Summer Engineering Outreach Program for High School Students: Survey and Analysis

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ACADEMIC POSITION: (2009-Present) Associate Professor for the STEM Affinity Group, School of Natural Sciences and Mathematics, California State University, Bakersfield. Duties included teaching responsibilities in Undergraduate Biology, Graduate Level Science Curriculum, Philosophy, and Issues; Elementary and Secondary Science Methods; Student Teacher Supervision, and Educational Technology. Additional duties included grant writing, management, and evaluation; and university committees.

RESEARCH INTERESTS: Include teaching and learning cognition skills, informal learning environments and strategies, and curriculum design.

Work in Progress: Summer Engineering Outreach Program for High School Students: Survey and Analysis

Abstract

In the academic year 2011-2012, the Department of Electrical and Computer Engineering and Computer Science at the California State University Bakersifled started a summer exploratory program for local high school students interested in Engineering. The main purpose of the workshop was attracting underrepresented minorities and women to the discipline of engineering. This work in progress is supported by Department of Education Minority Science and Engineering Improvement Program (MSEIP), P120A110050. Students engage in a 4-week workshop focused on a diverse set of topics in the disciplines of electrical, electronics, computer, and mechanical engineering. A detailed assessment of participants' attitude and knowledge before and after the program shows that such a short program can be effectively applied to entice the students' interests in the field of engineering.

1 Introduction

In the academic year 2011-2012, the Department of Electrical and Computer Engineering and Computer Science at California State University, Bakersfield (CSUB) started a summer exploratory program for local high school students interested in Engineering. The main purpose of the workshop was attracting underrepresented minorities and women to the discipline of engineering. This work in progress is supported by Department of Education grant Y.

CSUB is situated in a county with low education achievement and below-average income households with poverty rate at 22%. The university is the only 4-year institution within a 100-mile radius. Statistics shows that in 2008, only 33% of incoming freshmen class were prepared to enter college-level English and only 48% were prepared to enter college-level Mathematics. In 2009, 11.9% of high school graduates enroll in a public 4-year institution [1]. In the meanwhile, due to the nature of industries in the area, college engineering graduates are in high demand. There is a strong need to motivate local high school students to pursue studies in engineering. In a national-wide review of STEM outreach programs, Jeffers et al. [2] found the need for STEM outreach programs in the United States to be great. Furthermore, Thompson and Consi [3] concluded that introducing students to engineering, and demonstrating that it can be fun and exciting, is an effective strategy of engineering outreach.

The effectiveness of summer high school science and engineering workshops has been reported in the literature [3–8]. In [4], Anderson et al. found that engineering outreach programs can increase the students' awareness of engineering. In this study, women were the focus participants of the engineering outreach program. There was a significant increase in the interest in pursuing engineering as a career among women participating in the program. In [8], researchers Yilmaz et al. concluded the success of the program is dependent on the quality of the "hands-on nature" of the engineering projects. The diversity of the engineering projects was very important to the success of the outreach program.

The activities at CSUB were modeled behind some of these efforts, while keeping the design in mind with the nature of the local high school students.

The remainder of the paper is organized as follows: Section 2) summer activities; Section 3) analysis of engineering survey results; Section 4) analysis of educational survey results; and Section 5) conclusion.

2 Summary of Activities

The first summer program in 2012 included a 4-week workshop on robotics. This initiative was focused on introducing students to many aspects of robotics and its impact on engineering. The students were given the opportunity to fully assemble a robot and program it through a computer interface. The program was concluded with a robotic arm competition that allowed the students to showcase their skills in front of faculty, staff, and their parents.

In 2012-2013, enhancements were made to the program to include multiple aspects in Engineering. The summer engineering program in 2013 focused on a diverse set of topics in the disciplines of electrical, electronics, computer, and mechanical engineering. The program was divided into four components:

1. The first component provided an introduction to basic electronics with laboratory exercises that focused on the application of electronic components. These laboratories introduced the students to modern engineering measurement equipment, e.g., oscilloscopes, power supplies, and function generators.

2. The second component of the summer project introduced students to different types of combustion engines, e.g., two and four stroke, and diesel engines, hybrid cars, and propulsion systems. The lab component corresponding to this part of the project required the students to assemble a mock-up of a four stroke engine.

3. The third component introduced students to the principles of electromagnetism, transmission lines, and power generation. The students assembled a DC motor and used different measurement equipment to test the input output relationship of a DC motor.

4. The final aspect of the summer program focused on the advancements in the field of robotics. The students assembled and programmed a robot to carry out specific tasks. The program concluded with a robotic competition and celebration that was attended by faculty and students' parents.

3 Analysis of Engineering Survey Results

In this section, we summarize and analyze some of the engineering survey questions and the participants answers. The survey questions were provided to the students prior to the start of the summer engineering program and at the end of the program.

Table 1 summarizes the questions and percentage of the students that answered these questions correctly during the pre- and post-surveys. One can conclude that a percentage higher than 80 indicates that the majority of the students were able to grasp a specific concept correctly. The

Table 1: The results of the engineering survey for the summer program.

Question	% Answered Correctly Pre-survey	% Answered Correctly Post-survey
Engines: Do diesel and gas engines operate the same way with respect to the fuel they use.	46.67%	86.67%
Engines: How does a combustion engine work?	50.00%	85.71%
How does a transistor work?	30.77%	69.23%
How does a diode work?	7.69%	69.23%
Do you know how to use a "breadboard?"	62.50%	93.75%
How does an X-Ray machine work?	38.46%	83.33%
How does an oscilloscope work?	38.46%	72.73%
How do you measure an electric current?	62.50%	78.60%

results in Table 1 clearly indicate that through the span of this three week program, a majority of students were able to grasp a good understanding of many important engineering topics and tools. In fact, a quick comparison of the results between the pre- and post-surveys shows that on average the participants' ability to answer these questions correctly have improved by 38.78%. This may lead us to conclude that many advanced and important topics in fields of engineering and sciences can be taught to students in this age group over a short span of time. This more greatly indicates the importance of education at the K-12 level in ensuring that students have a successful career as scientists and engineers in future.

4 Analysis of Educational Survey Results

The goal of this summer program is to increase the participation of women and minorities in the STEM field. The program was, thus, designed to attract students from these groups. Moreover, the program was designed to encourage students to take part in concurrent enrollment, which allows distinguished students to challenge themselves beyond the highschool curriculum. To this end, the program was designed and executed with many hands-on experiments and site visits to entice the students' interests in the STEM field.

The results of post survey show that, as a whole, the program was very successful at meeting the students' expectations and exceeding it. These results in combination with the results of the engineering survey clearly shows that the program achieved its goals. In fact, 100% students mentioned that they would recommend the program to their peers while 57% of the students mentioned that the program exceeded their expectations. This supports our claim from the previous section that, if designed properly, a densely scheduled and fast paced program in the STEM field can be successfully utilized to educate and entice the students' interests. In fact, the results of this program indicate that this approach can be effectively applied to enhance the participation of minorities and women in the STEM field.

The results in Figs. 1 and 2 indicate that were able to attract a large number of minorities and women to the program. It is noteworthy that although the participation numbers for men exceed

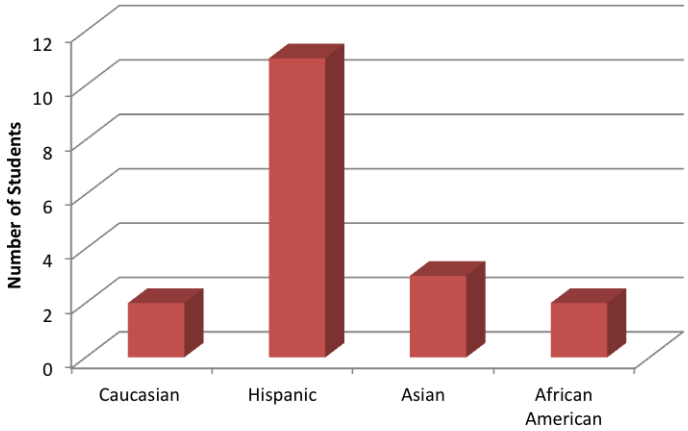

Figure 1: The ethnicity of the participants in the summer engineering program.

the ones for women in the program, they are very close to one another. This is very encouraging since most engineering programs in major universities throughout the nation are dominated by male students, which is contrary to the overall participation of women in higher education. In other words, although there are more women that participate in higher education, the number of women in engineering programs significantly lags that of their male counterparts. Moreover, by

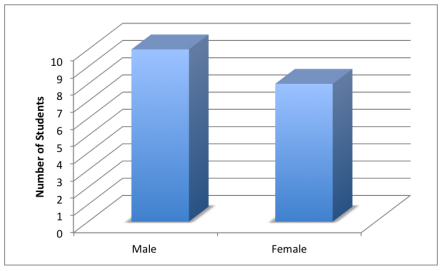

Figure 2: The gender of the participants in the summer engineering program.

combining the survey results in Figs. 1 and 2 with the engineering survey results presented in Section 3, one may conclude that the participation and performance of women and minorities in STEM and engineering as a whole can be significantly enhanced through the adoption and expansion of hands-on programs such as the one that was supported by this summer engineering program grant.

Fig. 3 presents a chart of competency of the participants based on their seniority in high school. Based on the goals of the program, the selection process focused on selecting junior students for the program and this is indicated by the outcome of the survey results in Fig. 3. However, based on the pre and post survey results presented in Section 3, it can be deduced that the process of enticing students to participate in higher education STEM programs can start from an earlier age via the use of hands-on laboratory experiments and exercises related to the field. In fact, based on the feedback received from the main instructor in the course, many younger students that participated in the program showed great enthusiasm for many parts of the project and were able to keep up with their junior and senior counterparts.

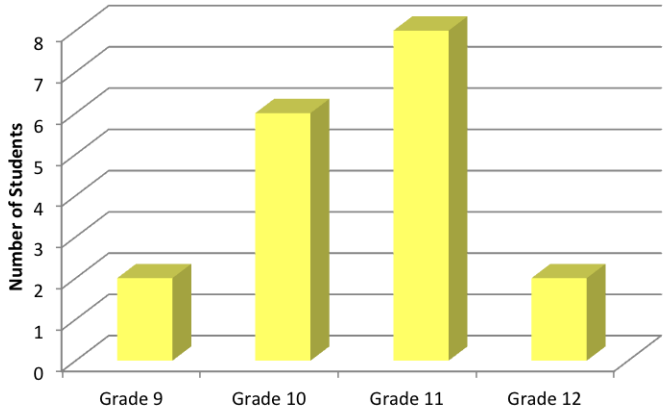

Figure 3: The competency of the participants quantized based on their seniority in high school.

5 Conclusion

In this paper, the outcomes of a summer engineering program for promoting the topics in the field of engineering are investigated. A detailed assessment of participants' attitude and knowledge gained have been conducted and analyzed. The pre and post surveys that were presented to the students indicate that the students have acquired a greater understanding of many topics in the field of engineering. In fact, the survey results indicate that after completing the summer program, students were more enthusiastic about pursuing a career in engineering, which was one of the main goals of this initiative. Moreover, the participants in the program were mainly from underrepresented groups, which furthered the goals of this program and the grant in promoting the discipline of engineering amongst minorities and women.

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