The Path to STEM Careers: Student Perceptions of College Pathways and Barriers to Success

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Abstract

The projected need for professionals with degrees in STEM fields is increasing while the undergraduate enrollment, secondary school students, to determine the personal and educational factors that contribute to participation and success in STEM fields. Factors that contribute to the decisions of secondary school students to pursue programs and careers in STEM disciplines will be identified. Questions about the students' future career path, as well as questions regarding people and situations influencing students' career selection will be analyzed. Comparisons between genders will be performed across grade levels.

Introduction

According to the annual Survey of the American Freshman, National Norms, for the last two decades about one-third of freshmen entering college planned to study STEM. In 2006, 44.7% of Asian freshmen, 34% of Black freshmen, and 29.5% of White freshmen reported that they intended to major in STEM[1]. Where 24.2% of the White freshmen were female, 39.4% of the Asian freshmen were female, and 32.1% of the Black freshmen were female[1]. These numbers represent an increasing trend of a diverse demographic composition of students planning to major in STEM.

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 untraditional pools such as women and underrepresented groups are growing proportionally, with them making up 1/2 to 2/3 of the population, the new majority, of the United States. If the United States is to maintain 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.[2] 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" [3] 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?

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."[4] Research also shows that minority attrition in STEM fields is primarily due to a hostile, isolationist environment.[5]

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[6]. 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.[7] 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 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 Lickert scale. The questions on gender and ethnicity were categorical. The questions over confidence and desire to pursue or persist were multiple choice.

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 nineteen students were surveyed. Of these, forty eight were in middle school (8^{th} grade), thirty one were in high school (12^{th} 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 Caucasian females strongly agreed that females were proficient in STEM.

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.

In this comparison, the other notable difference was each group's ratings on the proficiency of Hispanics. Hispanic females rated their Hispanic peers significantly higher than the Caucasian females' ratings of their Hispanic peers.

African American males gave the lowest proficiency rating for their Hispanic peers. Asian males gave the lowest proficiency rating to African American peers.

There was a significant difference in the opinions of Caucasian college students and those of middle and high school with regards to peer proficiency. Caucasian college students strongly agreed that certain groups of students are naturally more proficient in STEM.

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.

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.

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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