GC 2012-5665: INTRODUCTORY TEACHING PLAN OF ELEMENTARY ENGINEERING DESIGN FOR FRESHMEN MAJORING IN CIVIL AND ENVIRONMENTAL ENGINEERING

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Introductory Teaching Plan of Elementary Engineering Design for Freshmen Majoring in Civil and Environmental Engineering

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This study was undertaken to develop a course of elementary engineering design for Korean university students majoring in civil and environmental engineering. The course plan primarily includes learning programs and activities for the creation and the optimization of ideas. Through two independent design projects, students will become acquainted with and practice the core concepts of the course. The design project was based on a survey of Korean university students majoring in civil and environmental engineering. The overall plan is intended to prepare students for success in upper-level major courses.

Keywords: Cement-boat, Civil and Environmental Engineering, Design project, Elementary Engineering design, Toothpick bridge

1. INTRODUCTION

Engineers function as creative problem solvers who improve standards of living. State of the art engineering advances result from interdisciplinary endeavors and creative thinking. Modern, knowledge based society requires engineer to not only be experts in their areas of specialization, but also competent team workers who communicate well with others for creative problem solving. (Burghardt, 1999) Fundamental abilities underlying creativity include professional knowledge about engineering design, responsibility, good teamwork, high ethical standards, and lifelong study. Many universities have developed generic introductory courses designed to foster creativity. However, courses that are not tailored to the characteristics of different majors may actually have detrimental effects on originality and hinder student curiosity.

This paper suggests a course plan in elementary engineering design for Korean university freshmen majoring in civil and environmental engineering. The course primarily focuses on creative problem solving and consists of four parts. (Fobes, 1993). First, we present a general introduction to engineering, including qualifications and responsibilities, teamwork, and basic economic design. Problem definition, visualization of ideas, and concept design are emphasized during the second part of the course. The third part emphasizes creativity, idea generation and selection. (Higgins, 1994) Finally, the course discusses engineering ethics, as well as environmentally friendly and sustainable design. Students conduct two projects during the semester that illustrate the basic concepts and materials required of civil and environmental engineering.

2. CONTENTS AND PRACTICAL EXERCISE

Before designing the course, we conducted an extensive survey of over 150 professional engineers. (Wankat, and Oreovicz, 1993) The questionnaires explored important functions of engineers including planning, teamwork, and communication. One notable finding of survey was that professional engineers did not consider knowledge of civil and

environmental engineering to be a top priority.

The course plan described in this paper is intended for use as a core course for Korean university freshmen majoring in civil and environmental engineering. Incorporating the results of survey in the course plan is a good example of customer needs-based course development, and could therefore be helpful for engineering students who would acquire abilities that would make them attractive as potential employees.

The course is one semester long. Table 1 summarizes the main contents of the course and practical activities that help students to understand the course. Course materials were prepared before the beginning of the semester. Table 2 shows the grading policy used in the course.

Table 1 Course content and assignments

Contents	Activities	Homework
Introduction/Team	Team membering/ Meeting	Minutes
Team work		Project #1
Communication	30 second message	Video Clip analysis
Problem definition	Problem definition statement	Manual investigation
Idea creation	Brainstorming and other methods (Mchalko, 1991)	Problem resolution
Creative problem solving	Ranking methods	Project #2
TRIZ	Inconsistency	
Eco-Design, Engineering ethics		

Based on data from the National Statistical Office of Korea, the average Korean adult reads one book per month, and over 24 percent of the Korean population does not read books. Most Korean adults spend their weekends watching TV, using the Internet, and using iPhones for about 4 hours. However, they invest only 8 minutes per weekend reading, including newspaper reading. Andre Gide once wrote, “I took out one book from the bookshelf and I read. And I put that book back. Now, I am not whom I was”. As an essential source for creative thinking, reading plays the same role as water the plants. It is impossible to over-stress the importance of book reading for creative thinking. Therefore, students are required to read three books during the semester and submit a critique of each. Even if three books reading during a semester does not affect creative thinking greatly, it may broaden student thought and reading practice.

Team size should not exceed four members, and each team must have a unique name representing its goal or hopes. During the four years that the author has offered the course, there have been approximately 40 teams with unique and different team names. After each team was formed and named, a team member was responsible for presenting the team members during class, and the presentation was recorded on video including PowerPoint materials. After of the lectures concentrating on communication skills, each team was responsible for revising its introduction and presenting its members and materials again. Each team was required to submit a report regarding the video clips (Davis, 2001) before and after. Students were encouraged to establish course websites and to record formal minutes for each team meeting. Examples are shown in Figure 1 and 2.

Table 2 Grading policy

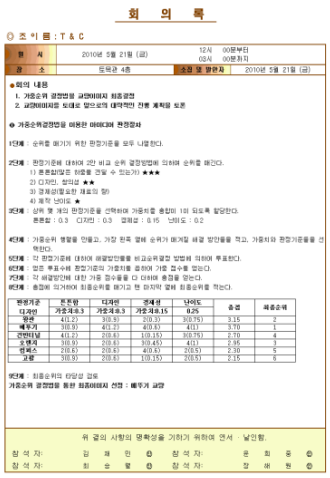
Item	Weight(%)	Note
Attendance	5	Individual
Activities and Homework(including Portfolio)	15	Team
Project #1 & 2	30	
Exam and Quiz	30	Individual
Criticism after reading	10	
Peer evaluation	10	

Figure 1. Example of website

3. TEAM PROJECTS

Two team projects were required during each semester. The project topics were selected through surveys (Friedman, 1991) of over 300 students majoring in civil and environmental engineering that asked, ”What is the first thing that comes to mind when you think of civil and environmental engineering?” The most common answers were “cement,” “bridge,” “soil,” “wood,” and “river,” respectively. These items were then incorporated in two projects, one the construction of a cement-boat, and the other the construction of a toothpick-bridge. The cement boat project allowed students to practice

basic concepts such as buoyancy, cementation of materials, concept design, and visualization of abstract ideas. Students were required to use only intuition to complete projects. Restrictions included the volume of the boat (500 cm^3) and the use of only two materials (cement and sand). Figure 3 shows an example of a project in process. Several products and cement-boat racing are shown in Figure 4.



회 의 록

○ 조 이 름 : T & C

일 시	2010년 5월 21일 (금)	12시 00분부터 03시 00분까지	
장 소	도목관 4층	소집 및 담관자	2010년 5월 21일 (금)

●회의 내용

1. 가중순위 결정법을 교면바이저 최종결정
2. 교면바이저를 도대로 많으로의 대략적인 진행 계획을 도표

◆ 가중순위결정법을 이용한 바이저의 최종결과

1단계 : 순위를 매기기 위한 판정기준을 모두 나열한다.

2단계 : 판정기준에 대하여 2인 비교 순위 결정방법에 의하여 순위를 매긴다.
1) 튼튼함(많은 하중을 견딜 수 있는가) ★★★
2) 디자인, 심미성 ★★
3) 경제성(필요한 재료의 양)
4) 제작 난이도 ★

3단계 : 상위 몇 개의 판정기준을 선택하여 가중치를 충전히 1의 되도록 할당한다.
튼튼함 : 0.3 디자인 : 0.3 경제성 : 0.15 난이도 : 0.2

4단계 : 가중순위 행렬을 만들고, 가장 좌측 열에 순위가 매겨질 배열 방안들을 적고, 가중치와 판정기준들을 선택한다.

5단계 : 각 판정기준에 대하여 배열방안들을 비교순위결정 방법에 의하여 부표한다.

6단계 : 앞은 부표수에 판정기준의 가중치를 곱하여 가중 점수를 얻는다.

7단계 : 각 배열방안에 대한 가중 점수들을 다 더하여 총점을 얻는다.

8단계 : 총점에 따라에서 최종순위를 매기고 한 마지막 열에 최종순위를 적는다.

판정기준 디자인	튼튼함 가중치:0.3	디자인 가중치:0.3	경제성 가중치:0.15	난이도 0.25	총점	최종순위
원판	4(1.2)	3(0.9)	2(0.3)	3(0.75)	3.15	2
배두기	3(0.9)	4(1.2)	4(0.6)	4(1)	3.70	1
곤면바이저	4(1.2)	2(0.6)	1(0.15)	3(0.75)	2.70	4
오뚜기	3(0.9)	2(0.6)	3(0.45)	4(1)	2.95	3
캡퍼스	2(0.6)	2(0.6)	4(0.6)	2(0.5)	2.30	5
고깔	3(0.9)	2(0.6)	1(0.15)	2(0.5)	2.15	6

9단계 : 최종순위의 타당성 검토

가중순위 결정법을 통한 교면바이저 선정 : 배두기 교깔

위 결의 사항의 명확성을 기하기 위하여 연서 · 날인함.

참 석 자: 김 재 민 ㊞ 참 석 자: 문 희 중 ㊞

참 석 자: 최 승 봉 ㊞ 참 석 자: 장 세 원 ㊞

Figure 2. Minutes for regular team meetings

Figure 3. Project #1

Figure 4. Project #1 and boat racing tournament

By the middle of each semester, the students had learned most of the class content. Students were required to apply methods for engineering design such as idea creation and selection, visualization, and sketching, rather than intuition, to complete Project #2, the construction of a toothpick bridge. Students were asked to design a bridge 30 cm in length using only toothpicks and thread. The bridges were tested for maximum load resistance. Figure 5 shows the bridge design process, and Figure 6 shows some examples of finished projects. Students learned basic mechanical concepts and the behaviors of materials including wood, cement, string, sand, and water, which are essential subjects addressed in upper level courses. The teamwork involved in completing projects helped students to absorb information about conflict resolution, communications skill, processes from concept to product, economic use of material, and load resistance.

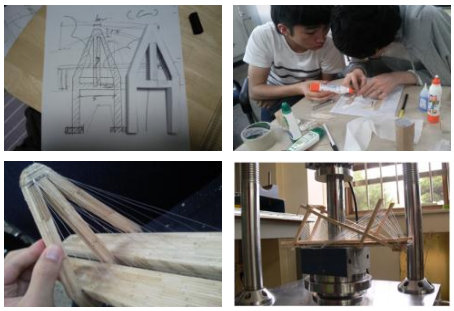


Figure 5. Process for Project #2

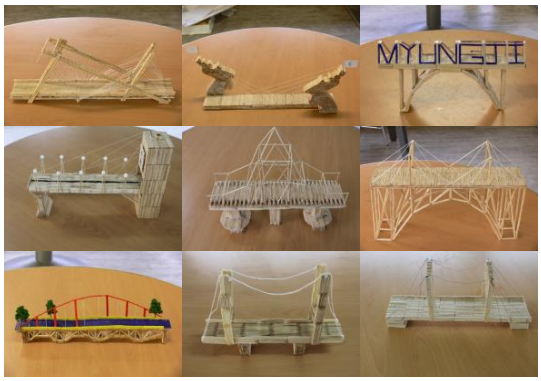


Figure 6. Examples of Project #2

4. CONCLUSION

This paper summarizes the development of a course in introductory engineering design for Korean university freshmen. The class addressed idea generation, decision making, communication, teamwork, eco-design, and engineering ethics, and required the completion of two major projects. The

contents of the course and the projects were selected based on the results of surveys of professional civil and environmental engineers. The projects were designed to provide preliminary experience with core concepts of civil and environmental engineering. The course was intended mainly to help students acquire the fundamental skills necessary to prepare them for upper-level major courses in civil and environmental engineering.

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