AC 2009-456: RECRUITING DIVERSE STUDENTS TO ENGINEERING CAREER PATHS

Robin Hensel, West Virginia University
Robin A. M. Hensel, Ed.D., is the Assistant Dean for Freshman Experience in the College of Engineering and Mineral Resources at West Virginia University.

Jason Wynne, West Virginia University
Jason Wynne is a senior Mechanical Engineering major in the WVU College of Engineering and Mineral Resources and has assisted with the Engineers of Tomorrow summer camp program as a peer mentor.

Reagan Curtis, West Virginia University
Reagan Curtis, Ph.D., is an Associate Professor of Educational Psychology in the College of Human Resources and Education at West Virginia University.

Gary Winn, West Virginia University
Gary L. Winn, Ph.D., is a Professor in the Industrial and Management Systems Engineering Department at West Virginia University.
Recruiting Diverse Students
to Engineering Career Paths

1.0 Introduction

The need to increase recruitment of minorities into engineering is well documented. The question becomes how best to attract and recruit these students to and retain them in engineering programs. Who or what can best influence the decision-making process of a young minority student?

2.0 Background

In the sections below, the need for increased diversity in engineering is presented, one institution’s actions to meet that need is described, and the model upon which that program was built is explained.

2.1 Need for increased diversity in engineering

“Although researchers and policy makers disagree on the nature and extent of the engineering “shortage” in the United States, few dispute the need to attract capable students, especially girls and certain minorities, into technical careers. Women, African Americans, Hispanics, Native Americans, and some Asian American groups are significantly underrepresented in engineering, based on their proportions in the population at large.”¹ For example, women comprise 50.7% of the U.S. population (2005 est.) and 57.4% of all students enrolled in degree-granting institutions (2004), but are awarded only 20.5% of engineering bachelor’s degrees and make up only 11.0% of the engineering workforce. African Americans comprise 12.8% of the population (2004) and 12.5% of all students enrolled in degree-granting institutions, but are awarded only 5.3% of engineering bachelor’s degrees and make-up only 3.1% of the engineering workforce.² “If current demographic trends continue, by 2050 almost half the U.S. population will be non-white (U.S. Census Bureau, 2002). In the future, engineering solutions will have to be acceptable to this increasingly diverse population, and the engineering profession will have to draw more heavily on underrepresented groups for the country to maintain, let alone increase, its technological capability (NAE, 2004)”¹

2.2 Engineers of Tomorrow

Increasing the number of high school students choosing STEM college paths, and ultimately STEM careers may be one way to attract the kinds of jobs to a region that provide long-term, diversified, economic growth, higher salaries, and subsequently a higher standard of living for local residents. In pursuit of that goal for West Virginia’s residents, West Virginia University's (WVU) College Engineering and Mineral Resources embarked on a multi-intervention plan to attract high school students to STEM careers, and put more STEM graduates into the STEM
career pipeline, with a focus on women and underrepresented minorities. The primary vehicle for this project is a STEP grant through the National Science Foundation (NSF) which supports exactly this kind of initiative.

An important part of the "Engineers of Tomorrow" (EoT) project is mentorship, or peer influence defined loosely as a structured, informal relationship among high school students and engineering undergraduate or graduates for the purpose of sharing information about college life, college courses, career choices, and engineering as a profession. Mentorship channels are interpersonal at the EoT summer camp, for example, but also include virtual communities such as Facebook, special help for engineering students in freshman calculus and physics courses, and special on-line, “bridge courses” to foster interest among high school students in engineering and STEM careers generally before they get to college.

2.3 Social Stress Model

In an effort to provide a sound, research-based foundation for “Engineers of Tomorrow”, the program faculty adapted a well known, robust model of drug and alcohol prevention known as the “Social Stress Model” first mentioned in the psychosocial research by Jason and Rhodes in the 1980s. The social stress model of substance abuse builds upon and integrates knowledge from numerous psychosocial theories and models. According to this theory, the likelihood of an individual engaging in drug abuse is a function of the stress level and extent to which it is offset by stress modifiers such as social networks, social competence, and [social] resources.

The model has been applied in West Virginia among inner-city youth as part of a drug and alcohol awareness program and as part of a helmet use and bicycle safety project. More recently, the same robust model has been used to predict alcohol use among rural adolescents and among Hispanic immigrants. The same slightly modified model of social stressors and moderators which influence vulnerability or decision making is relied upon to predict substance abuse by the World Health Organization’s Programme on Substance Abuse by adding cultural and environmental variables.

The social stress model was used in the Engineers of Tomorrow project because of its: (1) broad acceptance and research base in the US and around the world; (2) adaptability to substance abuse but also other modes of ecological stress encountered by youth (drug abuse, smoking, bicycle and helmet safety, and for our case, the lack of peer models for STEM careers); and (3) ability to explain how youth adapt to their environments and make decisions. In our adaptation, the social stress model suggests that a community by itself, or schools by themselves, or family units by themselves, rarely have the resources, expertise, training or wherewithal to support sound decision making by youth (here, STEM career or college decisions). In impoverished and under-resourced Appalachian communities as well as in many urban centers with large minority communities, the stressors are unique and include poverty, unemployment, lower college completion rates, lower family incomes, higher dependency rates, isolation by geography, and others. We propose that age and culture-matched peers can moderate the stress generators.

Based on this model, social networks, social competencies, and social resources directed at making STEM oriented career choices are used as moderators and prevention methods.
example, among social stressors to youth choosing a STEM career, poverty and low college completion rates would mean that a given youth will have few or no role models (brothers, sisters, uncles, parents, and so forth) to consult with about college living, dorm life, how to select courses, much less STEM or engineering careers. Low family incomes probably mean that a given Appalachian youth has less opportunity to afford college, and with fewer adult role models and community resources, he or she may never learn about scholarships that might be available.

The stressors and moderators which influence career choice in our model are illustrated in Figure 1. Despite the type of stressors (economic, unemployment, low college completion rates, etc.), one type of moderator peer influence, appears to be able to moderate a variety of stresses. The model employed in this research uses peer influence to help youth make informed choices about careers and the value of STEM career choices.

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<thead>
<tr>
<th>Social &amp; Economic Stressors</th>
<th>Moderator Category</th>
<th>Project Interventions</th>
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<tbody>
<tr>
<td>High unemployment</td>
<td>Social Networks</td>
<td>Peer influence</td>
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<td>Low college completion rates</td>
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<td>Web course</td>
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<td>Out-migration of college graduates</td>
<td>Social Competencies</td>
<td>TIME Kits</td>
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<td>Low family income</td>
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<td>Calculus readiness</td>
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<td>Geographic isolation</td>
<td>Social Resources</td>
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<td>Freshman program</td>
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<td>Summer camp</td>
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Figure 1. Suggested Stressors and Stress Moderators for Minority STEM Students (adapted from Winn, et al. 2009).

3.0 Methodology

During the 2008 Engineers of Tomorrow summer engineering camp, a voluntary and IRB approved survey was administered to the student participants. Student responses to relevant questions were collected, compiled, and analyzed (n = 53). The specific questions used are presented below.

3.1 Demographic Description of Population

The survey included general demographic data, including the student’s age, grade in school, race or ethnicity, and gender. Students were also asked if they had a family member who is an engineer, and if so, to list the relationship of that family member to the student (i.e., mother, father, brother, sister, aunt, uncle, etc.). If a student had a relative who is an engineer, that student was asked to estimate how much influence that relative had on the student’s decision to
explore engineering as a career option. Student responses were compiled and are presented in the results section of this paper.

### 3.2 Student preferences for Communication

Student responses were collected on two questions relating to their preferences of the person with whom they would want to communicate in a specific circumstance.

**Question:** When I visit West Virginia University with my family to talk about college, I would prefer to talk to a:
- Male engineering professor (MEP)
- Female engineering professor (FEP)
- Male engineering student (MES)
- Female engineering student (FES)
- Male WVU engineering graduate working in the field (MEG)
- Female WVU engineering graduate working in the field (FEG)

**Question:** If I found myself having trouble with my college courses at WVU, I would prefer to have [help from]:
- Male engineering professor (MEP)
- Female engineering professor (FEP)
- Knowledgeable male engineering student (KMES)
- Knowledgeable female engineering student (KFES)
- Multiple answers (MA)

The data were collected and analyzed, and are presented in the results section of the paper.

### 3.3 Understanding Student Interest in Engineering

Students were queried about their reasons for studying engineering and about what would cause them to be more interested in engineering. Regarding their reasons for studying engineering, students were asked to select as many of the following statements as they believed applied to them. Their responses were tallied and are presented in the results section.

1. I prefer to study engineering because I could help create cleaner fuels as a chemical engineer (ChE)
2. I prefer to study engineering because I could help build safer or faster cars as a mechanical engineer (ME)
3. I prefer to study engineering because I could build robots as an electrical engineer (EE)
4. I prefer to study engineering because I could build robots that help people as an industrial engineer (IE)
5. I prefer to study engineering because I could improve people’s health through biomedical engineering (BioE)
6. I prefer to study engineering because I could build more unmanned airplanes in aerospace engineering (AE)
7. I prefer to study engineering because I could create safer coal mines in mining engineering (MinE)
8. I prefer to study engineering because I could find new sources of oil and gas in petroleum engineering. (PNGE)
9. I prefer to study engineering because I could build faster computers as a computer engineer (CpE)
10. I prefer to study engineering because I could… none of these interest me (None)

Students were also asked a series of statements to determine what perceptions about engineering could help them become more interested in engineering. These statements follow.

1. I believe that I could be even more interested in engineering if it were about improved or safer bridges and buildings.
2. I believe that I could be even more interested in engineering if it were about making people healthier through engineering.
3. I believe that I could be even more interested in engineering if it were about helping poor people get better technical jobs.
4. I believe that I could be even more interested in engineering if it were about making cars and trucks safer if they crash.
5. I believe that I could be even more interested in engineering if it were about preventing terrorism using my engineering skills.
6. I believe that I could be even more interested in engineering if it were about learning to run a company that helped people through engineering.
7. I believe that I could be even more interested in engineering if it were about helping people live longer through engineering.
8. I believe that I could be even more interested in engineering if it were about improving car or home safety for infants and children.
9. I believe that I could be even more interested in engineering if it were about … none of these really interest me.

Students were asked additional questions to learn about their motivation for exploring engineering as a career option. Specifically, they were asked to indicate whether or not the following statements were true about their decision-making process:

1. I am thinking about engineering as a career because I have a family member who is an engineer.
2. I am thinking about engineering as a career because I heard about the high salaries engineers can earn.

The responses to these questions were compiled and analyzed. The data is presented in the results section.
3.4. Student perception of gender differences

The following statements were made and students were asked to indicate their belief about which gender was better at the specific tasks. Response categories included: Girls are much better; Girls are a little better; Neutral; Boys are a little better; or Boys are much better.

The statements to which the students responded were:

1. When it comes to managing my time at college for engineering courses, who is better at it?
2. When it comes to other course work besides engineering, who is better at it?
3. When it comes to doing difficult math, who is better at it?
4. When it comes to math scores on their SAT or ACT, who is better?
5. When it comes to verbal scores on the SAT or ACT, who is better?

3.5 Student percent of the interpersonal contact involved in different careers

Students were asked to indicate their degree of agreement or disagreement with the two statements about the amount of direct interpersonal contact in engineering and in nursing. The specific statements were:

1. I believe that a career field like nursing has more direct contact with people than other fields.
2. I believe that a career field like engineering has more direct contact with people than other fields.

Students responded by indicating one of the following options: Strongly Disagree; Disagree; Neutral; Agree; or Strongly Agree.

4.0 Results and Discussion

The following sections present the summary and analysis of the data collected.

4.1 Demographic Description of Population

Participants in the Engineers of Tomorrow Summer Camp had an average age of 16 and were entering, on average, grade 11 in the fall. As shown in Figure 2, of the 53 students surveyed, 33 (62%) were White/Caucasian, 16 (30%) were African American, 2 (4%) were Asian/Pacific Islander, and 2 (4%) were “Other.” The percent of African American students attending the Engineers of Tomorrow Summer Engineering Camp was significantly higher than the percent of African Americans in the general population of high school students.
Figure 2. Graph of the Engineers of Tomorrow Summer Camp student racial distribution

Figure 3 shows the gender distribution of the students at the Engineers of Tomorrow Summer Engineering Camp. Of the 53 students attending, 22 (42%) were female and 31 (58%) were male. While the percent of female students who attended the camp is higher than the current percent of female students enrolled in engineering undergraduate programs, nationally, it is still somewhat below the representation of female students in the general population of high school students.

The gender distribution of each of the two primary racial categories was analyzed.
When considering only the population of White/Caucasian students who attended the Engineers of Tomorrow summer camp, the percent of males who attended, 73%, was much higher than the percent (27%) of females who attended. This difference is shown in Figure 4.

Within the African American student population, however, the gender distribution was nearly opposite the gender distribution of the White/Caucasian population. As shown in Figure 5, of the African American population who attended the Engineers of Tomorrow summer camp, 25% was male and 75% was female.
Students were also asked if they have a family member who is an engineer. Figure 6 presents the student responses.

![Graph of the percent of students who have a relative who is an engineer.](image)

Most students in the Engineers of Tomorrow program, regardless of race, did not have a family member who is an engineer. While only a few students had a female engineer in the family, no African American students had a female engineer in their immediate family. Engineering female role models are rare, in general, but are extremely rare in the African American population.

Of the students who had family members who are engineers, 72.8% of the Caucasian students and 85.7% of the African American students indicated that the family member influenced their decision to explore engineering as a career option. These data point to the significance of family role models.

**4.2 Student preferences for Communication**

When asked who they would like to talk to about college when they visited a college campus, most of the White/Caucasian students indicated they would prefer to talk to a male engineering professor, while most of the African American students indicated they would prefer to talk to a female engineering student. That data is presented in Figure 7. While there appears to be a difference in preference between races, it could be due to the gender breakdown of the sample. Seventy-five percent (75%) of the African American population was female, and that group indicated a preference to talk with a female student. Seventy-three percent (73%) of the Caucasian population was male and the Caucasian group indicated a preference to talk with a male student. It is possible that the race variation observed is not due to race, but to gender. The data appears to indicate that students tended to want to get advice from both their own race and gender. Both groups, however, preferred to talk to a student over a professor.
The following abbreviations are used in the graph in Figure 7:

- MEP: Male Engineering Professor;
- FEP: Female Engineering Professor;
- MES: Male Engineering Student;
- FES: Female Engineering Student;
- MEG: Male Engineering Graduate working in the field;
- FEG: Female Engineering Graduate working in the field.

There were more females than males in the African American group and the highest percent of the responses of the African American group was the response of talking to a female student. Similarly, there was a higher percent of Caucasian male students than there were Caucasian female students, and the highest percent response for Caucasian students was to talk to a male student. Students appear to want to talk to someone most similar, by gender and age, to themselves.

Another possible reason that African American students indicate they prefer to seek advice from a student is they have not seen any African American engineering professors. Engineering colleges have many Caucasian engineering professors, and very few, if any African American professors. In some schools, the only Black faculty are international; they may be African, but not African American, and therefore, not from a similar background or culture.

Figure 8 displays the student responses to the question about who they would like to present engineering information at their school.
Again, the response of African American students is strongly in favor of having a female present information to a high school audience, whether a female professor, a female engineering student, or a female engineering graduate working in the field. There is also a stronger pattern of favoring a student presenter, over an adult, in general. The response of Caucasian students, strongly favors having a male presenter, and there is even support for the male engineering professor. Again, given the gender disparity in both of these populations, students seem to be indicating that they want someone “like” themselves, in age and gender, to present information to them.

4.3 Student response about their reasons for studying engineering

Figure 9 shows the distribution of student interest in specific engineering disciplines. Students could select as many majors as they wanted. They indicated their interest to the following statements:

1. I prefer to study the engineering because I could help create cleaner fuels as a chemical engineer (ChE)
2. I prefer to study engineering because I could help build safer or faster cars as a mechanical engineer (ME)
3. I prefer to study engineering because I could build robots as an electrical engineer (EE)
4. I prefer to study engineering because I could build robots that help people as an industrial engineer (IE)
5. I prefer to study engineering because I could improve people’s health through biomedical engineering (BioE)
6. I prefer to study engineering because I could build more unmanned airplanes in aerospace engineering (AE)
7. I prefer to study engineering because I could create safer coal mines in mining engineering (MinE)
8. I prefer to study engineering because I could find new sources of oil and gas in petroleum engineering. (PNGE)
9. I prefer to study engineering because I could build faster computers as a computer engineer (CpE)
10. I prefer to study engineering because I could… none of these interest me (None)

Figure 9. Graph of student interest in engineering discipline.

The percent of Caucasian students interested in each major is higher than the percent of African American students interested in each major. The data appears to indicate that a higher percent of Caucasian students show an interest in several engineering disciplines. Perhaps the African American students do not show as much interest because they do not know as much about what each type of engineer does.

Students were also asked if they would be more interested in engineering if it were about …. (a list of items). Students could indicate their interest in or agreement with as many of the statements as they wanted. Figure 10 shows their responses.
The top responses indicated by African Americans are: helping people be healthier (56%), helping people live longer (44%), and helping the poor get better technical jobs (38%). The top three responses indicated by Caucasian students are: helping people be healthier (36%), learning to run a company (36%), and preventing terrorism (33%). While “helping people be healthier” was the top response for both races, the percent of students who indicated that response was higher in the African American population. Again, this result may also be a factor of the predominance of females in the African American population of this study. These results may indicate a gender difference more than a race difference.

Also noteworthy, is the overall distribution of the data. Responses for the Caucasian population are less variable than that of the African American population. Perhaps, this difference is an indication that the African American students know less about what engineers do. These responses indicate that they don’t know that engineers do help people be healthier, help people live longer, and help the poor in a variety of ways.

Students need to learn more about the nature of engineering before they get to the University, but how? Will creating “engineering class” in high school be successful at informing students about the nature of engineering and the variety of career options open to individuals with an engineering degree? To answer this question, at least in part, students were asked what they would like to see to provide them the information they need to make a decision about their future career. Figure 11 shows the student responses to the statement, “To help me make a decision in high school about my future career, I’d like to see this.” The options students could select...
included: (1) a 15-minute lecture at my high school with facts about engineering and WVU; (2) a one-hour lecture at my high school with facts and details about engineering and WVU; (3) a realistic engineering design project at my high school that I can participate in; and (4) Other.

![Activity Preference for Career Information, by Race](image)

Figure 11. Graph of the student responses to the statement, "To help me make a decision in high school about my future career, I'd like to see this."

The data clearly indicates that students, regardless of race, prefer to do realistic design projects to learn about engineering rather than to listen to a presentation about engineering!

The motivation factors of family influence and financial reward cannot be ignored. Twenty-four (24%) of the Caucasian students and 19% of the African American students indicated that they were considering an engineering career because of a family member who is an engineer. As stated above, for those students who have such family influence, it is an effective recruitment to the field of engineering. Unfortunately, our data show that few of these students had family members who were engineers.

An important motivator for the students is the earning potential for engineering professions. Sixty-one (61%) of the Caucasian students and 63% of the African American students indicated that they are considering an engineering career because they have heard about the high salaries that engineers earn.

The data appears to indicate that while high school students do not understand what engineers do or the influence engineers have on society, they do get the message that engineers earn a comfortable living.

4.4. Student perception of gender differences
Students were predominantly neutral on all direct questions about perceived gender differences. Students did not think girls or boys were “better” at time management for engineering coursework, other coursework, doing difficult math, SAT or ACT math scores, or SAT or ACT verbal scores. These students seem to believe, or know they are supposed to believe, that there are no gender differences in these activities.

4.5 Student percent of the interpersonal contact involved in different careers

Using a Likert Scale, students were asked to indicate their level of agreement or disagreement to two statements regarding the amount of direct contact with people that exists in nursing and in engineering. The first statement was: “I believe that a career field like nursing has more direct contact with people than other fields.” Figure 12 shows the student response to this statement.

![Response, by Race, to Nursing & Direct Contact Statement](image)

Figure 12. Student response, by race, to the statement that nursing has more direct contact with people than other fields.

Students of both genders believe that Nursing has more direct contact with people than other fields. A higher percent of African American students agreed with that statement than the Caucasian students.

Figure 13 shows the student response to the statement “I believe that a career field like engineering has more direct contact with people than other fields.”
Caucasian students were either neutral or agreed with the statement that engineering has more direct contact with people than other fields. A much higher percent of African American students were neutral about the statement. This discrepancy may indicate that African American students know less about the nature of an engineering career than Caucasian students.

5.0 Conclusions and Recommendations

Overall, the student responses supported the following conclusions:

(1) Students prefer to hear engineering messages from someone similar to themselves demographically. This conclusion is evidenced in the study by the following results:
   - African American female students (75% of our African American students were female) preferred to hear from and talk to female engineering students about college and career options.
   - Caucasian male students (73% of the Caucasian students in this study were male) preferred to hear from and talk to male engineering students or professors.

(2) Caucasian students may know more about the different engineering careers than African American students. This conclusion is evidenced in the study by the following response differences:
   - Caucasian students showed more interest in each of the engineering majors than African American students.
   - The most popular prospective engineering major selected by both African American and Caucasian students was Mechanical engineering.
   - The second two most popular majors for African American students were BioEngineering and Petroleum and Natural Gas Engineering
Five engineering majors, including Chemical Engineering, Computer Engineering, Industrial Engineering, Aerospace Engineering, and Petroleum and Natural Gas Engineering, were tied for the second most popular major selected by Caucasian students.

(3) Motivation for entering an engineering profession may differ by race and gender. While both African American and Caucasian students in this study agreed on the number one reason that would motivate them to enter an engineering field, the two groups differed on their secondary and tertiary motivational reasons. Both groups (56% of African American students and 36% of Caucasian students) state they would be interested in engineering if it would help people be healthier. Caucasian students also indicated they would be interested in engineering if it would help them run a company (36%) or prevent terrorism (33%), while African American students indicated they would be interested in engineering if it would help people live longer (44%) or help the poor get better technical jobs (38%). Since 75% of the African American students in this study were female and 73% of the Caucasian students in this study were female, the differences in the type of engineering for which each group expressed interest may indicate a gender difference and not a race difference. Further investigation is needed to determine whether or not these differences are due to racial or gender difference.

Overall, students do appear to be more comfortable seeking help from, more willing to listen to, and more influenced by someone who is “like” them in age, gender, and race. The efficacy of the social stress model with its emphasis on using social networks as modifiers, seems to be relevant. Students seem to “hear” the message from younger presenters, who share demographic characteristics with the students.

While the presence of an engineer in one’s family seems to have some influence on whether or not the student considers pursuing a career in engineering, most of the students in our population did not have such a family member. Since currently there are so few minority engineers in the U.S., there are very few minority families who have the positive influence of an engineer. These students must look to others, outside their family, for that influence. They need mentors! For those minority students who have the opportunity to become a mentor, they grow in confidence and develop leadership skills. A perspective on mentoring from an African American undergraduate mentor is provided in the Appendix.

Students, both African American and Caucasian, are motivated to choose a career in which they believe they are helping people. They respond to active, hands on lessons, rather than hour-long lectures about engineering careers. Based on these responses, K-12 recruiting activities need to focus on sending young, college-age students into the K-12 classroom to lead interesting hands-on exercises that illustrate the “helpful” nature of engineering. Young people today are driven by goals of improving their communities and making a difference in the world, as well as by the opportunity to make a comfortable living. Engineers do change the world! To convince a diverse population of young students to enter the field of engineering, we must first convince them of their opportunity to solve significant social, medical, and technological problems, and by doing so, to define the future. That message, delivered by age, race, and gender appropriate, enthusiastic young people, will be heard!
REFERENCES

2 ibid., p.22.

APPENDIX

Personal Experience of Mentoring at WVU
By: Jason Wynne

In high school, I never had a mentorship program that encouraged me to go into engineering. There were programs for sports; there were programs for other academic endeavors but never anything related to engineering. I always knew that I wanted to be an engineer but I never knew why, and in Pittsburgh there weren’t a lot of places to go to cultivate this interest that I had. As a college sophomore, when I found out about the “Engineers of Tomorrow” program, I instantly knew that I wanted to be a part of it. It gave us, as young engineers ourselves, the opportunity to reach out and mentor to young high school students and not only try to re-enforce their interest in engineering, but also as an opportunity to mentor to kids who might be looking for direction in their life. Some of the most rewarding moments of my life have been a result of this program.

I remember working two other jobs in addition to the camp, and when I would get back to the dorms to be with the students, they would sit around me and ask me questions about how I managed working and school, they would ask about my favorite classes and they asked questions about how much I enjoyed working with the EoT program. And they weren’t just asking to be
polite; they generally seemed intrigued by my story. It felt like they looked up to me, and that they wanted a model for how to handle being a college student. One night I had even let them all stay up later because they had been on their best behavior, and we watched a movie. At first I expected them to get out of hand with their new found freedom, but I was pleasantly surprised that they were not only well behaved but also quiet. With a group of twenty-five high school students in one cramped room, silence is the most amazing noise that you could ever hear. After finishing the movie and sending the students to their rooms, I realized something amazing from what had just occurred. I’ve had the opportunity to be something much more than just a counselor or an instructor; I got the chance to be a mentor, I got the chance to be a friend.

**Acknowledgement and Disclaimer:**
“This material is based upon work supported by the National Science Foundation under Grant No. 0525484. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.”