

Analysis of Stakeholder Attitudes For a Pre-College Outreach Program

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Abstract

The 21st century economy demands an educated workforce, particularly in science, mathematics, engineering and technology. However, New Jersey, like many other states, is increasingly unable to adequately prepare sufficient numbers and quality needed for an advanced technical workforce.

The Pre-Engineering Instructional and Outreach Program (PrE-IOP) has been initiated to enlarge the future pool of qualified high-tech workers in New Jersey, including those who have been historically underrepresented (such as minorities and women). This comprehensive program has two major components. The Instructional component includes the adaptation of pre-engineering curricula for use in middle and high school science and math classrooms and the provision of summer institutes for teacher professional development. The Outreach component involves the implementation of an “Engineering the Future” outreach program and the formation of alliances with three groups of stakeholders: educators, counselors and parents. It will include assessments of attitudes towards engineering and technology, a career alternative assessment, and a comprehensive information campaign about the rewards of science, engineering, mathematics and technology (SMET) professions.

More positive attitudes towards engineering as a career is one of the outcomes that will be used to determine the efficacy of this outreach program. To this end instruments to measure high school students’ and adults’ attitudes are being developed. This paper will discuss the design and pilot study of these assessments and initial benchmark results for high school students.

1. Introduction

The 21st Century economy demands an educated workforce, particularly in science, mathematics, engineering and technology. Individual states and the nation are increasingly unable to maintain a high quality and diverse technological workforce. The United States Department of Labor forecasts that new science, engineering, and technology jobs will increase significantly by 2010.¹ According to the National Science Board, new engineering, technology and science jobs will increase at almost four times the rate for all occupations.²

New Jersey can be considered a microcosm of the United States because of its diverse population and the extent to which technology drives the state's economy. In a poll released by New Jersey Institute of Technology in October 2001, New Jersey residents stated that while math and science play a critical role in their lives, their children are graduating from New Jersey high schools with insufficient knowledge of those subjects.³ Thus, the current decline in the number of students interested in science and math is of major concern, not only to the growth of New Jersey's economy, but to the United States' economy as well.

Many higher education institutions have reacted to these projected shortages with a proliferation of outreach programs for students and teachers and recruitment efforts with students. Recent reports on student programs indicate an increased focus on providing engineering experiences and an introducing students to what engineers do.⁴⁻⁷ Programs for teachers have included training and curriculum development that integrates reform efforts^{6, 8-9} and state content standards.^{5, 7, 10-11} All programs include evaluation components which attest to their successes. However, very few of the programs report on impacts beyond the operation of the workshop/training program. Several of the projects follow up the programs with assessment of the impact in the classrooms.^{5, 6, 9-10} There are also few studies that report on the impact of the programs on pre-college student attitudes toward and knowledge about engineering. Robinson, et.al.,¹² have reported that more knowledge of engineering was associated with more favorable attitudes towards engineering in in-service and pre-service teachers (average age of 35). In addition, others have reported that attitudes of first year undergraduates towards engineering are related to whether or not they will persist in engineering majors.¹³⁻¹⁴ However, these instruments were developed for adults and college students and are not appropriate for secondary school students.

Since adequate mathematics and science preparation is essential for success in the pursuit of engineering degrees, investigations of pre-college students' willingness to take mathematics and science courses have been conducted. NACME (National Action Council for Minorities in Engineering)¹⁵ studied students' and parents' attitudes towards and knowledge of middle school and high school mathematics and science education. In a pre- and post- design respondents reported their attitudes to science and math in 1995 and five years later. In the intervening five years, outreach campaign was implemented to inform students and parents about the importance of studying mathematics and science. The follow-up survey found that the disparity between students' expectations for their future careers and their current patterns of enrollment in mathematics and science remained unchanged. While favorable attitudes towards and interest in mathematics increased, especially amongst minority students, 50% of all responding students still planned to take only the minimum mathematics required for high school graduation.

The NACME studies¹⁵ indicate that Outreach initiatives alone may not be enough to change many students' choices. It is generally accepted that the alternative strategy - good programs that provide enrichment and familiarize students with what engineers do - can also influence students' choice of careers. Our initiative is based on the assumption that programs utilizing both strategies can have a synergistic effect to significantly increase the number of students pursuing engineering and technology careers.

2. Design of the Survey

The survey being developed to measure high school students' attitudes to engineering is comprised of five sections: 1) attitudes to engineering; 2) self assessment of engineering skills and knowledge, 3) self-confidence of academic abilities and skills, 4) academic history (i.e. courses taken in high school), and 5) a short demographic section that includes questions about their exposure to people who are engineers and their knowledge of engineering as a career.

The survey adapted from two existing surveys: "Freshmen Attitudes to Engineering"¹⁴ and "Engineering Principles for High School Students."¹² Engineers who have worked in industry and/or teach engineering courses provided feedback on items from the two existing surveys and suggested a number of additional items for the attitudes to engineering and self-assessment of engineering skills and knowledge sections. Several brainstorming sessions with high school curriculum experts, engineering faculty, and students advisors were held to discuss what types of information should be asked in the academic history and demographic sections.

Section 1 (attitudes toward engineering) asks students to indicate the degree to which they agree or disagree with statements about engineers and engineering using a five-point Likert scale. Statements refer to stereotypes of engineers, skills necessary for engineering, the perceived rewards of becoming an engineer, and what engineers actually do. Section 2 (self-assessment of engineering skills and knowledge) asks students to report their opinions of their own skills, interests, and preparation for engineering careers also using a five-point Likert scale. Both sections provide an "I don't know" response that will be used to assess the extent to which students lack the knowledge to respond to the survey effectively. Section 3 (self-confidence in academic abilities and skills) asks students to indicate how confident they are about their abilities in specific subject or skill areas, again using a five-point Likert scale. For each subject or skill, students are given the option of indicating they have never taken a course related to that subject or skill. In Section 4 (academic history) students indicate which science, math and language arts courses they have taken in school (i.e. general math as opposed to advanced placement math). Section 5 (demographic information) asks for the respondent's gender, grade, race/ethnicity, location of their school, and whether they have any friends or relatives who are engineers or are studying to be engineers. The final item, an open-ended question, asks students to name different kinds of engineers and to give an example of the work each type of engineer does.

Several drafts of the survey were reviewed and revised based on feedback from engineers and interviews with a small number of students who were asked to complete the survey. A review of the initial draft of the survey by a panel of judges identified seven potential sub-scales within the "attitudes toward engineering": section. 1) money and prestige, 2) what engineers do, 3) cost vs. benefits of becoming an engineer, 4) personal inclination toward engineering, 5) contributions made by engineers, 6) personal characteristics of engineers, and 7) academic and technical characteristics of engineers. Three possible sub-scales within Section 2 "self assessment of engineering skills and knowledge " were also identified: 1)

self-efficacy for engineering related skills, 2) general academic self-efficacy, and 3) personal interest.

3. Pilot Study

For the initial pilot study, 431 male and female high school students (grades 9-12) from urban and suburban schools in NJ completed the survey when they attended a career day at an engineering school. Items in the first and second sections, “attitudes toward engineering” and “self-assessment of engineering skills and knowledge”, have been subjected to a principal component factor analysis to explore the validity of their ten possible subscales.

Results of the factor analysis on the “attitudes toward engineering” section do not support the seven sub-scales identified by the panel of experts. Instead a six-factor solution, suggests a set of different possible subscales: 1) utility of engineers/ engineering, 2) interest and enjoyment in engineering, 3) how engineers think, 4) how engineers spend their time, 5) negative perceptions about engineers, and 6) money and respect. Cronbach’s alpha was calculated to measure the internal consistency of items identified for each of the six sub-scales suggested by the factor analysis (utility=. 72, interest/enjoyment=. 85, how engineers think=. 75, how engineers spend their time=. 69, negative perceptions=.68, money & respect=.76).

Results of the factor analysis on the “self-assessment of engineering skills and knowledge” section show more support for the three subscales identified by the panel of experts. Although the item structure of the subscale was not identical to those named by the panel of experts, results suggest the same three subscales with an additional subscale “friends and self-confidence”. Cronbach’s alpha was calculated to measure the internal consistency of items for each of the four subscales (self-efficacy for engineering=. 83, school-related self-efficacy=. 57, personal interest=. 68, friends and self-confidence=. 65).

Several items in each section will be revised, replaced and/or eliminated as a result of these analyses and a revised version of the entire survey will be re-piloted with a smaller group of students some of whom will also be interviewed about their responses. Further revisions will be made after information from the interviews has been analyzed. The validity of the “attitudes toward engineering scale” and the “self-assessment of engineering knowledge and skills” scale will be further explored by looking at how scale scores and subscale scores correlate with i) students’ confidence (or lack of confidence) in engineering related skills and other unrelated skill areas, ii) other measures of students attitudes and abilities, iii) their exposure to people in the engineering field and other measures identified as relevant.

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