

WIP: Investigating Teachers' Perceptions of Engineering Majors

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Abstract— This research-to-practice WIP paper describes developing a survey instrument for assessing teachers' perceptions on the differences among engineering majors and careers. Studies have shown that teachers can influence their students' career choices. Several reasons that can potentially influence students to select engineering as a college major and to pursue one engineering field over another. There is a lack of existing studies that examine teachers' perceptions of engineering majors. While teachers may have some views about engineering, it is not clear if they know the differences between engineering majors and careers.

This study is motivated by the need for engineers in the area of chip design and manufacturing. The world has faced a global chip shortage problem. While this problem is slowly subsiding, semiconductor companies are facing a major problem due to the shortage of electrical engineers. There is a need for electrical engineers to design, fabricate and test computer chips. It is also estimated that over seven thousand electrical engineers are needed to replace the retiring workforce. This problem should be alarming because enrollments are either declining or growing at a slow pace for electrical engineering majors.

This study will help us better understand teachers' perceptions of the differences between engineering majors and careers. The findings of the study have the potential to help engineering departments market their electrical engineering programs to teachers and high school students more effectively.

Keywords— *Engineering education, teachers' perceptions; electrical/electronics engineers, engineering majors*

I. INTRODUCTION

For developed nations to remain competitive in engineering and technology, they must produce and keep science, technology, engineering, and mathematics (STEM) talent. According to report published by the U.S. President's Council of Advisors on Science and Technology (PCAST) [1], the STEM proportion of all university undergraduate degrees has been decreasing in the United States in the last decade. To meet the projected economic needs for STEM professionals, the

number of students graduating with STEM degrees in the United States will need to increase by 34% each year.

The world is experiencing a global chip shortage. While the problem is slowly subsiding, semiconductor companies are facing a major problem because of the shortage of electrical engineers. This problem hinders the growth of the semiconductor industry. Electrical engineers are needed to design, build, and test computer chips. For instance, Samsung is planning to build a \$17 billion chip plant in Texas. The plant is expected to open in 2024 and will need to fill over 2,000 high-tech positions. To address the manufacturing technical challenges and workforce shortages, Intel has announced that it has committed \$100 million investment to support semiconductor manufacturing education and research across the U.S.

It is estimated that 45% of engineers working in U.S. electrical utilities will be retiring in the next five years. This translates to over 7,000 electric power engineers needed in the U.S. electric utility industries. Enrolments are either declining or not growing at a needed pace for a number engineering majors in general. For instance, within our College of Engineering, we see a slow enrolment growth in electrical and computer engineering.

A student's choice of an engineering major can be influenced by many factors. Based on our experience conducting STEM professional development programs for teachers, we know that teachers influence student learning and interest in a STEM subject. In this paper, we review and survey studies that examine teachers' perceptions of engineering education and careers. We also look at studies that examine students' perceptions of engineering and engineering majors.

We provide the rationale behind the need for studies that examine teachers' perceptions on the differences between engineering majors and careers. This study is intended to help engineering departments market their engineering programs to teachers and high school students more effectively. The findings of this study will help recommend for developing targeted outreach and strategies for designing professional development programs for teachers to explain the differences between the engineering majors and the various engineering career paths.

II. EXISTING STUDIES ON PERCEPTIONS OF ENGINEERING

Several studies examined the perceptions of teachers and pre-college Students' Perceptions of Engineering. Summaries of those studies are presented next.

A. Pre-College Students' Perceptions of Engineering.

While there has been improved understanding among elementary students of engineering and science [2], some studies that examined pre-college students' understanding of what engineers do, have found that there are still misconceptions of the understanding of the role of engineers [3] and the lack of connections between design experiences in the classroom and the work of professional engineers [4, 5]. This suggests that much educational effort is needed to help students understand what engineers do through engineering camps [6], and develop special curriculum that helps bring an understanding of engineering [7, 8]. With the lack of understanding of the various engineering fields and careers, pre-college students may not be excited to select engineering as their major in college or pursue an engineering major that does not suit their career aspirations.

B. Teachers' Perceptions of Engineering

Teachers are the single most important factor affecting student achievement and can play an integral role in promoting students' interest in engineering [9]. Several studies have looked at teachers' perceptions of engineering education and engineering careers [10, 11]. Several models of teacher professional development programs have been reported along with the evidence of the degree of their effectiveness in promoting student interest in engineering [9, 12-17]. These professional development programs are designed to increase teachers' content knowledge of engineering and its applications to math and science. In addition to professional development, attempts to change and promote teachers' awareness of engineering, design curricula have been introduced in the classroom [18].

Existing studies examined teachers' perceptions of engineering [9-17]. However, there is a lack of research that examines teachers' perceptions of the differences between the engineering fields (that is, electrical engineering, computer engineering, chemical engineering, industrial and manufacturing engineering, civil engineering, etc.).

III. STUDY SIGNIFICANCE AND IMPLICATIONS FOR PRACTICE

A. Study Motivation and Significance

Several factors can potentially influence students to select engineering as a college major and to choose to pursue one engineering field over another. While teachers may have some views about engineering, it is not clear if they know the differences between the engineering majors and what career paths they can lead. For instance, a misconception about electrical engineers is they either install electric wires or are responsible of electrical power.

Based on the review of the existing literature, it is critical to conduct a study that examines the link between teacher's perceptions of the different types of engineering majors and engineering careers and student interest and motivation in pursuing a specific engineering major. The study should answer the following question:

- Do teachers' perceptions of engineering majors could influence what their students select as their undergraduate engineering major to pursue?

B. Study Implications for Practice

This study will help us better understand teachers' perceptions of the differences between engineering majors and careers and the extent to which they can influence their students in their selections of what undergraduate engineering major to pursue. The findings of the study would help engineering departments market their engineering programs to teachers and high school students more effectively. The findings of this study will help recommend for developing targeted outreach and strategies for designing professional development programs for teachers to explain the differences between the engineering majors and the various engineering career paths.

IV. SURVEY DEVELOPMENT

A. Survey Questions

We developed a survey instrument to explore the reasons that influence teachers' perceptions of engineering, engineering majors, and engineering career. The survey questions are designed to measure the degree to which teachers differentiate between engineering majors and their awareness of possible career paths for electrical engineering graduates. In our survey development, we use a factor analysis approach which is a statistical technique that groups questions that correlated into a small number of factors [19]. Factor analysis is helpful in exploring or confirming the relationships between survey questions [19]. We organized the survey questions under factors that include college outlook and education, job opportunities, job satisfaction and earnings, and underrepresented minorities and gender stereotypes in engineering. The survey asks teachers to rate their answers for all the engineering majors offered by our college: electrical engineering, computer engineering, civil engineering, mechanical engineering, and manufacturing engineering.

1) Background Questions:

The first section of the survey instrument contains the following background questions about the teachers:

- What subject do you mainly teach?
- How many years have you been teaching?
- What grade level do you mainly teach?
- Have you been to any teaching workshops related to engineering?

2) Survey Factors

The survey questions use the 5-point Likert scale consisting of: (1) Strongly Disagree; (2) Disagree; (3) Neither Agree nor Disagree; (4) Agree; (5) Strongly Agree. The majors considered in the questions are: electrical engineering, computer engineering, civil engineering, mechanical engineering, and manufacturing engineering.

a) Factor 1: College Outlook and Education

This factor includes the following questions:

- The admission requirements for a ____ program are very competitive
- There are plenty of scholarship opportunities available for ____ majors
- It takes a long time to complete an undergraduate degree in ____
- The curriculum for these majors has very challenging courses

b) Factor 2: Job Opportunities and Professional Experience

This factor includes the following questions:

- There are plenty of internship opportunities for majors in ____
- There is plenty of demand for graduates with degrees in ____
- There is a wide range of career options available in ____

c) Factor 3: Job Satisfaction and Earnings

This factor includes the following questions:

- A career in ____ earns good money.
- There is a great job security in ____
- Job satisfaction is high in...
- There is an opportunity to advance in a ____ career

d) Factor 4: Underrepresented Minorities and Gender Stereotypes in Engineering

Questions under Factor 4 aim to explore teachers' perceptions of the abilities of minorities and women to succeed in a specific engineering field. This factor includes the following questions:

- Male students are likely to succeed in earning a degree in ____
- Female students are likely to succeed in earning a degree in ____
- Minorities are likely to succeed in earning a degree in ____
- Students in ____ programs have good social skills

e) Factor 5: Typical Engineering Skills and Work

This factor includes the following questions:

- A student who has taken many AP courses should consider a degree in ____

- A student who is interested in working in the automotive industry should consider pursuing a degree in ____
- A student who is interested in working in the electronics industry should consider pursuing a degree in ____
- A student who is interested in robotics should consider pursuing a degree in ____
- A student who enjoys or excels in mathematics will likely succeed in earning a degree in:
- A student who enjoys or excels in science will likely succeed in earning a degree in:
- The following engineering fields involve working on product design:
- The following engineering fields involves inventing new products

B. Teachers' Feedback on Survey Questions

The first draft of the survey instrument was sent out to five secondary education teachers in the region to solicit their feedback on the survey questions. The feedback was provided by five teachers: two science teachers (11th grade level), one history teacher (12th grade level), one math teacher (9th grade level), and one Advancement Via Individual Determination (AVID) teacher (9th-12th grade levels). We specifically asked teachers to provide their answers to the following questions:

1) Do you find any questions in the survey that you think could be leading or biased that respondents might feel compelled to answer in a particular way?

Most teachers did not find the questions of the survey to be leading or biased. They said that the questions were well-written and provided several options to choose from.

Two teachers, however, pointed out that the survey assumes that the teachers are familiar with the different engineering fields. This could lead the teachers to provide inaccurate answers if they are not familiar with the different engineering majors.

To address this feedback, descriptions of the different engineering branches are added before the survey questions. Also, examples of popular engineering subfields and specialties within each branch of engineering are provided.

2) Are there questions that you think are vague or use unfamiliar terms, that could be open to various interpretations?

Teachers did not think that any of the questions were vague or used unfamiliar terms. They said that the questions were to the point and were not open to interpretation.

3) Do you think the answer choices for each question include the full spectrum of potential answers?

Teachers said that all answer choices included the full spectrum of potential answers.

- 4) Do you think the survey is too long and should be shortened?

Teachers indicated that the length of the survey is perfect.

V. CONCLUSION AND FUTURE WORK

The process of choosing engineering as a major for high school students can be very convoluted. Based on our experience STEM professional development programs for teachers, we know that teachers influence student learning and interest in a STEM subject. In this paper, we reviewed and surveyed studies that examine teachers' perceptions of engineering education and careers. We also looked at studies that examine students' perceptions of engineering and engineering majors. We provided the rationale behind the need for a study that surveys teachers' perceptions of the differences between engineering majors and careers. This work in progress presented the survey instrument that we developed, and the feedback received by a group of teachers who reviewed the instrument. Our next effort is to pilot test the survey to validate the questions and identify any problems before deploying the survey in the region.

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