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Empowering Female College Students in Pursuing Careers in Science, Technology, Engineering, and Mathematics (STEM)

Jordan Armstrong

Spring 2023

Senior Capstone

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Abstract

As the STEM field continues to grow, it is evident that there is a need to close the gender gap between males and females. This senior capstone examines the evolution of the acronym STEM and how programs have attempted to narrow the gender gap, but it is not easy to completely close the gap. Through a literature review and surveys with educators at the high school and university levels, this research project looks at the factors that have empowered female students to pursue careers in STEM. The findings provide insight into what has led female college students to pursue careers in STEM.

Introduction and Background

The acronym STEM has become an overarching term for a section of education and careers over the past decade. STEM relates to the educational fields of Science, Technology, Engineering, and Mathematics. When looking back at the first use of the acronym, "...was introduced in 2001 by scientific administrators at the U.S. National Science Foundation (NSF)..."(Hallinen, 2023, para. 1). The term was first coined back in 2001. While the acronym was not in the current form we know today, it was rearranged by biologist Ramaley(2001), going from Science, Mathematics, Engineering, and Technology (SMET) to Science, Technology, Engineering, and Mathematics (STEM). Even though it is a relatively new way to discuss this section of education and careers, it has become widely used.

The career fields that make up STEM have had a massive impact on the evolution of STEM education. Efforts have been made worldwide to expand the workforce that makes up the field. This has caused a growing "...importance placed on the role of educational programs in preparing students to participate in the workforce and compete in the global economy was signaled by the continued participation in the early 21st century of dozens of countries in the periodic international comparisons (TIMSS and PISA) of student knowledge and skills…"(Hallinen, 2023, para. 10). Emphasizing preparing students for a career in STEM has allowed the field to grow in opportunities, especially as our world moves forward in technological advances. STEM fields include but are not limited to Professional Hacker, Data Scientists, Nuclear Engineers, Chemical Engineers, Spotify Learning Engineers, Legoland Designers, STEM Specialists for Discovery Education, K-12 STEM Educators, Astronauts, and Technical Writer(JMU, 2023). There have been countless advancements in the fields, but there

continues to be a common thread that is continuing to be addressed. Various groups continue to be underrepresented in these fields, specifically women.

Women have been underrepresented in STEM-based fields for years. While females have been making gains toward reducing the gender gap, there are still wide gaps in careers like physics and computer science(Kantrowitz, 2022, para. 2). Females worldwide and in our country play an integral role in the advancement of society. Being underrepresented in STEM fields is a necessary issue that needs to continue to be worked towards solving. By looking at preparation and outreach programs, we may find trends in what empowers female students to pursue careers in these fields.

My primary research question that will drive my research is: How are female college students empowered to pursue careers in Science, Technology, Engineering, and Mathematics? The following questions will continue to move my research forward and develop my literature review: What is STEM? What does a STEM career look like, and how has it evolved? What does the research say about empowering female college students to pursue STEM careers? How were current female students attracted to pursue careers in STEM in high schools and at the college level? What are some ways female students were empowered to pursue careers in STEM? Are there programs at high schools and colleges or universities designed to empower female students to pursue STEM careers? If so, how are they implementing their programs? How could high schools, colleges, and universities increase the number of female students pursuing careers in STEM to bridge the gap between the numbers of males to females?

To answer the previously stated questions, I have looked into the current literature that was available at the time.

Literature Review

Science, Technology, Engineering, and Mathematics have long been male-dominated. Throughout the educational journey of many females, they have been pushed away from these fields, reducing the possibility of them striving to pursue one of the careers. There is a wide gender gap in the STEM fields, and proportionally, "...Women make up only 28% of the workforce in science, technology, engineering, and math (STEM)..."(AAUW, 2023, para. 2). While different fields have a different gender gap, almost three-quarters of positions in STEM are held by males overall. With males holding the vast majority of positions, entering a field with very little representation of women can be intimidating.

The limited representation of women can be linked to a number of factors like stereotyping and negative bias. Some stereotypes are fed into the educational system surrounding STEM subjects from a young age. There is usually a heightened focus on male figures in STEM than women(Ramsey et al, 2013, para. 5). When discussing subjects like math and science, many inventions and advancements are from male figures, and rarely is a female name associated with the topic. Stereotypes are another impact on the gender gap that harms the number of women we see in the field. Being male-dominated can cause the work environment to be unwelcoming to women who are entering. This can "...remind women that others expect women to have a weaker math and science ability than men, thus heightening awareness that they may be judged in terms of this stereotype(Ramsey et al, 2013, para. 4). Changing these factors that dissuade women from entering the STEM fields can be remedied and reduced by aiding the work of various private organizations. However, there are ways that organizations like universities have continued to narrow the gender gap.

As research has continued to identify the potential problems leading to a wide gender gap, substantial research has been conducted to test potential solutions. Stanford University has encouraged campus groups to work together to "...amplify and encourage the influence of women in STEM"(Kubota, 2020, para. 1). As stated previously, the gap has been decreasing, but one group from Stanford noticed that as positions in STEM become more senior, the gap increases once again. As a group, they work within the community to support and develop the desire to work in STEM with many women. They have created a safe space for women to learn about STEM and create a community of women that can support each other. Kubota (2020) asserted that:

> "The Women in STEM groups at Stanford support many activities, bridging professional, personal and cultural enrichment. They host networking and career development events, where attendees can find mentors, meet with industry professionals and learn how to ask for raises. They have informal community-building events, like paint nights and hangouts to discuss the week's highs and lows. Hermanas in STEM and the Society for Advancement of Chicanos and Native Americans in Science co-host Háblame, a catered lunch at the School of Medicine where everyone speaks Spanish"(para. 11).

As a group, they are following one of the many steps discussed by the Guevara-Ramírez team to help empower the number of women in STEM. More specifically, they are following "Rule 2: Empower other women through solidarity between them"(Guevara-Ramírez et al, 2022, para. 11), which aims to create solidarity among women in STEM fields. To continue to empower women in STEM, Guevara-Ramírez et al (2022) state that there are overall ten distinct rules. However, in most cases, bringing women together as groups continues to be the most common response to narrow the gap.

The constant influence of quality STEM education from a young age can also increase the likelihood of a young girl choosing to enter a STEM field when she is older. Beginning in

early education, "... [fewer] girls are willing to engage in STEM activities with age, and lower levels of participation are already observed in advanced studies at [the] secondary level"(Yabas, Kurutas & Corlu, 2022, p. 249). As the research evolved, they began to notice that not only did girls lose interest in early education, but it actually began in preschool. This means that girls are already being pushed away from STEM education from as early as three to four years old. To combat this, having programs to intervene with this separation are critical. As a general rule, encouraging STEM education can start at home through the type of toys bought for young girls. In many situations, when looking at toy buying patterns, "... it is common to give science-related toys to a boy, a stereotype that might incline boys toward science careers"(Guevara-Ramírez et al, 2022, para. 35). On the other hand, it is amplified when similar patterns are conducted at schools. Actions such as buying toys add to the prejudice that boys are more suited for STEM-related careers than girls.

Another baseline to increase the number of females in STEM would be to avoid the "Matilda" Effect. Science historian Margaret Rossiter "...coined her most famous expression, the 'Matilda Effect,' to describe the bias that denies recognition to women's work."(Guevara-Ramírez et al, 2022, para. 6). Even though this phrase dates back to 1993, it can be continuously used to address the position we are still currently going through. Rossiter originally had this phrase to demonstrate the more generalized effect that is seen when there are fewer women in the workforce, but it has continued to be used to define the evolution of the gender gap in STEM. Guevara-Ramírez et al. asserted that:

> "While women have gained significant ground in the scientific world, there is still a lack of recognition. For example, enterprises tend to hire men, rate them better in their applications, and pay them higher salaries. Furthermore, reviewers tend to give positive comments on scientific papers in which men are the first author. There is also a disproportionate number of citations to studies written by female scientists and

> fewer award nominations and collaboration opportunities for women. Thus, it is important to eliminate the 'Matilda Effect' to ensure the recognition of women's work and scientific achievements"(para. 7).

To continue to fight the gender gap and the overall "Matilda Effect," we must continue to find ways to create inclusive workplaces, spread women's work on various platforms worldwide, work towards gender-neutral hiring practices, and continue to support young girls in STEM fields.

All over the United States, some programs are doing their part to bridge the gender gap evident in STEM fields. Some are year-long programs, while others run like summer camps and are more short-term. These programs are designed to empower young girls to pursue careers that fall under the umbrella of STEM or even allow them to feel that they have a place in the field. Programs like *Girls Develop It, STEM For Her, Women Who Code, Girls Who Code, IGNITE Worldwide, Techbridge Girls,* and *Girlstart* are some of the few programs that are available in the United States(Coster, 2021, para. 10-34). Most of these programs lean towards the technology part of STEM, but their goals are similar. They are all here to give young girls a chance to see themselves in the fields of STEM. Some provide trained teachers, field trips, scholarships, study groups, and the ability to participate remotely. Even a few are award-winning programs, like *Ignite Worldwide* (Coster, 2021, para. 20). They are doing what they can to reach these young girls and are even providing resources to those in less fortunate socioeconomic backgrounds. While programs may start the fire inside of these young girls to pursue STEM careers, there are still so many other advocates that can continue to do to push them through to college.

On a smaller level, having role models and mentors for young girls can and should be highlighted. Having a guiding figure and someone these young girls can relate to will allow them to see themselves in the fields surrounding STEM. Thompson (2023) notes that "by providing

guidance and support, mentors help females overcome obstacles, navigate their careers, and shatter the glass ceiling. The significance of mentorship cannot be overlooked, and many successful women in STEM have cited mentor guidance as critical to their success"(para. 4). It allows women to be heard and know they can look to someone in a time of need. Giving mentors the necessary tools to support their mentees will give them the chance to work in a place of STEM while having the resources to succeed.

The government has even continued to try to reduce the gender gap that is seen in the STEM fields. Since the 1970s and the introduction of Title IX, there has been an increase in the number of women continuing their education, but they are still underrepresented in STEM fields. (Kong et al, 2020, para. 8). While laws like Title IX have been established to eliminate discrimination, the writing still has opaque areas. A cause of this is the difficulty when defining discrimination, as it can be easy to dismiss it as something else, and it varies from case to case. If there were specific and detailed definitions of what constitutes discrimination, we could continue to weed out discrimination in the workplace surrounding STEM(Kong et al, 2020, para. 15). Governmental steps have continued to be taken to narrow the gender gap seen in STEM. In 2021, "...The Women and Minorities in STEM Booster Act of 2021 (S. 2217 and H.R. 4366) seeks to increase the participation of underrepresented demographic groups in STEM fields"(Kantrowitz, 2022, para. 21). This bill aimed to bring funding to various online, outreach, student mentoring, and recruitment programs for underrepresented groups in STEM, including women. Unfortunately, this bill died in Congress, demonstrating the vast need for funding for these programs to build the country(U.S. Congress, 2021). However, on a smaller scale, it would have provided resources for girls and women to begin their journey toward STEM fields.

While there are massive forms to decrease the gender gap, to understand the drive for current female college students, I developed specific methods to collect data.

Methods and Procedures

At the beginning of the semester, I was still deciding what to focus my capstone on, but finding a topic related to my minor in Mathematics was a priority. I began by looking back at my time at California State University, Monterey Bay, in math courses to find any inclination that would spark my interest. One thing that immediately caught my attention was the small proportion of female students in my upper-division coursework. There have always been rumors about the gender gap between males and females in the STEM fields, and this became the spark that I wanted to investigate for my capstone project. Upon meeting with Dr. Thao, I narrowed my research to look at the sources that empower female college students to pursue careers in science, technology, engineering, and mathematics (STEM). To thoroughly conduct my research, Dr. Thao and I came up with primary and secondary research questions that would be the map of my research.

Over the course of four weeks, I continued to find literature that was relevant to my research questions. I was able to find sources from other individuals that had noticed the same phenomena and were able to work towards solutions to reduce the gender gap in STEM-based fields. As my research continued, I went to two Mathematics Professors to help gain data from current female students about their journey toward obtaining a career in STEM. I conducted two surveys developed around the information I had gathered from my literature sources. The first survey was for current female students (See Appendix A for Anonymous College Student Survey Questions), and the second was for the two professors (See Appendix B for Anonymous

Professors Survey Questions). The two female professors helped me obtain data by sending the survey to female and female-identified students in their courses.

With their help, I got responses for the student survey that brought a lot of insight into my primary research question. I had my survey open for about three weeks, but around the two-week mark, responses slowed down. Even though my responses slowed down, the responses that were received helped me to answer my research questions.

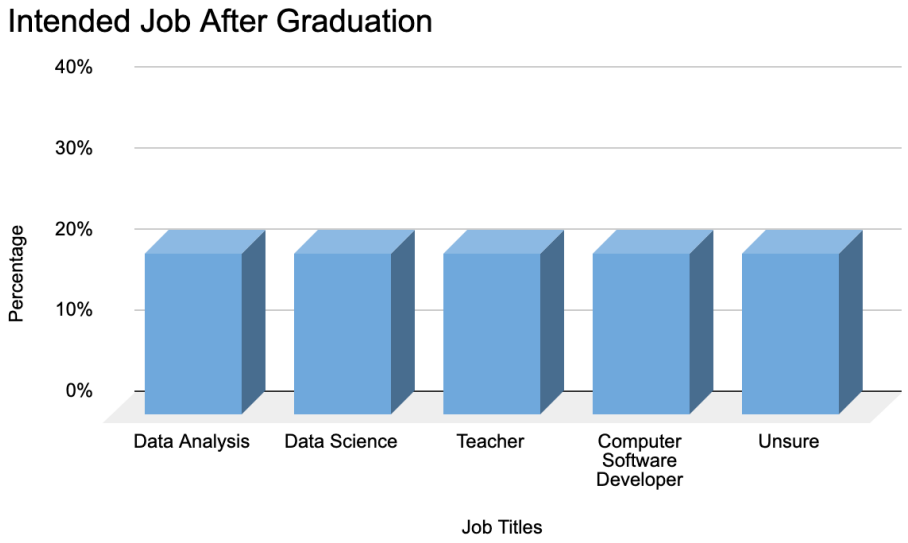
Results, Findings, and Discussion

What is STEM?

The acronym STEM relates to the subject fields of Science, Technology, Engineering, and Mathematics. While STEM relates to subject matter taught in school from elementary to the university level, it also encompasses professional careers in those fields.

What does a STEM career look like?

The usual STEM careers include Data Analysis, Chemical Engineering, Educators, Aerospace Engineering, Geologists, and Mathematicians, to name a few. Upon completion of the research, there were four specified careers that the female students shared in the survey that they intend to enter upon graduation. While five students answered the survey (See Appendix A for reference), only four jobs were listed, as one student needed clarification about the specific career they intended to pursue. Two students answered that they would enter careers surrounding the interpretation of data: Data Analysis and Data Science. The third student stated that they intended to enter the education field to become an educator, and the fourth shared that they intended to become a Computer Software Developer (See the graph below for the dispersion of the responses).

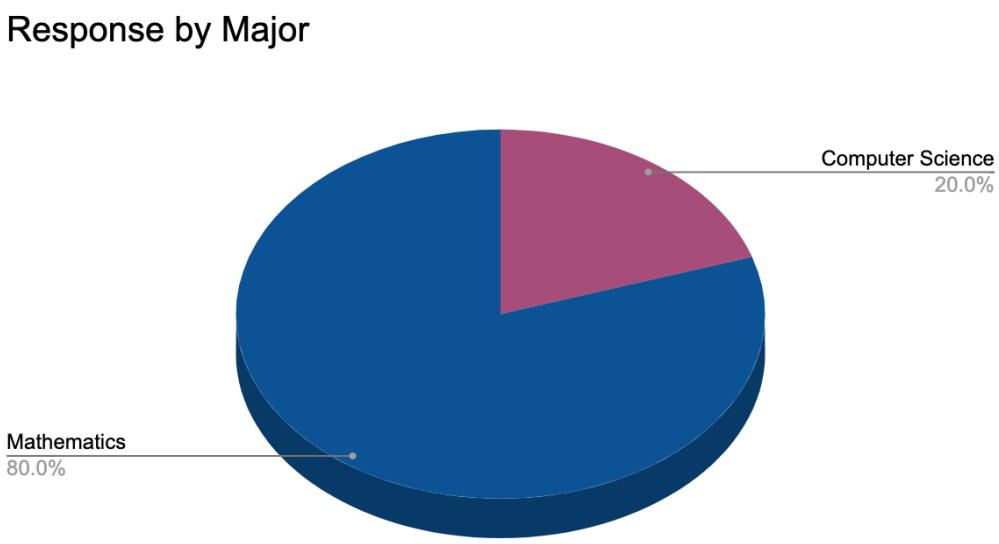


What does the research say about empowering female college students to pursue STEM careers?

Even with the gender gap closing in STEM fields, we must continue to empower female students to pursue STEM careers. Most of the effort needs to happen at a younger age before many are told or shown that it is historically a place for men. Making workplaces more accessible and less intimidating is one way to bring more women to the field, especially in male-dominated work environments. Research has also shown that the ability to bring awareness to women's strides in STEM can show younger females that their efforts are wanted in the field. The efforts can and should be made towards middle childhood and older; however, if we do not catch girls early on, there will continue to be fewer female college students to empower into STEM careers.

How were current female students attracted to pursue careers in STEM in high schools and at the college level? What are some ways female students were empowered to pursue careers in STEM?

When looking at the survey response from the female students in STEM-based majors (See pie chart below for dispersion of majors from the respondents), they all had a very similar answer. Influential people. Influential people in their lives or outside had all given the encouragement needed to pursue a future career in STEM. The five female students had all entered the STEM majors because they were encouraged to by people like their mothers, high school mathematics teachers, or other educators in their educational journey (See Appendix A for specific answers). Initially, it was thought that many responses would demonstrate the effectiveness of outside organizations; however, the data obtained from the survey demonstrates that for these female students, the encouragement came from people much closer to them.



Are there programs at high schools and colleges or universities designed to empower female students to pursue STEM careers? If so, how are they implementing their programs?

Various outside programs are designed to empower female students to pursue STEM careers. Coster (2021) mentions a few that can be seen nationwide and even worldwide: *Girls Develop It, STEM For Her, Women Who Code, Girls Who Code, IGNITE Worldwide, Techbridge Girls,* and *Girlstart*(para. 10-34). While these programs are private programs that run outside of a typical school day, some programs are funded by schools to foster that desire. Many colleges will run summer programs or camps that are designed for students to come and take part in STEM-related activities. Universities, like Santa Clara University, hold summer programs that reach children from early elementary to high school. On the other hand, it is not designed specifically for female students, which could eventually lead to young girls feeling the unwelcoming workspace that can deter them from entering the field later on. These programs are necessary to bring the STEM fields to young girls as long as they know the potential risks that could lead to girls pushing away from STEM.

Upon completion of my research, there were a few problems and limitations that became apparent.

Problems and Limitations

Over the course of obtaining data, I came across two significant problems. When getting answers to my survey questions, I only received five responses from students and one from a professor. Initially, I sent my two surveys to three different professors, each teaching approximately two to three sections of math courses. All three are female mathematics professors teaching upper and lower-division courses. Lower-division courses refer to the courses with

numbers from one hundred to two-hundred ninety-nine, and the upper-division courses are those with corresponding numbers greater than three-hundred. Two professors were able to respond to my initial emails asking them to share the survey with their female and female-identifying students. However, only one(Professor A) filled out the professor-specific survey. This was the first major problem that I faced in obtaining data. While one professor provided helpful information, I could have gained more insight if the second professor had responded.

The second significant problem I faced during this process was the limited number of student survey responses I received. The two professors mentioned before were able to send the survey out to their students. Professor A sent the survey out to two classes they teach, and Professor B sent out the student survey to three courses. The student survey was sent out to many students; however, I could only obtain five responses. This limits the amount of data to analyze and the ability to get a greater insight into the problem of the gender gap in STEM-based fields.

The overall problem faced during this process was the need for responses to my surveys. I had the surveys open for three weeks, but it may have been more helpful to try to go into the professor's courses to explain or ask students to complete the survey. I understand that this could have been a reason for the limited responses because it was something that students did not have to fill out. The optional survey resulted in fewer responses, limiting the total number of responses I received.

One question remained unanswered when it comes to limitations that were evident regarding the data collected. Upon completion of the survey, I realized that none of the students who responded stated that they had been empowered to enter the STEM field based on the support received from outside programs. I had no data supporting the following research questions: Are there programs at high schools, colleges, or universities designed to empower

female students to pursue STEM careers? If so, how are they implementing their programs? All of the students that shared their answers stated that a specific individual in their lives empowered them.

Determining the problems and limitations has allowed me to determine possible solutions to reduce the gender gap in STEM fields.

Recommendations

Throughout my research, it has become clear that two primary changes could be made in our educational system to decrease the gender gap in STEM-based fields. Introducing young girls from an early age to STEM is a great start. This could include actions such as having posters of prominent women in STEM in elementary school classrooms. Most of the time, posters represent male figures and their accomplishments in STEM. However, if we can provide the exact representation in classrooms, starting at the elementary level, we could foster the idea that STEM fields are a place for women. This can continue to be amplified by presenting or acknowledging women in STEM advancement. Media like books or videos provided to students about these women would also provide supplemental information to allow young girls to see themselves in a STEM-related field.

As female students move through their education, adjusting how they are given STEM support could also increase the number of female students who decide to pursue STEM. This could be accomplished by providing a non-competitive environment for female students to engage in STEM activities. Joanne McGrath Cohoon, an associate professor in the Department of Science, Technology, and Society at the University of Virginia, says, “Research has shown many girls and other underrepresented populations value interaction and collaboration over competition. Create a learning environment where all students’ ideas and contributions have

value to create a space where different ideas, solutions and ways of thinking can be celebrated!"(Major, 2018, para. 7). With non-competitive environments, we could hear from all and demonstrate the value of each individual's input toward the discussion. We continue to widen the gap when we limit and support only one side of the viewpoints.

Conclusion

Increasing the number of women in STEM is crucial for the longevity of the fields but also for decreasing the gender gap further. There continue to be efforts made to reduce this gender gap, such as outside programs expanding their outreach, mentors engaging female students, and the push to make STEM education more accessible for female students. Upon asking current female college students what empowered them to pursue STEM, the overwhelming majority stated that mentors in their lives were. Continuing to mentor young girls toward STEM will forever decrease the gender gap. As young girls see themselves represented in the fields, they will continue gravitating toward these programs. However, if we continue to push young girls away from STEM, the gap will widen, and we will lose more female students in the efforts to make STEM more accessible.

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Appendix A

Anonymous College Student Survey Questions

1. What is your current major? (Written Response)

   80% - Mathematics 20% - Computer Science

2. When is your intended graduation?

   Spring 2023 - 40% Fall 2023 - 0% Spring 2024 - 40% Fall 2024 - 20%

   Spring 2025 - 0% Fall 2025 -0%

3. Are you planning on entering the STEM field after graduation?

   Yes - 100% No - 0%

4. What is your job goal after graduating college? (Written Response)

   Data Analysis - 20% Data Science - 20% Teacher - 20%

   Computer Software Developer - 20% Unsure - 20%

5. Have you changed your major since starting your college journey? If yes, please state your previous major and why.

   Yes - 40% No - 60%

   English - 1 Chemistry - 1

6. Did you start your college journey at a community college or come straight to the university?

   Community College - 60% Straight to University - 40%

7. Were there outreach programs at your high school or college to encourage female students to pursue STEM-related majors? If yes, please name the program.

   Yes - 0% No - 100%

8. If it was during your years at high school, what grade level was the program trying to reach?

   Freshman - 0% Sophomore - 0% Junior - 0% Senior - 20%

   Not at the high school level - 80%

9. If it was during your college experience, what classes were more prevalent for having representatives come to inform you about the program? (Written Response)
    - N/A - 80%
    - Major Proseminar, Data Visualizations, Math 320 (mostly professors who knew more about programs)
10. If there was no outreach program, was there an individual who encouraged you to pursue a STEM-related major? If yes, please state their relationship to you. (Written Response)
    - N/A
    - “My decision to pursue a STEM-related major came from the support of my family members and math teachers throughout my high school years.”
    - “high-school teacher”
    - “My mother is an electrical engineer who encouraged me to pursue a STEM field.”
    - “yes, my high school teacher”
11. If there was no outreach program or individual, who encouraged you to pursue a STEM-related major, who/what encouraged you? (Written Response)
    - “Truthfully I didn’t think I could make or find a good-paying job with my English degree.”

- “I had always admired women figures in STEM, and seeing others do it encouraged me to pursue my decision.”

Appendix B

Anonymous College Professor Survey Questions

1. What is the area of your highest degree?
2. What/who empowered you to pursue a degree in a STEM-related field?
3. Did you know before starting your degree that you would pursue a STEM-related major, or did you change your pathway during college?
4. Did you hold another profession before becoming a professor?
5. Have you seen a rise in female students over the years you have been a professor?
6. In your experience, are there more female students in your lower or upper-division college courses?