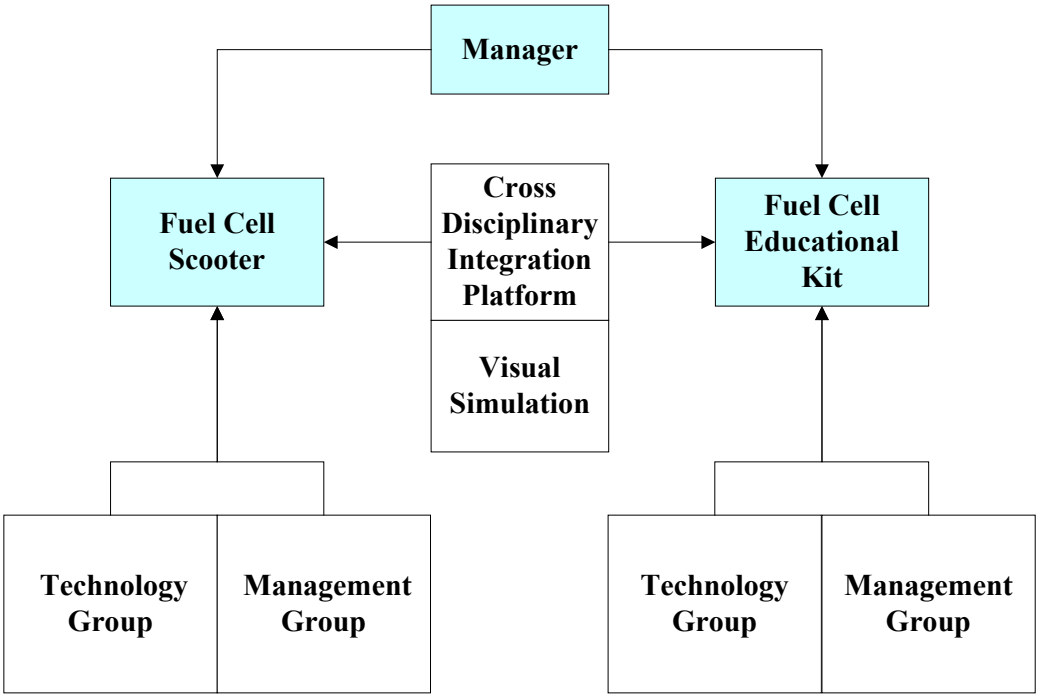

Fig.2 Organization Chart of the Virtual Company

A general manager is chosen by the students as the coordinator for the virtual company. The students were divided into two teams. Each team developed a different fuel cell based products. To promote interdisciplinary cooperation between the students and enhance their ability to run a company, a Cross Disciplinary Integration platform was formed. The mission of this platform was to provide a forum for students to understand the real challenges in the industry. Several industry representatives were invited to conduct 90 minute seminars for these students on different topics(Table 1). These seminars were conducted every two weeks. Some topics related to teamwork and technical experiments were also provided by the participating professors. Upon completion of the seminar session offered by the invited speakers, the students were asked to regularly present their progress till the completion of the products. Another common requirement for both teams is the development of 3D electronic

catalogue, therefore two to three students from each team who took the course of 3D visual simulation and virtual reality form a visual simulation group to take over this mission. Two products were developed in the virtual company, a fuel cell scooter and fuel cell educational kit.

Date	Time	Speaker	Topic
2003/3/26	12:30~14:00	Prof. Chen, Ming-Hui, YZU	Cross-functional Team Management：A Creativity Perspective
2003/4/9	12:30~14:00	Hsu, Ming-Hsi, Project Manager, China Development Industrial Bank	Evaluation of Enterprise Investment
2003/4/23	12:30~14:00	Li, Ying-Cheng, Manager, Asia Pacific Fuel Cell Technology Ltd.	Status and development of Fuel Cell
2003/5/7	12:30~14:00	Prof. Yang, Ta-Chung, YZU	System Diagnosis
2003/5/21	12:30~14:00	TIC-100 Contest Winner, National Chengchi University	TIC-100 Contest Experience Exchange
2003/6/25 ~2003/9/3	12:30~14:00	Team Leaders	Progress Report of Fuel Cell / Educational Kit
2003/9/10	12:30~14:00	Fuel Cell / Educational Kit	Rehearsal of Product Demonstration
2003/10/1	12:30~14:00	Fuel Cell / Educational Kit	Product Demonstration Day

Table.1 Seminar of Virtual Company

（1）Fuel Cell Scooter：

To meet the promise of an efficient, quiet, pollution free vehicle, the students were divided into two groups to develop a fuel cell scooter. The technology group included chassis design, fuel cell stack fabrication, electrical control design, gearshift system, and system test. This technology group was comprised of students from the departments of Mechanical Engineering and Electrical Engineering. All of the group members put great effort into carrying out their fuel cell scooter designs with creativity and perseverance. Once the scooter was completed, students from the visual simulation began their work to design and edit an electronic catalogue. By browsing the electronic catalogue, the customers could easily understand the product functions and evaluate the pros and cons. The management group that mainly formed by the students from business school then proposed the business plan, comprised of a market survey, technology analysis and product outlook.

（2）Fuel Cell Educational Kit：

The mission of the team was to develop an educational kit based on the methanol fuel cell concept that could assist students in elementary and secondary school to understand green technology such as the fuel cell. A new fuel cell stack design with an X shape air-flow system that increases the air-flow capacity and fuel cell efficiency was developed. In addition to the product development, a 3D electronic user manual was developed in which the basic fuel cell concept and the way to conduct a simple methanol fuel cell experiment were illustrated. The management group then proposed the business plan for the fuel cell educational kit. According to their market survey, this educational kit has a great technological advantage in the sector and will have a promising future.

IV. Results

（1）Fuel Cell Scooter

A 200W fuel cell shown was purchased and attached to the scooter. After the testing and analysis procedures were completed, the fuel cell scooter was completed in the laboratory, as shown in Fig.3.

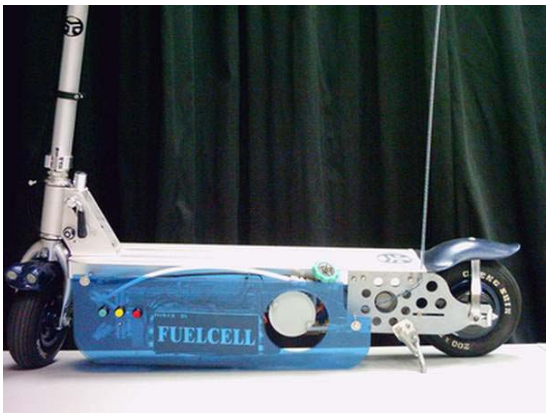

Fig.3 Fuel Cell Scooter

Students in charge of the scooter business plan conducted a market survey at the same time. They completed a comprehensive survey including visiting shops with related products and interviewing managers about the function, price and market value of the scooters they displayed. When they obtained the needed information from the market, they analyzed the cost based on the data provided from the technology group and looked into the potential for the proposed product. A business plan with the

related results and analysis was proposed to solicit the funding for the commercial scooter prototype.

（2）Fuel Cell Educational Kit

Because the educational kit needed only a small voltage fuel cell that could be manufactured at the campus, the students designed an X-shaped fuel cell, as shown in Fig.4, to fit their needs.

Fig.4 X-Shape Fuel Cell

When the fuel cell was completed, students began to construct several appliances to demonstrate fuel cell applications such as the mini fan and electrical motor. The final product is shown in Fig.5.

Fig.5 Fuel Cell Educational Kit

On the other hand, the management group collected feedback from teachers at elementary and secondary schools, and the science education center and asked questions related to the need for a fuel cell educational kit. They then analyzed the

manufacturing cost and benchmark performance with similar products imported from foreign countries.

（3）Course Assessment and Student Evaluation

The course assessment and student evaluation was specifically designed for the modular courses and virtual company to determine how satisfied the students were with regard to the course contents, instructor teaching skill and the virtual company operating infrastructure. The survey results are as follows:

		Agree%	No Comment%	Disagree%
Modular Courses	1. The teaching materials and lesson content in the modular courses are suitable.	73.91	21.7	4.3
	2. The lesson content is satisfactory in both quality and quantity.	82.61	13.04	4.35
	3. The lesson outline was well organized and planned in order to assist students in learning the material.	73.91	21.34	4.35
	4. The teacher explained difficult theories in simple language and followed up with easy to understand examples or teaching materials.	73.91	26.09	0
	5.Totally, the teaching attitude of the teachers in the modular courses is satisfied.	73.91	21.74	4.35
Virtual Company	1.The speech on specific topic arranged by the virtual company assists students in the operation of the company.	91.30	0	8.7
	2.The activities of the virtual company are well planned and helped to improve interaction among the team.	60.88	26.08	13.04
	3.Knowledge and techniques learned from modular courses are useful during the operation of the virtual company.	60.88	26.08	13.04
	4.Virtual company provides chances of integrate and application , and provides platform to exchange idea and helps team work.	73.92	17.38	8.7

	5. Virtual company built a truly environment in Hi-Tech industry to help students from different background to learn the ability of system integrate, and try to promote ability of communicate, coordinate, and business administration.	73.92	13.04	13.04

Table.3 Outcome of Student Evaluation

In the modular courses, 73.91% of the students agreed that the teaching material content used in the course were suitable, 21.7% had no comment and 4.3% felt disagreed. This result showed that the teaching materials used in the courses were suitable and appropriate to the students' needs. The survey results on the course content showed that 82.61% of the students agreed that the course outline was well organized and planned in such a way that helped the students learn the related topics. In teaching performance, 73.91% of the students agreed that the teacher always explained difficult theories in simple terms and sometimes followed up with examples or teaching materials to help student understanding. 73.91% of the students agreed that the teacher's attitude was satisfactory, 21.74% had no comment and 4.35% disagreed with that.

For the virtual company, 91.30% felt that the seminar on specific topics arranged by the cross disciplinary integration group assisted the students in operating the company, while 8.7% disagreed. This result showed that 60.88% agreed that the virtual company activities were well planned and helped to improve team interaction, while 26.08% had no comment and 13.04% disagreed with the activity schedule. 60.88% said that the knowledge and techniques learned from modular courses were useful in operating the virtual company. This result is related to the students' frequency in taking part in the virtual company operation. At the beginning of the program, we planned to create a true industrial environment for the students. The survey showed that we were successful in creating an industrial environment. 73.92% of the students agreed a true industry environment was built to help students from different backgrounds learn systems integration, and helped to promote their ability to communicate, coordinate and manage business. Most of the students agreed that the virtual company provided the chances to apply integration, and a platform to exchange ideas that helped teamwork and entrepreneurship.

Conclusion

A traditional entrepreneurship curriculum might include classes on business instead of product development. Entrepreneurship takes the right combination of inventiveness,, solid business advise, encouragement, and above all, a healthy environment that fosters experimentation. We feel that this trial program was successful on several fronts. The students became excited about fuel cell technology and the potential benefits of a fuel cell product. This program gave the students a true sense of what it means to work in interdisciplinary teams to design complex functioning systems. We feel that this program provides undergraduate students with the chance to participate in operating a real company. The students gained valuable experience in teamwork, communication skills, project planning, procurement and entrepreneurship. To expand and improve the program, different technologies such as green technology and e-life will be included in the future. We hope that more students from various disciplines will be attracted to entrepreneurship education.

Acknowledgement

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Biography

TZE-CHI, HSU, Ph.D., obtained his degree from Northwestern University in 1991 and then became

an associate professor of Mechanical Engineering Department at Yuan Ze University. He served as Associate Dean of General Education from 1994 to 1995 and Dean of Student Affairs at Yuan Ze University since 1995. He was drafted by the government to become the director general of Department of International Programs of National Science Council on March, 1999. He returned to campus on February, 2001 and is currently a professor of Department of Mechanical Engineering at Yuan Ze University, as well as the Seceretary General of the university. Dr. Hsu's main areas of research include tribology, computational mechanics, experimental mechanics and engineering education. He starts to teach "Introduction of Engineering" from 1994 for the freshmen in the engineering school and intends to offer the course such as " History of Science and Technology " or " Creativity and Engineering " to students whose major are not engineering in the future.

BEE-SHAN, HAN is the research assistant for the Cross Discipline Curriculum of Knowledge Innovation Program at Yuan Ze University. She holds a Degree of Bachelor of Education in Educational Psychology and Counseling from the National Taiwan Normal University in 2002.