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BOARD # 295: Research Experience for Teachers (RET) site: Helping secondary school teachers promote student interest in engineering using bioengineering examples.

Dr. Prajnaparamita Dhar, The University of Kansas

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NSF Research Experience for Teachers (RET site): Helping secondary school teachers promote student interest in engineering using bioengineering examples.

The undergraduate engineering student population in the US continues to lack significant diversity, with a disproportionally high number of White and Asian males. To build a diverse engineering workforce, it is important to create a pipeline of diverse students who are interested in engineering [1]. The Inquiry Driven Engineering Activities using Bioengineering Examples (IDEA-BioE) project was designed to engage secondary science and mathematics teachers in research focused on biomedical engineering and translate those experiences into modules that teachers can implement in their classrooms.

Surveys show that interest in engineering among pre-college students, especially girls and students from racial and ethnic minority groups, is often low (relative to other STEM fields such as medicine), in part due to students' lack of understanding as to what engineering is. Negative stereotypes of engineers (e.g., as "nerdy" or socially awkward) and low levels of confidence and self-efficacy, particularly among girls, also influence student interest in engineering. This suggests the need for interventions at an early age. However, simply exposing students to engineering design principles is not sufficient to create interest in engineering careers among a broad range of students; interventions must also address social and psychological barriers [2].

We identify two sets of challenges to promoting interest in engineering and engineering careers among K-12 students. First, teachers may not be aware of the scope and specifics of the engineering field. In addition, teachers who are primarily trained in science pedagogy may struggle to incorporate and explain engineering concepts within science courses [3]. Second, students may be disinclined to engage with engineering for a variety of reasons. Students may be unaware of what engineers do [4]. Students may also struggle to see themselves in the engineering field due to racial and gender stereotypes and a lack of role models [5], [6]. In addition, perceptions of engineering as a field that primarily involves working alone, requires brilliance to be successful, and is done by those who are nerdy or socially awkward [7], [8], [9] may negatively impact student interest in engineering.

Our program involved an immersive six-week summer experience for preservice and practicing teachers. Practicing teachers were intentionally recruited from school districts and schools with high social-economic and racial diversity in the student population. Participants were matched with bioengineering-focused research lab experiences from a variety of disciplines including chemistry, chemical engineering, and mechanical engineering. While teachers were working on their assigned research projects, the final deliverable was development of modules for implementation in their classrooms. To aid in module development, the teachers also attended module development workshops that addressed engineering design, next generation science

standards, best practices for lesson design, and relevant educational psychology concepts (e.g., growth mindset, occupational values, STEM anxiety).

Following the completion of the program, teachers implement the modules in their classrooms. Survey data from the participating teachers' students was analyzed for this work. The participating students were in grades 6, 7, 8, and 11 and ranged in age from 10 – 17. At pre-intervention, 186 students were recruited, 2 declined participation, and 9 agreed to participate but did not complete the survey, for a final sample of 175 students. At post-intervention, 196 students were recruited and 5 declined participation, for a final sample of 191 students.

Measures: The student survey included two parts. The first part included a series of three open-ended questions: (1) What is engineering?, (2) What do you think a typical day at work is like for an engineer?, and (3) What kind of person do you picture when you picture an engineer?. The second part was a 16-item attitude measure designed to measure student perceptions of engineering and engineering careers, including both positive (e.g., engineers help people) and negative (e.g., engineers cause harm to the environment) attitudes.

Results:

Results from the open-ended questions showed that students' understanding of engineering was more complex and more accurate from pre- to post-intervention. For example, students were more likely to mention problem solving as an aspect of engineering after exposure to the lesson module (e.g., "engineering is how to build things to solve problems", "engineering is the use of science and math to problem solve"). Similarly, students were more likely to mention helping others or making the world better as an aspect of engineering after exposure to the lesson module (e.g., "you invent things that make life easier for other people", "I think it's making the world a better place like water filtration"). Students' post-module definitions of engineering also reflected knowledge of engineering design principles (e.g., "creating something and testing your creation", "making things better and redoing things over and over", "making a plan and making it better", "the process of how things are made, like testing and improving").

Results from the attitude survey indicated statistically significant increases in scores on the following attitude items:

Item	Results	p values
When I grow up, I would like to have a job that uses engineering	$F(1, 357) = 10.41$	$p = .001$
I am good at engineering	$F(1, 355) = 17.76$	$p < .001$
Everyone uses engineering, not just engineering experts	$F(1, 356) = 14.46$	$p < .001$
Engineering helps make life better	$F(1, 354) = 4.08$	$p = .044$

People who look like me use engineering	$F(1, 354) = 12.16$	$p < .001$

Together, our post-implementation survey results demonstrate the effectiveness of our RET program. Given that the participating teachers were recruited from schools with high racial and socioeconomic diversity, we believe that this program will also help establish new pipelines for student recruitment.

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