

AC 2009-1712: ASSESSING PEER ATTITUDES AMONG STEM STUDENTS AND THEIR POTENTIAL EFFECTS ON THE RETENTION OF FEMALES IN STEM PROGRAMS

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Introduction

One of the major socio-technological changes in the United States is that of a growing diversity of workforce. Demographic projections show the traditional pool that supplies today's technological workforce is shrinking, while nontraditional pools such as women and underrepresented groups are growing. If the United States is to remain competitive and continue to flourish in the competitive global marketplace, it must draw on all of the talents in its population. The need for a highly skilled technical labor force, the new majority, and the aging population are several factors that drive the need for a comprehensive look at changing the culture of engineering.

The underutilization of women and minorities in science and engineering is a problem of national priority. Not only is the social equality of minorities and women at stake, the quality of the United States technical labor force is also in danger. Diversity and quality should be seen as complementary and not as mutually exclusive. One way to increase the technical pool and attract women and minorities to technical careers is to “change the conversation”¹ and focus on promoting understanding of engineering and technology literacy to the public. Even with increased efforts nationwide to recruit women and minorities in the STEM fields, there seems to be a missing piece. How can the attrition rate of women and minorities be improved?

Much attention has been paid to the attitudes and interests of female students regarding their desire to pursue postsecondary education in STEM as well as their persistence in these efforts. Various initiatives have been launched to increase the recruitment and retention of these populations through outreach programs, mentoring, summer activities and the like. The National Science Foundation and the American Association of University Women have invested nearly \$90 million to support over 400 projects with a focus of fostering the interest and participation of females in the STEM fields.² A brief sampling of programs aimed at increasing recruitment and retention of females in STEM or support for women in STEM fields:

- National Girls Collaborative Project
- National Center for Women & Information Technology
- Nerdgirls
- The Gender Chip Project
- WEPAN – Women in Engineering Proactive Network

- SWE – Society of Women Engineers
- Girls Tech
- GirlStart
- IBM EX.I.T.E.
- Girl Scouts
- Alliance of Technology and Women
- Girls Inc.
- GEMS
- Engineer Girl – National Academy of Engineering

These are all excellent programs which are making phenomenal strides in the support of females in STEM education and the STEM workforce. These programs have accomplished much and progress continues in the effort to create interest in and desire for the pursuit of postsecondary education among females. Less attention, however, has been paid to the pervasive attitudes and actions of their peers within the STEM fields and throughout the STEM pipeline and how those attitudes may have a deleterious effect on the retention rate of females in STEM programs over time.

Among the numerous studies on women and minority students and why they fail to achieve degrees in STEM fields, the focus is on the students' characteristics, but less attention is focused on institutional characteristics and peer perceptions. When young women entering technical careers were asked what social factors concerned them about the climate of STEM fields, the responses indicated the traditionally high indicators of “discrimination,” “prejudice/hostility,” and “lack of acceptance.”³

Another limiting factor for women and minority students to achieving degrees in STEM fields is their individual perception of their ability to succeed in a given situation, known as self efficacy, influences their thoughts, feelings, motivation, and behavior.⁴ Four factors contribute to the development of self efficacy: mastery experiences, vicarious experiences, social persuasion, and physiological states. Vicarious experiences include peer comparisons, social comparisons with others, and the impact of models. The vicarious experience of women and minority students can prove to have a strong effect on their individual self efficacy when they have limited personal experiences in STEM fields.⁵ The perceived anxieties and fears about capabilities as indicators of a lack of ability to succeed, physiological states of self-efficacy lead to lower self-confidence.

It is proposed that students' underlying attitudes and perceptions about the engineering field and their peers affect attrition and retention rates.

We are measuring middle school, high school, and college students to determine:

- Attitudinal differences among student populations
- Extent to which the attitudes and these factors are correlated with retention and perceived academic performance in STEM
- Extent to which the perceptions STEM students have of student populations affect the climate for that student population

Before effective initiatives can be developed to reduce the high attrition rate of women and minorities in STEM fields, a more in-depth understanding of students' underlying attitudes and perceptions of engineering and their peers is warranted.

Procedure

Students in middle school, high school and college were surveyed regarding their desire to pursue or their persistence in STEM education (degrees) and the factors which influenced their intention to persist. They were also surveyed regarding their opinions about their peers with regards to proficiency in STEM education/fields. The surveys were predominately those use by AWE (Assessing Women and Men in Engineering). Sections were deleted that did not fit the scope of the study and a few questions were added regarding peer perception.

The anonymous surveys included questions on the following:

- Gender
- Ethnicity
- Opinions of peer proficiency with regards to gender
- Opinions of peer proficiency with regards to ethnicity
- Confidence in own skills to succeed in STEM coursework
- Desire to pursue or persist in STEM education
- Opinions regarding influence of environment on desire to persist (college only)

Other questions on study skills and strategies were also included in the survey but will not be included in this study. The questions over peer proficiency, and environment were structured as a four-point Lickert scale. The questions on gender and ethnicity were categorical. The questions over confidence and desire to pursue or persist were four point Lickert scale. The questions over influences on desire to persist were four-point Lickert scale.

Because of the convenience sampling method used, there is to be expected some difference between the response of the middle school, high school and college respondents' desire to pursue

or persist in STEM as the middle school students surveyed were in a general science course and both the high school and college students surveyed had self-selected into rigorous STEM centered coursework. In addition, all three campuses surveyed are predominately white. We would suspect that there exists the possibility that the responses would be different at campuses with different demographics.

The student responses were then analyzed using SPSS repeated measures design (mixed method) with three between–subject variables (gender, ethnicity, grade band) and ten within-subject variables (response to opinion questions).

Results

One hundred and eighteen students were surveyed. Of these, forty eight were in middle school (8th grade), thirty were in high school (12th grade) and forty were in college (freshmen engineering course). These were convenience samples of two science courses at one Texas middle school, two senior AP physics classes at one Texas high school and one freshmen engineering class at a Texas university.

Table 1. Participants by Demographics and Academic Rank.

Female	31
Male	87
African American	10
Asian	3
Hispanic	13
Caucasian	88
Other	4
Middle School	48
High School	30
College	40

Opinions regarding proficiency

There was a significant difference between the male and female response to female proficiency in STEM. Males overall and across all ethnicities disagreed that females were proficient in STEM whereas females agreed that females were proficient in STEM. (On four-point Lickert scale, Male mean with regards to female proficiency was .6709, Female mean with regards to female proficiency was 1.333 with 0 as strongly disagree and 3 as strongly agree).

There was also a significant difference in the response to the question regarding female proficiency in STEM education. Caucasian females strongly agreed that females were proficient in STEM whereas Hispanic females disagreed.

There was a significant difference in the opinions of college students and those of middle and high school with regards to peer proficiency. Regarding the opinion that some groups of students are naturally more proficient at STEM and using the same Lickert scale, middle school students mean was 1.02, high school mean was .9862, college student mean was 2.242. The general consensus here is that middle/high school students disagree that certain groups are naturally more proficient and that college age students agree that certain groups are naturally more proficient.

Desire to persist in STEM

Perhaps most significantly, among the students who reported that they would probably not be persisting in engineering (college level only) females and minorities primarily reported that they were significantly influenced by environment in this decision. This is in contrast to white males who reported that they would probably not persist in engineering listing their primary significant influence as grades.

Using the difference between confidence in persistence levels before entering the program and confidence in persistence levels at the end of the introductory engineering course, females responded with a $-.5714$ (indicating a drop in their confidence or desire that they will persist in the program). Males responded with a mean of $-.1714$ (indicating a drop in their confidence or desire to persist in the program but of a smaller magnitude than females). With regards to factors influencing their persistence in the program, the factor of greatest weight for females was listed as class climate (mean of 2.2857) in contrast to grades (mean of 1.287). Males listed class climate (mean of 1.529) in contrast to grades (mean of 2.274) as strength in influencing their persistence in the program.

Generalizability of results

While this preliminary study has shown some interesting results it would be unwise to make blanket generalizations about the correlations or causations hinted at here. Pathways for more generalizable results are explored in the section on suggestions for further study.

Implications

Numerous studies have been completed and position papers written on female and minority recruitment and retention in STEM education and STEM fields and how to improve it. Most of our efforts heretofore have been on how to bolster the interest and confidence of females and minorities in STEM further education. In addition, there have even been studies and policy papers completed on how to market STEM, specifically engineering, to the general public.

What we have not addressed with as much fervor however, is how a potentially inimical environment affects the retention of students we have recruited. It seems logical that this is the approach that researchers have taken overall as it would seem much easier to change the attitudes and perceptions of a sub-group (especially if they have something to gain) than the larger culture (in which the dominant demographic may perceive that they have something to lose). In other words, we create the desire for further STEM education among females and minorities, we give them the mental tools to succeed in further STEM education, but when they arrive in our halls they may be met with an unwelcoming environment and the negative attitudes of their peers.

While our efforts to inspire interest and confidence in further STEM education and careers among females and minorities are noble and necessary, it is not the whole picture. It seems that it would increase the efficacy of our model to address the whole picture including the attitudes of the group which dominates STEM fields, namely white males. Most cultures are slow to change and engineering and STEM should be thought of as a culture, with gatekeepers and its own particular code. Given the declining enrollment and retention of American students in STEM education and the consequent effect this will eventually have on the American STEM workforce, it would seem that it is time for a cultural change.

Suggestions for Further Study

As mentioned previously, the samples for this study were convenience samples and consisted of one middle school teacher's students (two classes), one high school teacher's students (two classes) and one college faculty's student's (one class). It would be important to replicate this study or one similar with other faculty classes sampled as we may be seeing an effect of the particular faculty rather than a trend generalizable to the larger population. In addition, it would be important to pull samples from a targeted middle school (math/science magnet) to more closely align it with the self-selected nature of the AP high school class and the college engineering class samples. Concomitantly, it would be important to also sample the general high

school population as well as the general college population to ascertain whether or not these opinions differed from those of the more specialized classes, namely AP physics and freshmen engineering. Larger sample sizes would be beneficial. Given the time and resources, a qualitative study using focus groups which would allow for more open ended questions would help to define the most relevant and powerful areas of potential correlation/causation.

Additionally, an ethnographic study of engineering specifically or STEM in general “cultures” would be helpful to provide a more clear lens in which to view ourselves and our blind spots with regards to attitudes and perceptions within our ranks.

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