BRIDGING THE GAP AND PREPARING FOR ENGINEERING

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Abstract

This paper presents the experience obtained from the 1992 summer program. Twenty-three female high school students participated. A laboratory demonstration course provided them with a comprehensive understanding of engineering disciplines. A design course introduced the product development cycle in engineering through a project approach. Applying the knowledge gained from the classroom, they designed a porch glider, then manufactured or procured the glider's components, and finally assembled them. During the six-week program, they were highly motivated and enthusiastic in learning engineering fundamentals and developing critical thinking skills. They experienced college life and gained confidence in choosing careers in science and engineering.

I. Introduction

The world is witnessing dramatic changes in technology. There is a pressing need in this country to develop a technically skilled, globally competitive work force. Although such need demands a strong education in science, mathematics, and engineering principles, few high school students are prepared for or even interested in those areas or careers. Therefore, there is a gap between the high school training and the college education. We need to demonstrate to high school students that science and mathematics are not abstract, but rather they can be interesting, challenging, enjoyable, and relevant to their careers. It has been a well-known fact that women are still under represented in science and engineering.

Recognizing the strategic need to reach this pool of talent, the University of Maryland offers the summer study in engineering program to female high school students[1-3]. Every year, high school women, after the completion of their junior year, enroll at the College Park campus. During a six-week period, they take two engineering courses and earn six credit hours. In the 1991 Summer Program, we successfully introduced engineering design to the participating students in the Introductory Engineering Science course[3]. Through a project approach, they applied what they had learned to a real product design process. By actually building a seesaw, they were exposed to a product development cycle and gained important hands on experience. In the 1992 Summer Program, we enhanced the project approach and let the participating students design and build a porch glider. Furthermore, we reformed the second course - The World of Engineering. Six laboratory demonstrations were included to create a unique environment for the students to learn various engineering disciplines. By gaining a comprehensive understanding of "What is engineering?" and "What does an engineer do?", they bridged the gap and were prepared for science and engineering careers.

In this paper, we present our experience from teaching the 1992 Summer Study in Engineering program. In section 2, we outline the program structure and major activities with emphasis on the improvement in offering laboratory demonstrations. In section 3, we present our observations, the results from the student evaluations, and the responses from their parents. Section 4 summarizes our work.

II. Program Structure and Major Activities

In order to attract young and intelligent high school women to science and engineering, special concerns that affect them must be recognized and a structure dealing with these concerns must be developed. Effective teaching methods should be used to motivate them and provide them with a stimulating experience in engineering[4-5].

2.1 The Need

From our observations, lack of knowledge about engineering and lack of confidence in their ability to succeed are two major concerns among female high school students. The following paragraphs are taken from their essays written on the first day of the summer program.

> "One of the purposes of high school is to get students acquainted with various subjects so that they will be aware of all the possibilities surrounding them when they choose a career. Unfortunately, many women students, who graduate from high school, know little or nothing about the engineering field. After taking many challenging classes in high school, I am least familiar with the engineering field. My math class is the only class which is closest to the engineering in particular. My parents are both electrical engineers. Many times I tried asking my parents what exactly they do at work. They would go into these long, technical explanations about the designs of their latest projects. I would end up being more confused than ever. I am in this program, so that I can be offered information about engineering simply enough for a high school student to understand."

> "My expectations of this program are great, yet obtainable. I hope to be able to narrow down or even choose the field of engineering I plan to pursue. I hope that this class will be able to challenge me intellectually and stimulate my interest. I hope to gain more experience and expand my knowledge about computers. I expect to be able to work with various people on different projects, at the same time be able to get a taste of what college life is. Hopefully in the next six weeks I will be able to accomplish all my goals, yet still have a fun time."

2.2 Program Structure

Figure 1 illustrates the program structure of the 1992 summer program. It consisted of two engineering courses and a set of social activities. A faculty member taught the Introductory Engineering Science course. A graduate student was assigned to coordinate the lab demonstrations in the World of Engineering course and grade the lab reports. Two staff members of the Dean's Office were in charge of organizing field trips, seminars, and social activities. On the first day of the six-week program, the Associate Dean gave a welcome speech and student advisors presented an orientation outlining college life with a campus tour. A program evaluation was conducted on the last day of the six-week program, with a farewell luncheon.

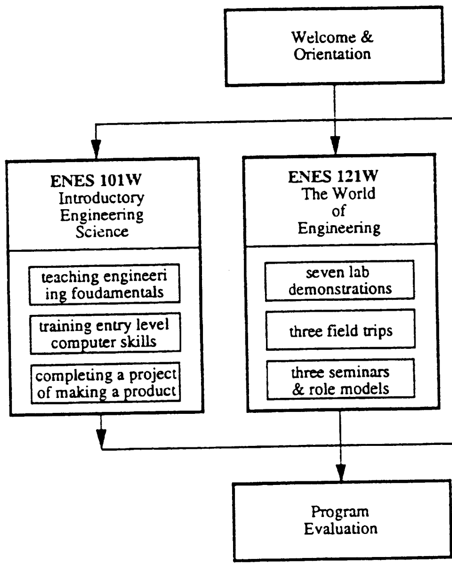
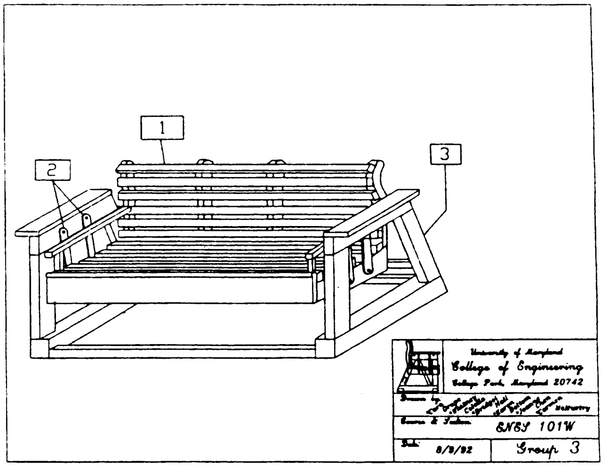


Figure 1 1992 Summer Program Structure and Major Activities

2.3 Major Activities

Major activities during the six weeks are listed in Fig. 1. The Introductory Engineering course was arranged on Mondays, Wednesdays, and Fridays. The World of Engineering course was arranged on Tuesdays and Thursdays. On a 40 hours/week teaching schedule, a distribution of 22.5, 15, and 2.5 hours for the three components was made.

In the summer program, the Introductory Engineering course serves as the core because we teach engineering fundamentals and entry level computer skills in word processing and graphics. By using a product-driven approach, we encourage them to apply what they are learning to what they are making. Such a dynamic learning process provides an engineering design experience which is crystal clear to them[6]. In the 1992 summer program, the selected product was a porch glider, requiring twenty to thirty parts to make it. A process from design, to manufacturing/procure, to assembly and testing within six weeks represented a real challenge to the students. To our surprise and satisfaction, they relied on their team efforts, went through each stage of the product development cycle by overcoming one difficulty and another, and accomplished their goal by presenting four porch gliders, each with unique style. Figure 2a illustrates an assembly drawing of one of the designed porch gliders. Figure 2b presents a scene of team work during the glider assembly.



(a) Assembly Drawing of a Designed Porch Gilder

(b) Working Together as a Team

Figure 2 Design, Manufacturing, and Assembly of a Gilder Product

In the World of Engineering course, lab demonstrations covered mechanical, chemical, biomedical, fire protection, nuclear, civil, and electrical engineering fields. The participating students were required to hand in lab reports which were then graded. Field trips included the National Institute of Standards and Technology (a government research institution), GM Minivan Manufacturing Plant at Baltimore, and Parkway Waste Water Treatment Plant. We organized the participating students to meet on-campus women engineering students. We invited off-campus women engineers serving as role models to present seminars. Through these channels, we exposed them to a variety of engineering disciplines and led them, step by step, to understand "What is engineering?" and "What does an engineer do?" For example, the CNC machining lab (part of mechanical engineering lab) required each student to write a computer program and use the program to make a part. The excitement of new technology convinced them that they were learning the skills for tomorrow.

Social activities are important. The process of students interacting among themselves and with instructors is an active learning process and a process to strengthen their personal development. This is especially true for the summer program because summer has been conceptualized as vacation for American teenagers, even for some of parents. To the participating students, coming to college during summer shows their determination and willingness to sacrifice. We organized volleyball games and parties with the high school students in other programs, making sure that they were happy and had a secure learning environment.

III. Responses and Evaluation

As expected, the six-week program kept the students busy. In the morning, they attended classes, learned computer skills, and participated in lab demonstrations. In the afternoon, they did homework and worked on the glider project as a team. They had a true taste of college life. At the conclusion of the summer program, the evaluations showed that they were very satisfied with their achievements. The following paragraphs are taken from their summary reports.

> "This summer I have learned many new and exciting concepts that not only have sparked my interest in engineering, but have made me certain that engineering is the right career choice for me. There are four different aspects about the summer program that I have thoroughly enjoyed. These aspects are the computer learning, class instruction about engineering concepts, team work, and the glider project."

> "I never really believed that we could actually build a glider. Even when we were designing, calculating and making vital decisions. I never understood how it would all magically come together. Using power tools was a completely new experience for me. I learned all about jig saws, band saws, power drills, electric sanding and ratcheting. If my mother knew I had my hands two inches away from high-speed metal drill which can pierce steel, she would keel over. Little did she know I became 'queen of the saber saw.' This has never happened before. My dad was never the handyman type, so I never learned what a ratchet was or how to use one. But now, all of a sudden, I was fiddling with drill bits and sawing two by fours. Before this course, I didn't even know what these things were. We learned from each other. What one person did not know or was not good at would be done or taught by another."

We also received very positive responses from the students' parents. They often called to inform us that their children studied hard at home in the evening and at weekends. They visited the College Park campus to observe what their children were doing, and were deeply impressed by their children's accomplishments. They valued the program highly. Some of them donated their material resources and contributed their time and effort working with the instructor to assure a successful ending. The significant progress made by their children inspired hope in their children for a bright future.

After the summer program, we still keep close contact with the participating students. We also actively assist them in the process of pursuing college education. Upon their request, we send our letters of recommendation to admission offices of universities. By the end of 1992, seven out of the eight students who made early applications have been admitted to engineering programs by universities.

IV. Conclusions

Our experience with the 1992 summer program was extremely favorable. The two engineering courses provided a unique learning environment for the participating woman students to acquire and understand basic engineering concepts. The design project generated enthusiasm which, in turn, motivated them to actively participate in the learning process. They applied what they learned in the classroom to what they needed in the product development. Through team work, they made friends and better understood the social aspects of working together. Such a "real" engineering experience has overcome the gap in preparation for college education and laid the ground work for a future success in science and engineering.

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