



Women in STEM: What Experiences Influence Decisions

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Abstract

In the United States the number of Science, Technology, Engineering, and Mathematics (STEM) degrees earned by women is extremely low: 19.2% in engineering, 18.2% in computer science, 58.2% in biosciences, and 43.1% in mathematics¹ and West Virginia University Institute of Technology (WVU Tech) has recently started a program to increase mentoring to young women enrolled in STEM fields on campus in hopes of increasing the number of women graduating in the programs. This paper will explore and assess the experiences of female undergrad students in STEM fields, including those who changed majors within the STEM fields or out of the STEM fields, using anonymous surveys with a focus on gaining insight into why some female students leave STEM fields (particularly engineering). Data will be analyzed for recurring themes among the students in their experiences both positive and negative (e.g., moments they thought they wanted to quit, experiences that caused them to feel they could or could not achieve a STEM degree, what changed their mind about staying, or what event caused them to switch to a different field). Though this research the authors' hope to gain insight into why some female students leave STEM fields and others stay. The goal of this paper is to correlate experiences of the female students with their subsequent actions on completing a STEM degree (or not). The hope is to pinpoint specific actions universities, colleges, and STEM based organizations can take to decrease the loss of female talent within the STEM fields. Additionally, this research hopes to illuminate experiences that encouraged females to remain in the STEM fields, add these actions to women mentoring programs at the university, and, thus, help future generations of women college students.

Women in STEM at West Virginia University Institute of Technology (WVU Tech)

West Virginia University Institute of Technology (WVU Tech) is a small school (population of less than 2000) that has a large number of first generation students and students who attended high school while living in small towns (population 5,000 or less). Admission requirements for all majors is either a high school GPA of 3.0 or 2.0 and a general ACT score of 18². Admission to the engineering program also requires a 19 on the math section of the ACT². Only 19.38% of the Fall 2017 cohort has a general ACT score above 23². Because of this, the majority of STEM students at WVU Tech begin in pre-engineering and general education courses in order to catch up to the prepared STEM students. The large percentage of students who take a year of preparation courses for an engineering major, combined with a large number of first generation students presents unique challenges to these students. The Leonard C. Nelson College of Engineering and Sciences at WVU Tech has few female students pursuing STEM degrees and, thus, there is isolation among female STEM majors. Given that the National Science Board has published data showing a sharp decline of students enrolling in STEM fields^{3, 4}, efforts have been made by WVU Tech to decrease the isolation of current students with a student organization, and outreach activities have been used to hopefully increase future numbers of women in STEM. The majority of STEM female faculty at WVU Tech are in the sciences with only four in engineering

and computer science, so cross discipline efforts are extremely important for students in majors without female mentors. The authors' used anonymous online surveys to investigate the experiences of women undergraduate students both in STEM fields and those who decided against STEM fields in hopes of supplementing these efforts already ongoing at the university.

Method of Data Collection and Evaluation of Data

All study participants were undergraduate students (both male and female) enrolled at WVU Tech during the Spring 2018 semester. Participants were e-mailed an invitation to participate in the study, which was a twenty minute survey on Qualtrics. The survey had a large number of multiple choice questions, a few short answer questions, and a few select all questions. Participants agreed to participate in the study by clicking on the survey link and completing the survey on Qualtrics where all the data was stored and guaranteed to be anonymous as no IP addresses or identifying information was asked for or stored. The provided survey link was the same for all invitations and the link was sent to all students at West Virginia University Institute of Technology. The IRB approval acknowledgement is on file at West Virginia University. Data collection took place during the Spring 2018 semester and was completed by 38 female students and 30 male students.

The survey collected data that focused on the following: (1) areas that students feel they struggle with, (2) issues they are have completing classwork (particularly in STEM courses), (3) their background prior to enrolling at WVU Tech, and (4) experiences with their major. Additionally, data was collected for student opinions' on student organizations and student services on campus. The authors used the data collected to correlate experiences and themes among various populations: (1) college students in general, (2) STEM college students, (3) male students, (4) STEM male students, (5) female students, and (6) STEM female students. After the survey closed, particular interest was given to themes that were specific for STEM female students including three areas: (1) how they differed from the male students including background and experiences, (2) impact of various experiences on women at WVU Tech, and (3) the female students' attitudes towards STEM fields. The general college students and general STEM college student data was used as a baseline for comparison. Additionally, the male STEM student data was compared to the female STEM student data. Using the emerging themes, suggestions of possible action for colleges and universities to take within their STEM program to increase the success of the STEM students and STEM female students were made in this paper.

Questions from the Survey

As described earlier, the approximately twenty minute survey was composed of a wide variety of questions. The authors developed all the questions to the survey with the feedback and suggestions of others who often work with the STEM student population on our campus. Below are example questions from the survey (Table 1).

Table 1: Example Survey Questions

Are you majoring (or planning to) major in a STEM field? Yes No
Are you or have you been a member of any STEM organizations? Yes No
Suggestions for what WVU Tech or student organizations could do to help you stay in your current major and/or complete college?
Why do you feel it is important to encourage people to stay in STEM fields? Or not encourage people to stay in STEM fields?
Who was a significant source of encouragement for you to pursue a college education?
Has there been anyone who has been a significant source of discouragement for you to pursue your major? Yes No
Do you feel there was skills or background your fellow students knew that you did not? Yes No

Table 2: General Population Survey Results Summary

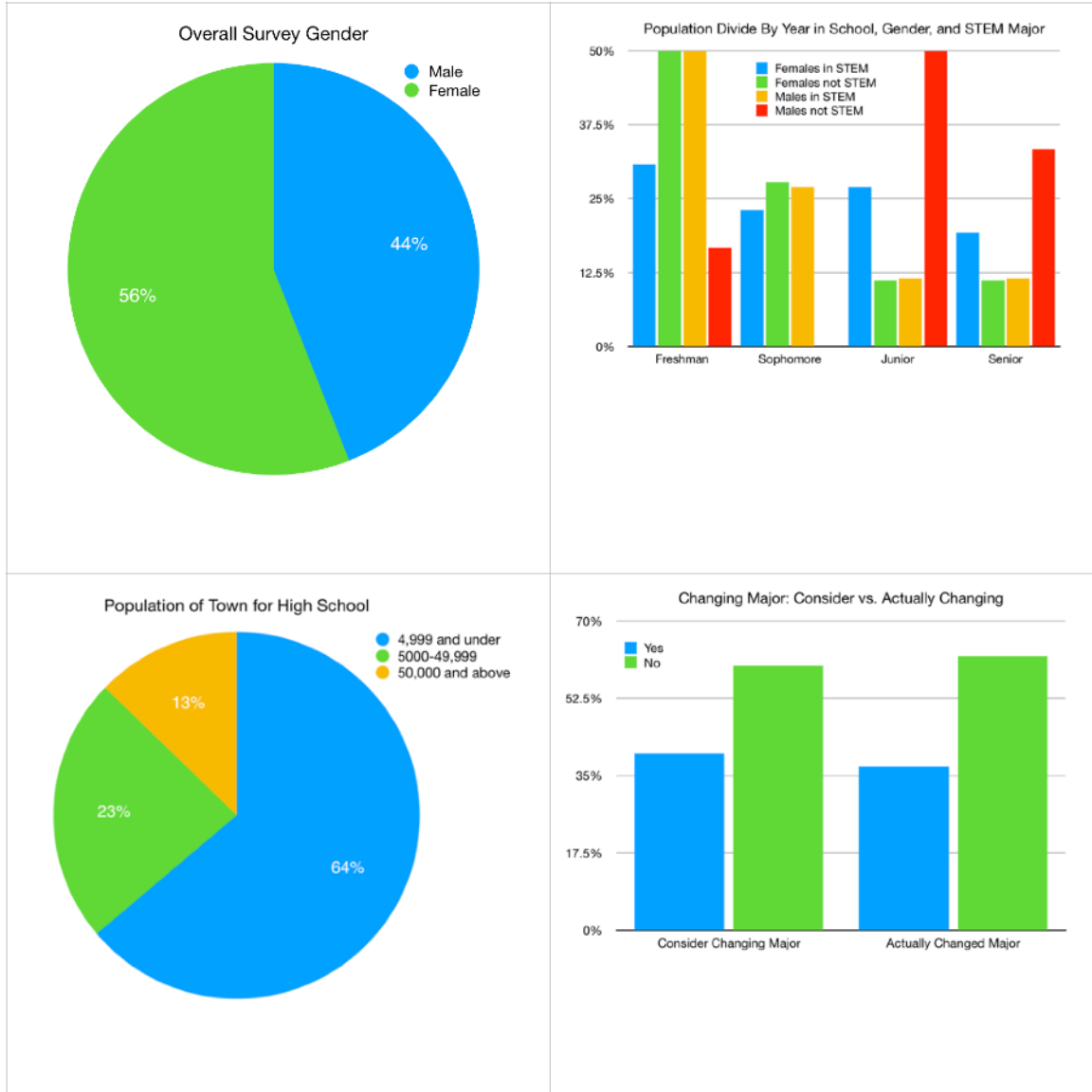
Question	Data
STEM Major	70% in STEM, 30% not STEM
Feeling Background Differed from Others	60% Yes, 40% No
Top Areas of Missing Background	Math, Engineering, General College/University Knowledge
Grades Influencing Decision to Stay at WVU Tech	74% Yes, 26% No
People Discouraging Staying in College	22% Yes, 78% No
Top Three Campus Services Used	Advising, TRIO, Tutoring
Member of Student Organizations and Helpfulness	70% Yes, 30% No, 93% feel it is helpful, 7% do not
Importance of Student Organizations	49% Yes, 51% No

Results

Approximate fifty-five percent of the survey respondents were female students and sixty percent of those students planned to major in a STEM field. Of the female students, thirty-three thought about pursuing a STEM major but decided not to and, overall, forty-two percent considered changing majors at some point. (Also, the same percentage reported changing a major at some point). The general background information of the responses from the survey were summarized

in Table 2 and Table 3. Table 4 compared the female vs. male data and Table 5 summarized some of the Female STEM themes examined by the authors.

Table 3: General Population Survey Result Graphs



Overall, there were no differences in the numbers of first generation students between the male and female populations. the majority of students surveyed attended high school in towns with 5,000 people or less and this remained true regardless of which subgroup of the population was examined. However, when comparing the male STEM students and the female STEM students, there were differences within the students not from a small town. More of the female STEM students attended high school in towns with population within 5000-49,999, than the male STEM students. However, more male STEM students went to high school in towns with populations 50,000 and above than the female STEM students (27% vs. 8%). Eight-one percent of the male

STEM students were majoring in engineering (i.e., chemical engineering, civil engineering, computer engineering, and mechanical engineering, etc) and only nineteen percent were majoring in the various science fields. Sixty percent of the female STEM students were majoring in the various science fields (e.g., biology, mathematics, computer science, chemistry, etc) with forty percent majoring in engineering.

Table 4: Female vs. Male Survey Summary

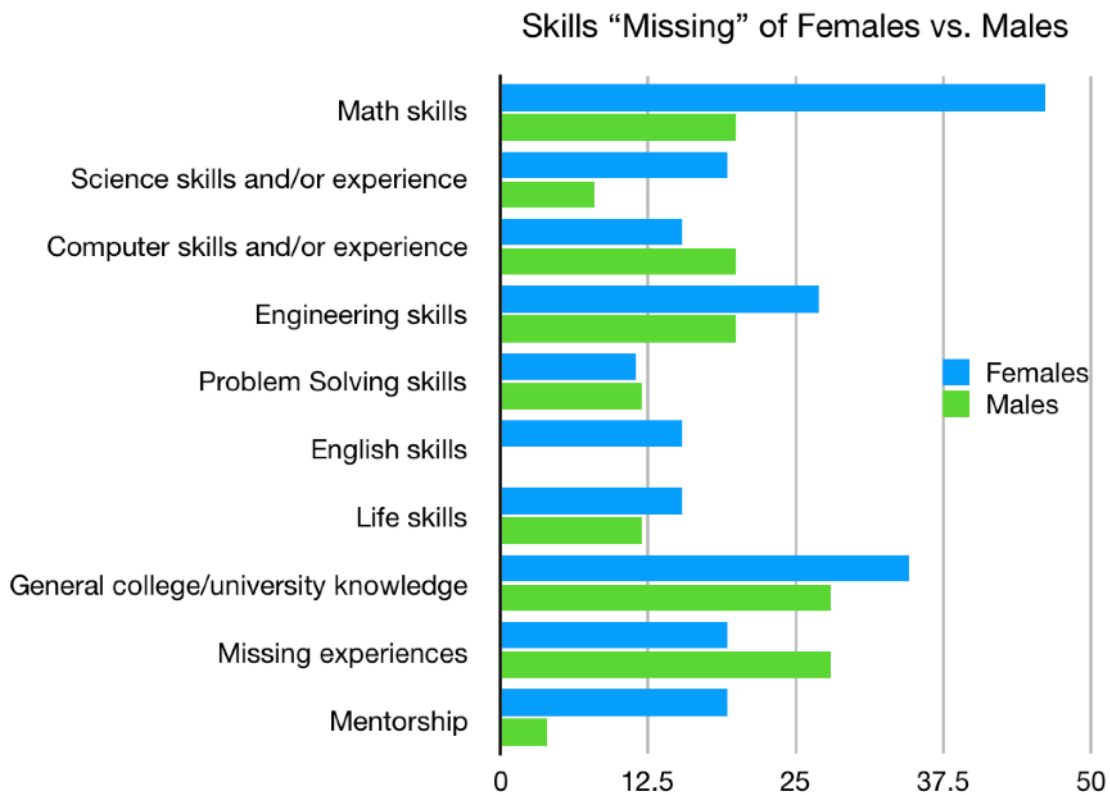
Question	Female Student Data	Male Student Data
Consider Changing Major	44% Yes, 56% No	27% Yes, 73% No
STEM Major	61% Yes, 39% No	83% Yes, 17% No
Consider a STEM Major, but changed or decided against	33% Yes, 67% No	40% Yes, 60% No
Member of STEM Organization	27% Yes, 73% No	47% Yes, 53% No
Feeling Background Differed from Others	63% Yes, 37% No	57% Yes, 43% No
Top Areas of Missing Background	Math, General College/University Knowledge, Engineering, Science	General College/University Knowledge, Missing Experiences, Math, Engineering
Grades Influencing Decision to Stay at WVU Tech	68% Yes, 32% No	81% Yes, 19% No
People Discouraging Staying in College	24% Yes, 76% No	20% Yes, 80% No
Top Three Campus Services Used	Advising, TRIO, Tutoring	Advising and TRIO (tied), Tutoring

Table 5: Summary of Themes for Female Students

Encouragement to Pursue College	Family (with a few citing faculty, career plans, and outside sources)
Encouragement to Pursue Major	Family, Faculty, Mentors, and Self
People Discouraging Staying in College	24% Yes, 76% No
Discouragement to Pursue College	Expense not worth it, Good jobs without a degree, Looked down at or implied bias, Implied lack of skill
Discouragement to Pursue Major	Gender issues, Unconscious bias by suggesting other fields, Expectations of knowledge of material never taught, Lack of Financial
Top Campus Services Used	Advising, TRIO, Tutoring, Adventures/Doughnuts with the Director (tied)

Female students reported slightly higher feelings in regards to lack of background at sixty-three percent but cited many of the same missing areas of background as the general student population. However, the male students and female students rank them differently. Male students cited general college/university knowledge and missing experiences highest. However, 46.2% of female students ranked math as the top background skill they felt they lacked, compared to only 20% of male students, despite having reported a similar background of math courses taken. Female students also reported having a lack of science skills at a higher rate than male students (19.2% vs. 8%). There was virtually no distinguishable differences between math high school courses taken between the male and female STEM students. Female STEM students reported a very slight higher rate of taking biology and chemistry courses. Fifty percent of the male STEM students took physics in high school but only thirty-two percent of the female STEM students took physics. (Fifty percent of the female STEM students took college writing portfolio while only thirty-three percent of the male STEM students took the same course). (Detailed data can be seen in Figure 1).

Figure 1: Differences in Skills Perceived as “Missing”



The encouragement to pursue college and pursue their major, like the general population, was primarily driven by various family members and in particular, parents. The students reported a wider range of sources (family, faculty, mentors, etc) for encouragement to pursue their major but the data showed no substantial differences between females and males. However, the female

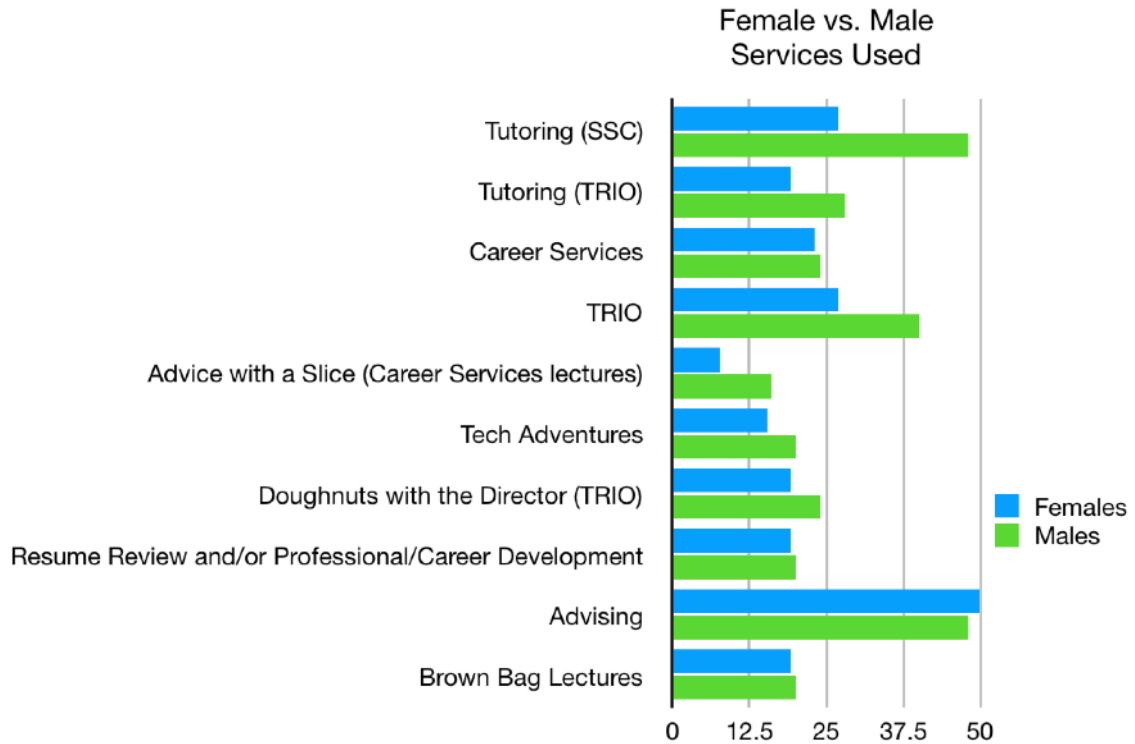
data showed a slightly higher number of student reporting themselves as a source of encouragement. 20% of female students also reported a lack of mentorship before and during college, compared to only 4% of their male counterparts.

Students, overall, reported various ways they were discouraged from pursuing college with females reporting a slightly higher percentage (23% female vs 20% male). Many reported very general discouragement related to the issue of college being too expensive for the return. Both genders reported discouragement relating to issues of intellect and ability, but the theme was more recurring and, in the authors' opinion from the anecdotal evidence, more strongly worded for the female survey respondents. Female students had a higher rate of reporting gender related issues when asked about discouragement to pursue a major, especially for STEM fields. Male students reported less discouragement of their major overall.

Both male and female students felt that student organizations were doing a good job of bringing students together (92% vs. 100%). However, 54% of male students are members of STEM organizations compared to 39% of female students. Of the students who belonged to STEM organizations, the students believed strongly (96% and 100% respectively) that these organizations were helpful. The general population (both men and women) suggested that student organizations on campus should have more social / fun activities, but 31% of female students ranked this as a top priority compared to 16.7% of male students. Overall, all students cited creating rooms for these organizations as a high priority, but STEM students focus was on that organization study space along with wanting higher rates of mentoring and faculty interaction. The female student data showed a similar trend, but included an additional desire for more career development workshops and events.

Both male and female students reported using the same top three services: advising, tutoring, and TRIO (as seen in Figure 2). However, the genders ranked them differently. Female and male STEM students met with their advisors regularly at the same rate 50% vs. 48% respectively. More male STEM students reported receiving tutoring than the female STEM students (48% vs. 26.9%). For both genders, about half of the students were first generation (male 50% and female 53.85%), but only 26.92% of the female students were members of TRIO compared to 42% of the male students. Additionally, while career development and resume review services were used at the same rate for both genders, male students were twice as likely to attend Career services lectures for additional advice. Anecdotally, some female students felt that the lectures on how to dress for interviews and business were directed to male students. Because of this, female students were asked to provide specific questions before these lectures and their concerns are now being addressed in each lecture. Additionally, the events were moved to a more central location on campus. Attendance, both overall and for female students in particular, is slowly increasing.

Figure 2: Differences in Services Used



Conclusions

The female STEM students took a wider range of courses (e.g., college writing portfolio) than their male counterparts, but took similar math and science courses with the exception of physics. However, female students are more likely to report that they are missing math and science skills, and 80% of female students report that grades influence their desire to stay in their major, compared to only 56% of male students. Despite this, male students are much more likely to seek out tutoring. The authors believe that female students are more likely to think that they either “have what it takes” or not and this will be reflected in their grades. The data shows that female first generation students are also not joining programs like TRIO (aimed specifically to help first generation students), which the authors believe is a contributing factor to these students avoiding STEM fields. The male students were more likely to be members of STEM organizations and other support programs on campus, which may be why they feel a much lower need of mentoring. Increasing peer and faculty mentoring for our female students as well as encouraging them to join STEM organizations may help fill some of these missing experiences for female students. The authors are recommending to WVU Tech that they specifically target female STEM and female first generation students during orientation with information regarding the services available on campus and the student organizations that they could become involved in.

Future Work

Given the themes that emerged from the above data and a desire to help future generations of female students, the authors would like to survey students deeper on these issues in order to gain a better understanding of the challenges faced by undergraduate female students. In particular, it would be interesting to explore the backgrounds and experiences of STEM students of both genders further to identify possible outreach or first-year STEM courses that would help all students be better prepared for a STEM major and increase success of a completed STEM degree. Additionally, the authors are preparing to extend this study to a larger survey population by giving it at other universities, thus, determining if the themes identified in this paper are specific to WVU Tech and their unique university environment or are recurring at multiple universities in a variety of sizes and locations. From the survey data, the authors' hope to add a mentoring program through a Women in STEM student organization at WVU Tech and survey students on the affects this program has on the students.

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