Creating a Pipeline: An Analysis of Pre-College Factors of Students in STEM

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ABSTRACT

This study seeks to understand the pre-college factors of undergraduate students who select a STEM major by specifically focusing on parental occupations, the level of parental influence on choice of major, and the characteristics of the high schools attended by STEM majors. This study draws upon survey data collected from a total of 4,567 college students in 2010 (n=1,881) and 2011 (n=2,686) from a variety of majors at ten large research universities. Results regarding parental occupation and choice of major influence suggest that students with at least one parent in a STEM field choose to major in STEM at a higher rate than those whose parents are in STEM. However, the results also suggest that students' choice of college major is greatly influenced by their parents, regardless of parent's occupation. Results regarding high school characteristics suggest that the vast majority of students in STEM majors matriculate from schools that are majority white and are of high socioeconomic composition. The findings inform recommendations for STEM recruitment efforts that include providing parents with knowledge of STEM programs and establishing partnerships between underrepresented high schools and large research universities.

Keywords: STEM, Conference Proceedings, Higher Education, STEM-Increase K-20 Interest and College Enrollment

INTRODUCTION

Efforts to increase the number of students earning science, technology, engineering, and math (STEM) degrees in the United States continue to influence postsecondary STEM recruitment and retention efforts. In order to increase the number of students studying and working in the STEM fields, more students need to choose a STEM major as an undergraduate. The need to diversify the STEM fields makes this an especially important decision for underrepresented students in particular. The purpose of this study is to better understand factors that may impact a student's decision to major in STEM fields at large, public, research universities. Literature suggests that students in STEM majors were exposed to the idea of pursuing a STEM career early in their education, long before their undergraduate career begins. This study seeks to understand the pre-college factors of undergraduate students who select a STEM major. The following research questions were investigated:

- Do differences in choice of STEM major exist among students with at least 1 parent in STEM?
- Do students report parental influence of major decision differently by parent occupation?
- What are the institutional characteristics of high schools from which students majoring in STEM fields matriculate?

Parental occupations, the level of parental influence on choice of major, and the characteristics of the high schools attended by STEM majors are examined to better inform higher education STEM recruitment efforts.

LITERATURE REVIEW

Parental Occupation

The literature regarding parental occupation and student's choice of college major often focuses on parent level of education, which is closely related to a student's socioeconomic status, rather than the parent's field of work. Parent's socioeconomic status has shown to have an indirect influence on students' success in college because it influences the pre-college factors experienced by the students (Gruca, Ethington, & Pascarella, 1988; Ware & Lee, 1988). Chen and Associates (2009) reported that students with family income in the top 25 percent or whose parents had at least some college education entered the sciences more than their lower income peers. Previous literature examining student majors and parental occupations is varied depending on student race/ethnicity, major, and gender. Astin and Astin (1992) found engineering students who have a father as an engineer are more likely to have a final major of engineering. Sheppard et al. (2010) examined motivations for students studying engineering. Sheppard et al. (2010) found parental motivation for students studying engineering was positively correlated with having a parent or sibling in engineering. In addition, Sheppard et al. (2010) reported that motivational factors were similar for first-year students and seniors. The researchers concluded that students' motivation for studying engineering develops before they enter a postsecondary institution.

Literature often emphasizes the importance of self-efficacy when a student is determining his/her interests and eventual college major. Bandura (1977) explains self-efficacy as a determinant in what one will do when faced with adversity. Self-efficacy will influence how or if one sees goals to completion. If a student has a parent in a STEM career, they will see that career as a feasible option, and it supports their commitment to the goal of a STEM career increasing their likeliness of persisting in that major field (Leslie, McClure, Oaxaca, 1998). Eccles (2005) connects these self-efficacy concepts more closely to parental occupation with the E*xpectancy Value Model of Achievement-Related Choice*. The model describes a student's expectation for success as dependent on a student's self-efficacy and the student belief regarding the difficulty of the goal they are pursuing. According to *Achievement-Related Choice*, educational and occupational choices are guided by several factors, one of which includes, "the individual's culturally based role schemas, such as those linked to gender, social class, religious group, and ethnic group" (Eccles, 2005, p.12). This paper will examine the parental occupations of students in different majors. Comparisons will also be made between male and female students to investigate the possibility of differences in major decision because of a student's "role schema" as described by Eccles (2005).

There is a significant amount of research that focuses on the influence of individual major and parent occupation on retention and completion of majors such as engineering, however, the literature regarding parent occupation and recruitment of STEM majors in general is limited. Recruitment efforts often focus on the individual students, but other efforts target the whole family in exposing them to STEM career options. This study will also shed light onto student's self-reported influence of major. Parental influence is often a reason for targeting the whole family when implementing STEM major recruitment efforts (Loftus, 2009).

High School Influences

In addition to parental influences, institutional characteristics of the high school which the student graduates from have also been known to influence students' decisions to enter the STEM fields. The influence of high schools on the post-secondary attainment has been thoroughly

discussed in the literature. Specific discussion on the high school institutional characteristics related to post-secondary STEM attainment is not as broad but provides a foundation for further discussion. According to Oakes (1990), "the critical period for encouraging students to enter the scientific pipeline is before high school; but, because students defect from science throughout their schooling, keeping students in the pipeline requires attention at all levels" (p. 157). Oakes (1990) also reports that school educational tracking within high schools limits the opportunities of students placed on a non-college preparatory track reduces the mathematical preparation needed to pursue a post-secondary degree in the sciences. Specifically, Oakes (1990) notes, that at the high school level, "minorities typically have fewer opportunities to learn science and mathematics. Girls exhibit more negative attitudes, pursue fewer opportunities, and by the end of high school score considerably lower than boys on measures of mathematics and science achievement" (p. 161-162). Legewie and DiPrete (2012) also found that high schools play an important role in shaping the educational pathways of women, particularly towards degrees in STEM.

Furthermore, according to Oakes (1990), high school socioeconomic composition affects the educational preparation necessary to pursue a post-secondary degree in STEM. Students that attend low socioeconomic high schools have fewer opportunities to enroll in advanced mathematics and science courses. Oakes (1990) posits that, within some low socioeconomic schools, "spending for science-specific resources is often the first to be curtailed, including the equipment and supplies necessary to provide science laboratory experiences, participation in museum-sponsored programs and activities, and the purchase of up-to-date science texts" (p. 181).

DATA AND METHODOLOGY

This study is part of a larger research project that uses qualitative and quantitative methods to examine women, students of color, and low income students in STEM fields at large research universities. The larger research project included an online survey taken by students at ten large, public research universities in 2010 and 2011. The survey was distributed to students through contacts in student-service offices for students in STEM and STEM departments on the ten campuses. This study draws upon the survey data collected from a total of 4,467 college students in 2010 (n=1,878) and 2011 (n=2,589) from a variety of majors at ten large research universities. The survey was specifically targeted to students in STEM majors, and the majority of the respondents were STEM majors, but all majors were eligible to respond. Underrepresented and female students were specifically oversampled to increase their response rate. The specific questions used in this particular study are:

- What was your father/male guardian's job title and in what industry did he work?
- What was your mother/female guardian's job title and in what industry did she work?
- Who most influenced your decision to choose your major? Guidance Counselor, Parents, Peers, High School Teacher, Minister, Sibling, Family Friend, Other (please specify), I prefer not to answer
- What High School did you graduate from?
- Did you take Advanced Placement classes in high school?
- Did you participate in any math or science related programs in high school?

Definition of STEM

There are many definitions of STEM used to study the underrepresentation of students in STEM fields. Often, these definitions are restricted to include only fields such as engineering and physical or life sciences. This study uses a different definition for distinguishing between parental STEM and non-STEM occupations and student STEM and non-STEM majors. For the purposes of this study, STEM occupations are those that require a postsecondary degree with a substantial amount of math or science curriculum. This definition was chosen based on the *Expectancy Value Model of Achievement-Related Choice*. A parent with at least a bachelor's degree in a math or science related field would possibly be able to break the "schemas" students experience early in their education.

Parental Occupation

The structure of the survey allowed respondents to specify their parent's job and industry through an open-ended text box, rather than asking them to choose from a pre-defined list that may not capture the breadth and depth of parental occupations. Based on this definition of STEM, parental occupation for all students in the survey was coded based on STEM, non-STEM, and unclassifiable/Prefer Not to Answer (PNA). Occupations in fields such as physical science research, life science research, math or science education, health occupations, and computer science occupations as well as computer support positions were included in the STEM category. Non-STEM occupations were occupations that would not be considered STEM such as occupations in the social sciences, non-math or science education, business, or law enforcement.

Student Majors

Student majors were categorized as STEM versus non-STEM according to the math or science required for the particular major. Majors such as engineering, engineering sciences, physical and life sciences, and nursing were considered STEM. Majors such as business, social sciences, education, and humanities were considered non-STEM. A complete list of majors can be found in the Appendix.

High School Characteristics

The analysis of the high school characteristics was limited to public high schools only. The reporting requirement of publicly funded high schools provides a rich database administered by the National Education for Educational Statistics (NCES) and allows for comparisons across many factors. NCES public high school identification numbers were matched to the student responses based on the reported name and location of the graduating high school. Institutional characteristics specific to each high school for the 2008-09 academic year were retrieved from the NCES Common Core of Data (CCD) and subsequently matched to each respondent based on the NCES identification number. The institutional characteristics included in the CCD used in this study include the racial and ethnic composition, socioeconomic status, and locale. Descriptive statistics and cross-tabulations with chi-square analysis were used to inform this study.

FINDINGS and DISCUSSION

Parental Occupation and Influence

Of the total survey respondents, 84.8 percent were STEM majors, and 28.4 percent of the total respondents had at least 1 parent in a STEM field. Of the respondents who were STEM majors,

38.8 percent had at least 1 parent in STEM compared to 31.2 percent of non-stem majors with at least 1 parent in stem ($p<.01$). 40.5 percent of female STEM majors had at least 1 parent in STEM compared to 36.1 percent of males. Nearly 53 percent of STEM majors who reported that their parent(s) most influence their choice of major did not have a parent in STEM.

The results regarding parental occupation suggest that students with at least one parent in a STEM field choose to major in STEM at a higher rate than students without parents in STEM. However, the results also suggest that students' choice of college major is greatly influenced by their parents, regardless of parent's occupation. Both STEM and non-STEM parents were reported to have the most influence on student choice of STEM major. Findings inform recommendations that include providing parents with knowledge of STEM programs. According to this survey, students with parents in STEM were more likely to be in a STEM major, but results regarding who most influenced a student's major suggest that parents can play an important role in encouraging STEM majors for their children. Perhaps the confidence instilled in students, especially females, seeing their parents in a STEM major could also be conveyed by informing parents of the importance of parental messages regarding STEM opportunities for their students. Increases in funding to recruitment programs during middle school and high school years to allow this information to be disseminated to parents as well as students is important to ensuring more students have access to STEM careers.

High School Characteristics

Of the sample of the total respondents that graduated from a public high school, 88.4 percent of students majoring in STEM programs and 85.9 percent of students majoring in Non-STEM programs graduated from high schools in which the racial composition was majority white. Similar results are found when school socioeconomic composition, as measured by percent free or reduced lunch, is examined. 86.6 percent of STEM enrollees and 84.0 percent of Non-STEM enrollees attended a high school where less than 40 percent of students qualified for the free or reduced lunch program. In regards to location of the high school, the highest percentage of students in STEM (46.7%) and Non-STEM (46.4%) graduated from a high school located in a suburban area.

The results regarding high school characteristics suggest that the vast majority of students in STEM majors matriculate from schools that are majority white, are of high socioeconomic composition, and are located in large, suburban locales. The differences in the findings of STEM majors and Non-STEM majors were not significant. This could suggest that pre-college high school factors affecting STEM access are no different than the factors affecting post-secondary education in general. While these findings reflect the sentiments of Oakes (1990) in that urban and low socioeconomic schools will produce lower levels of students prepared for STEM majors, concerns are raised regarding the ability of the U.S. to diversify the STEM fields and prepare a diverse STEM workforce. If the STEM pipeline is to include a more diverse population, the largest producers of students majoring in STEM fields should consider targeting its recruitment efforts in a more diverse way.

LIMITATIONS

Different definitions of STEM will result in different empirical results. Many studies investigating the pre-college factors of STEM majors use different definitions of STEM; this makes comparison of studies that investigate STEM fields difficult. For this survey, allowing students to respond to parental occupation questions openly allowed the researcher to record

students' perception of parental occupation. This was helpful in that students were not able to select an occupation from a list that sounded similar to their parents' position. However, this also made it difficult at times to get an accurate picture of some of the parental occupations.
This survey was targeted to students in STEM majors, which explains the large number of STEM major respondents. This also may not provide an accurate representation of non-STEM majors at the specific campuses involved. The survey did not have a diverse enough sample to investigate race or ethnicity differences among the respondents. Finally, these students are all from major research universities, which may suggest a certain level of education from their parents. The findings may also reflect the recruitment patterns and policies of large, research-intensive universities. Finally, the majority of respondents were not first generation college students, which may explain the influence of parents both in terms of choice of major and occupations.

FUTURE RESEARCH

Based on the findings of the study and the acknowledged limitations, future research could examine causal or correlation relationships between parental influences and high school characteristics. Also, more pre-college factors should be explored in helping to explain which students choose majors in STEM fields. More specifically, the STEM fields may be disaggregated to explore the similarities and/or differences between students majoring in Physical, Math, Computer Science, & Engineering, Agriculture & Biosciences, or Health Sciences & Psychology.

CONCLUSION

In order to meet the goals of the various STEM initiatives, more students need to be exposed to and provided the opportunity to access STEM related activities early in their education. As we have discussed, pre-college factors are important to establishing an educational foundation that allows a student the opportunity to purse a degree in a STEM field. Current levels of recruitment to STEM fields once students are in college may be not adequate enough to meet the demands of providing a diverse and qualified workforce for STEM occupations. As discussed earlier, early parental involvement may provide students access to the multiple opportunities within STEM disciplines. In order to increase the diversity of the STEM applicant pool, university recruitment efforts should increase their attention towards high schools with more diverse populations.

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APPENDIX
Classification of Student Majors

STEM
Agriculture, Agriculture Operations and Related Sciences
Biological, Biomedical Sciences
Computer and Information Science/ Support Services
Engineering
Engineering Technologies/Technicians
Health Professions and Related Clinical Sciences
Mathematics/Statistics
Physical Sciences
Science Technologies/Technicians

Non-STEM
Architecture and Related Services
Business, Management, Marketing, Related Support Services
Communication, Journalism, and Related Programs
Communications Technologies/Technicians, and Support Services
Education
English Language, Literature/Letters
Family and Consumer Sciences/Human Sciences
Foreign Languages, Literatures, Linguistics
History
Legal Professions Studies
Liberal Arts and Sciences, General Studies and Humanities
Multi/Interdisciplinary Studies
Natural Resources/Conservation
Parks, Recreation, Leisure, Fitness Studies
Psychology
Public Administration/Social Service Professions
Reserve Officer Training Corps (ROTC)
Social Sciences
Visual and Performing Arts

Table 1: Demographic and Background Information of Survey Respondents (n=4,467)

Variables	N	%
Gender		
Male	1824	40.8%
Female	2605	58.3%
Prefer not to Answer	38	0.9%
Race and Ethnicity		
White not Hispanic	3252	72.8%
Asian or Pacific Islander	551	12.3%
Hispanic or Latino/a	193	4.3%
Black, not Hispanic	171	3.9%
Other Race/Ethnicity	152	3.4%
Prefer not to Answer	126	2.8%
Native American or Alaskan Native	22	0.5%
Major Category		
STEM	3787	84.8%
Non-STEM	504	11.3%
Other	176	3.9%

Source: Project STEP-UP Survey, 2011; Authors' Calculations.

Table 2: Select Characteristics of High Schools Represented in Data (n=3,500)[1]

Majority White	88.1%	Avg. Free/Reduced Lunch Eligibility	19.9%
Majority Black	3.9%	City locale	23.0%
Majority Latina/o	1.1%	Suburban Locale	46.6%
Majority Asian	0.3%	Town locale	10.4%
Majority Native American	0.1%	Rural locale	20.0%
No Majority	6.5%		

Source: Project STEP-UP Survey, 2011; Authors' Calculations.

[1] Characteristic data was only available for public high schools. The remaining 967 cases attended various other high schools in which detailed data was not available.

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