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The Impact of a Summer Institute on High School Students' Perceptions of Engineering and Technology

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Western Michigan University (WMU)'s Summer Institute for Technology, "Design-Engineering-Technology: Enlightened Trial and Error" is a 2-week simulated design engineering program for high school juniors and seniors. The goal of the Summer Institute is to provide students an opportunity to interact with engineering professionals and practitioners in a simulated engineering product design process. This product development process is valuable because it corresponds with the type of interpersonal communication, problem-solving, and conflict resolution skills that leading firms and industry seek from new employees. The specific evaluation goals for this endeavor were as follows: 1) what are participants' beliefs about engineers and engineering and; 2) how have participants' beliefs about engineering as a career changed over the two-week Institute? Pre- and post-surveys were administered to the 36 participants to gather their opinions. Statistical results indicated that the participants' perceptions of engineering were significantly influenced. Furthermore, female participants' perceptions were significantly influenced to consider a career in engineering. Other findings and implications are discussed in the body of the paper.

Introduction

The United States of America is a country that thrives on technological advancement. We have an insatiable appetite for the latest technology and do not mind spending billions of dollars each year to satisfy our yearnings. Unfortunately, we are not as passionate about encouraging our youth to pursue careers in engineering and technology. The gap between the demand for engineers and the supply required by industry is growing and is not being filled by our own talent pool[1]. The problem of attracting students to engineering has been a topic largely debated. The most commonly cited reasons for the void in students is an undeniable image problem[2]

("Engineers are the *guys* who carry pocket protectors and wear black rimed glasses, the guys who love math and science – you know, geeks of the world") and a lack of understanding about what a career in engineering and technology may entail[3]. As stated by Mike Eby[2]: "Most kids worship athletes, rock stars, or actors. Some even look up to fireman, policemen, and doctors. But when was the last time you heard a kid say, "I want to be an engineer when I grow up!""?
It is for these very reasons that WMU's College of Engineering and Applied Science (CEAS) in conjunction with the State of Michigan's Department of Education, and Industry have created a unique Summer Institute for Technology (SIT) designed to energize students about a possible career in engineering or technology.

WMU's Summer Institute for Technology, "Design-Engineering-Technology: Enlightened Trial and Error" is a 2-week simulated engineering product development program for high school juniors and seniors. This SIT is one of 10 Summer Institutes sponsored by the Michigan's Department of Education that has involved over 13,000 students during the last 21 years. The Institutes are intensive learning experiences in the arts, sciences, and technology at colleges and universities throughout the state. The College (CEAS), in partnership with IDEO, a design-engineering firm based in California, and other local industries is in its fourth year of providing an interdisciplinary study program for students that involves various aspects of design process, ergonomics, engineering and technology, and business management. The goal of this SIT is to provide students an opportunity to interact with engineering professionals and practitioners in a simulated engineering product design process. This product development process is valuable because it corresponds with the type of interpersonal communication, problem-solving, and conflict resolution skills that leading firms and industry seek from new employees.

By involving students in an innovative approach to product design and allowing students to experience elements of an engineering design environment, it is thought that their interest in engineering as a future career will increase. Institute students discover how imagination, creativity, technology, and engineering tools combine to turn their ideas into reality. Active learning in a collaborative, discovery-oriented design environment that involves students in a competitive, real-world type of project provides the opportunity for the students to acquire and/or apply multiple talents and skills. The students are constantly challenged during the two weeks as they conceptualize and plan a product, develop models, build prototypes, evaluate and redesign their product, and present a finished product prototype and marketing strategy to the "contracting company" (i.e., industry people, Institute participants and parents).

Participants. Students completing the 10th or 11th grade received Summer Institute application information and materials from their high school guidance counselors. Students interested in the WMU's SIT completed and submitted the application materials, which included nomination and recommendation forms, a listing of relevant coursework that relates to engineering, technology, design or business, a written essay stating their interest, talents, and abilities related to science, arts, and technology. Thirty-six students were selected from the students who submitted applications. Not all of the students indicated strong interest on technology, or engineering and design for that matter. In recognition of the need to diversify the field of engineering, it was decided to have over 50% (actually 53%) of the participants to be from underrepresented groups, mainly female and ethnic minorities.

Instructors. Three professors from CEAS (Department of Industrial and Manufacturing Engineering) led the 2003 Summer Institute for Technology. These faculty members have expertise in industrial engineering, computer-aided design/manufacturing, statistics, optimization, ergonomics, and business management. They also have extensive experience working with high school students and have been involved in the previous three Summer Institutes in one capacity or another. In addition, a design/engineer from IDEO also served as an Institute instructor and other WMU faculty members from CEAS introduced relevant concepts at various sessions during the Institute.

Institute Activities. Students were formed into three design firm teams, each one led by one of the three Institute faculty members. The instructors and counselors formed the teams after observing the participants for a day and a half of activities. The intention was to have as balanced teams as possible in terms of personalities and skills. Each student had ample opportunities to contribute to problem-solving team efforts as they design and develop their product. Students participated in collaborative learning sessions about the design process, data collection from potential customers, and tasks to accomplish their goals that result in the manufacture of their prototype. Recognizing that students need to occasionally take a break from the intensive product design process, the instructional coordinators have also included "design challenges" that allow students to puzzle over a challenging problem for a short period of time. The program also builds in time for the students to interact with each other in peer evening group sessions in order to reflect on the activities of the day, address issues of concern, and focus on a topic of interest for high school students planning to be college students. The program has also included a variety of social and recreational activities, such as museum tours, baseball games, swimming, laser tag, and beach picnics.

Evaluation

In previous years, participants completed an end-of-institute questionnaire that covered topics of interest to the Michigan Department of Education. This statewide survey was adapted to reflect the experiences of WMU's Design SIT, investigating students' perceptions of instructor competency, personal growth in knowledge, interactions with instructors and peers, and their general experience of and reaction to institute activities. In general, the previous questionnaire responses indicated that most of the students had a high degree of satisfaction with what they learned and experienced through their design institute, including the class sessions, special challenge projects, and social activities. Students reported that they enjoyed interacting with peers, their team members, and the faculty. As a result, WMU faculty were confident in their process and their ability to conduct a beneficial SIT that provided students a rich learning experience and positive exposure to engineering.

Other questions that concerned the more intermediate and long-term outcomes of the Summer Institute became the focus of further evaluation. For example, the faculty wanted to know the impact of the Design SIT upon students' choice of college and major field of study. The engineering professors also wanted to know the impact of the SIT upon participants' perceptions of engineering as a profession, their plans to pursue engineering as a career choice, and their perceptions of WMU as a potential school for studying engineering. For this endeavor, the following evaluation questions were posed:

1. *What are participants' beliefs about engineering?*
    - *How have participants' beliefs about engineering changed over the two-week Institute?*
2. *What are participants' beliefs about a career in engineering?*
    - *How have participants' beliefs about engineering as a career changed over the two-week Institute?*

Methodology

A pre/post survey instrument was designed in order to track changes in participants' beliefs about engineering over time, from the beginning of the Institute to the completion of the Institute. Changes in participants' responses may indicate changes in their perceptions about engineering or engineering as a career. Furthermore, the pre-survey contains only a portion of the complete set of attitudinal items (approximately 30 items), while the post-survey contains all items (approximately 40 items). This is to mitigate data contamination through participant memory of items from the pre-survey. Because of the short amount of time incurred between survey administrations, participants may respond to the survey items based on memory rather than actual changes in attitude. New items in the post-survey offer a broader spectrum of data that mitigate the effect of participant memory.

The survey was adapted from an attitudinal survey designed for high school students to assess their beliefs about engineering[4]. The original survey was tested for both reliability and validity through pilot testing and statistical analysis. The survey was modified, however, to add more items about beliefs about engineering and to include items to assess participants' perceptions of engineering as a career. The survey addresses participants' beliefs about engineering, especially perceptions about teamwork, creativity, and sociability in engineering as a field. Although not reported in this paper, the survey also addresses Institute participants' perceptions about the quality of the engineering program at WMU as well as campus life at the university campus, and cultural life in Kalamazoo.

The survey is largely designed as a quantitative evaluation tool[5]. Quantitative survey items are scaled on a six-point scale from Very Strongly Disagree (1) to Very Strongly Agree (6). Survey items were written in both the positive and negative format (e.g., I think…, I do not think…) in order to increase the reliability of the scale. This helps prevent habitual responses from participants who tend to mark the same response for all survey items. Several qualitative, open-ended questions that invite participants to write lengthier responses were also added to give more depth and insight to the quantitative attitudinal data. Open-ended questions in the pre-survey address participants' motivations to attend the Institute and expectations for the Institute while open-ended questions on the post-survey address participants' learning from the Institute and suggestions for improvement.

Results

Table 1 presents the findings (t-tests) of our survey as related to the change in the participants' beliefs about engineers and engineering as well as the participants' change in perception of engineering as a career. From the table it can be said that in general the participants' (as a whole) perceptions of engineers and engineering were significantly influenced in a positive manner. We believe that the image of "the *guys* who carry pocket protectors and wear black rimed glasses, the guys who love math and science – you know, geeks of the world" has been successfully eradicated from the participants. It is felt that the combination of faculty mentoring and the participation of engineering faculty, practitioners, and engineering staff (host undergraduate and graduate engineering students) in non-engineering events has passively allowed students to observe the other side of engineering in a very positive light. Furthermore the student employees[6] who helped us facilitate this Institute were selected because they, as well, were passionate about their impending career choice. It is inevitable that high school students left the Institute excited about the prospects of a career in engineering and college in general. Although the survey did not indicate a significant difference in the pre/post response of the participants' perceptions on engineering as a career, the mean score was 5.1 out of 6.0 and would seem to indicate that a good portion of the group is considering engineering as a career. We are hopeful and are in the process of tracking the participants' progression in higher education.

One of the most exciting findings from the survey was that we were able to significantly influence the female students perceptions of engineers[7], as well as their potential for a career in this area. Besides the insights stated in the last paragraph about mentoring and viewing the human side of engineers, it is believed that our selection of student staff aided greatly in this success. Six out of the ten student facilitators were women in our engineering program, a higher percentage than in the IE program (21%). Inevitably, even though they were only assigned support responsibilities, they became role models and clearly demonstrated effective leadership to all the students. All these issues, coupled with one-on-one mentoring session by all staff members had a positive effect on the participants. In terms of the change in perceptions of the minority population in general we are encouraged. Although the statistics do not discern a statistical improvement, the trends are pointed in the right direction. Undoubtedly, some of these students will pursue careers in this area.

Conclusions

Based on the data presented in this paper, it can be said that the Design SIT at WMU has had a significant positive impact on the perception that high schools students have about engineering. The pre/post surveys indicate that there has been a shift in beliefs and thoughts about a career in engineering. This impact was more pronounced among female participants, which was of great satisfaction for the faculty involved. The long-term effects of the Institute are unknown at this point, however, we are still in the process of tracking final career choices by the participants. Additionally, the program has been recognized as good recruiting tool and funding is being sought to continue it.

Table 1. T-test results (significant: $p \leq 0.10$) for Pre-survey average score versus Post-survey average score, by groups (1: Strongly disagree; 6: strongly agree).

	All Participants	Males only	Females only	Minorities including white females	Minorities excluding white females	Caucasian males only
Perceptions of engineers or engineering						
Engineers spend most of their time doing complex mathematical calculations	Significant (3.9 – 2.5)	Significant (3.8 – 2.3)	Significant (4.1 - 2.8)	Significant (4.22 - 2.8)	Significant (4.3 - 2.9)	Significant (3.6 - 2.2)
Engineers deal primarily with theory	Significant (3.3 - 2.8)	Not Significant (3.2 - 2.8)	Significant (3.6 - 2.7)	Significant (3.5 - 2.8)	Not Significant (3.6 – 3.6)	Not Significant (3.1 - 2.8)
A problem with engineering is that engineers seldom get to do anything practical	Significant (2.3 - 1.7)	Significant (2.2 - 1.5)	Not Significant (2.5 - 2.1)	Not Significant (2.4 - 1.9)	Not Significant (2.5 - 2.1)	Significant (2.2 - 1.5)
Most skills learned in engineering would be useful in everyday life	Significant (4.4 - 4.8)	Not Significant (4.6 - 4.7)	Significant (4.2 - 4.9)	Significant (4.2 - 4.8)	Significant (4.1 - 4.3)	Not Significant (4.7 - 4.8)
Engineers need a great deal of natural ability for science and mathematics	Significant (4.4 - 3.9)	Not Significant (4.3 - 4.0)	Significant (4.6 - 3.7)	Significant (4.7 - 3.7)	Significant (4.9 - 4.0)	Not Significant (4.2 - 4.1)
Engineers spend most of their time working in offices	Not Significant (2.9 - 2.5)	Not Significant (2.7 - 2.5)	Significant (3.3 - 2.6)	Significant (3.1 - 2.4)	Not Significant (2.8 - 2.1)	Not Significant (2.8 - 2.7)
Perceptions of engineering as a career						
Engineering would be a highly interesting career for me	Not Significant (4.9 - 5.1)	Not Significant (5.2 - 5.1)	Significant (4.5 - 5.0)	Significant (4.6 - 5.0)	Not Significant (4.6 - 4.9)	Not Significant (5.2 - 5.1)
A career in engineering would be highly financially rewarding	Significant (4.8 - 5.2)	Not Significant (4.8 - 5.3)	Not Significant (4.9 - 5.1)	Significant (4.9 - 5.1)	Not Significant (5.1 – 5.1)	Significant (4.7 - 5.2)

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Biographies

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