The University of Maryland, College Park

Female Representation and Recruitment in STEM

A Qualitative and Quantitative Approach

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Professor,

I am writing to inform you about the progress and findings of my final research project. My research was motivated and inspired by my own observations throughout my time at the University of Maryland, and I wanted to see if I could support my observations through both primary and secondary research.

The goal of my project was to investigate the under representation of women in STEM fields at the University of Maryland. To gather data for my research, I conducted both interviews and surveys with students from all backgrounds. This included all genders, majors, and class standings. With the wide spread of data, I hoped to draw significant differences from distinct populations.

Through my research, I found that there is indeed a significant under representation of women in STEM fields at the University of Maryland. In my interviews, several female students and faculty members reported experiencing discrimination and bias in their academic and professional careers. These experiences often discouraged them from pursuing careers in STEM or made them feel unsupported in their studies.

The survey data also reflected these findings, with a large percentage of respondents reporting that they have witnessed or experienced gender discrimination in STEM fields.

Overall, my research strongly supports the conclusion that there is a need for greater support and inclusion of women in STEM at the University of Maryland. I believe that addressing this issue is crucial not only for promoting gender equality, but also for the success and innovation of the STEM fields at the university.

Thank you for the opportunity to conduct this research and for your support throughout the project.

Sincerely,

Omeed Zarrabian

Dear Members of the University of Maryland Community,

My name is Omeed Zarrabian, a current Junior at the University of Maryland, College Park studying Computer Science and Statistics. Throughout my coursework at the university, I have sat in many classrooms, multiple study groups, and interacted with a diverse range of undergraduate students and university faculty. With these experiences, I believe I am well equipped to comment on and conduct research as it relates to our school.

I am writing to bring to your attention the important issue of under representation of women in STEM fields at our university. As a student researcher, I have conducted a thorough investigation into this issue through interviews and surveys with students and faculty in STEM departments.

My findings confirm that there is indeed a significant lack of representation of women in these fields at the University of Maryland. Many female students and faculty members have reported experiencing discrimination and bias in their academic and professional careers, which can discourage them from pursuing STEM fields or make them feel unsupported in their studies.

This is a deeply concerning issue that needs to be addressed to promote gender equality and support the success and innovation of STEM at our university. I believe that by working together, we can create a more inclusive and supportive environment for all students and faculty in STEM fields.

I am looking forward to you having a chance to take a look at my research, as well as responding your comments/feedback. Furthermore, I hope that this letter will bring awareness to this important issue and encourage members of our community to take action to address it. Thank you for your attention to this matter.

Sincerely,

Omeed Zarrabian

*Executive Summary*

I went through my undergraduate coursework until my 1st semester of Junior year without having a single female professor in any of my classes, and still yet to have any female professors in my major classes. My experience was not unique, many of my peers and interviewees have had the same experience: completing their undergraduate coursework with no female professors.

Current initiatives to help bridge the gap of females in STEM include hackathons for underrepresented groups, scholarships, and women in STEM support groups and organizations. While these initiatives have their place and have been incredibly helpful, there might be a better solution.

The solution I want to propose is to increase the number of female professors in our STEM departments, and more specifically: Computer Science Departments. Having more female role models in these positions can encourage and inspire young women to pursue careers in STEM. It can also create a more inclusive and supportive environment for all students and faculty in STEM fields.

I suggest that the ratio of female to male professors to female to male students in STEM departments must be at least proportional, if not (and hopefully) greater.

First, having more female role models in the STEM field can be inspiring for female students. Seeing someone who looks like them and shares similar experiences succeeding in a STEM career can help female students feel like they too can pursue a career in STEM. This can be especially important for students who may not have many other female role models in their lives or who may feel like they don't fit the stereotype of a typical STEM student.

Second, having more female professors can help create a more welcoming and inclusive environment for female students. Female professors may be able to better understand and address the unique challenges and barriers that female students face in the STEM field. This can include issues such as a lack of confidence, a lack of support from peers or mentors, or a lack of representation in course materials.

Finally, having more female professors can also help to break down stereotypes and biases that may exist within the STEM field. When students see a diverse group of professors who are all successful in their careers, it can help to challenge any preconceived notions they may have about who can succeed in STEM. This can create a more inclusive and welcoming environment for all students, regardless of their gender.

Overall, increasing the number of female professors in STEM fields can help to inspire and support female students, create a more welcoming and inclusive environment, and challenge stereotypes and biases. This can help to bridge the gap of females in STEM and create a more diverse and representative community of professionals in these fields.

Introduction

In High School and more so in colleges/universities, the ratio of women faculty in STEM leads to an uncomfortable environment where female students are less likely to succeed and continue to pursue their academic endeavors. It may be true that professors are just professors, so one may argue that the gender of a given instructor does not matter. However, when women compromise only just 21% of full professors in STEM fields, and an even smaller 5% in engineering disciplines (Elbright, 2018), it presents a major challenge to female students. Having all male professors for many female students in STEM does not allow them to have a role model figure throughout their coursework. It also leads to a negative self-fulfilling prophecy that maybe being in STEM is not their calling, as they continue to observe a lack of women in the profession they are trying to pursue for themselves.

Furthermore, a lack of female professors leads to a toxic environment for female students where their male counterparts are less likely to collaborate with them or take them seriously (APA, 2014). For example, in the ever-growing field of computer/information sciences, only 16% of bachelor’s degree recipients are women (Forbes, 2022). In addition, women have a 23% higher drop-out rate than men in STEM majors throughout college (Forbes, 2022). From a purely moral standpoint, it is unfair to many female students trying to pursue academics and a future career in STEM.

These roadblocks and struggles that many female students must face may have hidden consequences that often go unnoticed:

The lack of female students in STEM is digging into the potential talent pool that companies can recruit from, and many companies are outsourcing jobs in other countries due to a lack of talent. Recruiting employees from other counties can increase costs for the company itself due to visa sponsorships and relocation assistance, which can likely decrease the raw amount of people the company can hire. The demand in STEM jobs is not slowing down anytime soon and is projected to keep on growing for the foreseeable future.

Additionally, there are very few female scientists who are mentioned in STEM fields, which makes history not on the side of women in these fields. Since men have historically predominated in STEM professions, it is considered taboo for women to pursue careers in science and technology. Women may feel stereotyped in certain disciplines, which may discourage them from pursuing these degrees or careers. The disparity in gender representation found over time may explain why there are fewer men than women working in certain industries.

Secondary Research:

Before conducting primary research, I looked at the information already made available and tried to widen my knowledge of the topic at hand.

The first notable statistic I found is that current computer science stereotypes became ubiquitous in the U.S. during the PC revolution. Before that, women earned a significantly higher proportion of undergraduate computer science degrees—37% more than they do today (Cheryan, 2022). This demonstrates that the problems I have identified do not yet have sufficient solutions.

According to the Organization for Economic Cooperation and Development (OECD), these countries have the following percentage of women in their nation’s STEM workforce:

* Sweden: 45%
* Finland: 42%
* Armenia: 42%
* Canada: 37%
* Australia: 35%

In comparison, the US comes in at 28%, which is even below the international average, which is calculated to be 29%. One may argue that these are all countries that “empower” women or traditionally have had gender equality throughout their history, unlike the US. However, this counterargument can easily be shut down when countries like Jordan and Iran who have a history of having gender inequality have higher percentages of women in their STEM workforce. For example, Jordan’s STEM workforce is made up of 40% women (Mastroianni, 2018). Even more surprising is the fact that nearly 70% of university graduates in STEM are women (Aryafar, 2020). It is clear that it is not a matter of “history” or “tradition”, it more has to do with the infrastructure of education and the pipelines that enable women to succeed.

Kamelia Arafar, an executive vice president and chief algorithms officer for Overstock.com, states that American companies should strive for increased diversity and inclusivity throughout their organizations. She also states that “we also need to remember the value of our personal stories in influencing young lives. If young American women and girls, including immigrants and minorities, are going to embrace STEM, they’re going to need more support and role models.” Additionally, a 2018 study of 6,000 American young women conducted by Microsoft concluded that girls who know a woman in STEM are more than 70 percent more likely to know how to pursue a STEM career and what types of specific jobs might utilize a STEM skillset (Aryafar, 2020). Both a professional in the STEM field and a professional study concluded that role-models and figures to look up to play a big role in the recruitment and retention of women in STEM. This concept of having role models is no surprise, as this concept can be applied to many other walks of life.

So, it is now clear that women will be more successful in STEM fields with someone to look up to. Because many students don’t have an opportunity to network with female professionals in the industry, they need to have that “role model” while in college.

Chart

Description automatically generated with medium confidence(Zippia)

Shown by the figure above, the number of female professors and instructors has not increased at all and has stagnated for the last decade. In addition to having more role models for female students, there are several other reasons why there needs to be more female professors in computer science, and by extension all other STEM majors.

Diversity in the field is important for fostering a more inclusive and innovative environment. When a field is dominated by one group, it can be difficult for those from underrepresented groups to feel welcome and supported. This can lead to a lack of diversity in thought and perspective, which can limit the potential for new ideas and approaches to solving problems. Having a more diverse group of professors can help create a more welcoming and inclusive environment for students, which can lead to better retention and success for all students.

Additionally, having more women professors in computer science can help to address the gender pay gap that persists in the field. According to the National Center for Women & Information Technology, women in computer science careers earn, on average, 86 cents for every dollar earned by their male counterparts. Increasing the number of women in leadership positions in academia can help to improve the overall representation and advancement of women in the field. While not directly related to attracting more female students, bridging the wage gap will have trickle-down effect which will lead to more females wanting to pursue a job in academia.

Chart, pie chart

Description automatically generated (The Brown Daily Herald)

Professor of Physics Meenakshi Narain of Brown University states that the gender gap in university faculty is indicative of a nationwide lack of pipelines for women studying STEM disciplines to enter academic careers (Mehta, 2022). Again, Professor Narain noted the importance of role models in motivating students to eventually pursue faculty positions.

Yesenia Gomez, a mechanical engineering student at Brown University stated that “the professor’s gender does affect (a course’s experience) in terms of how comfortable I feel approaching the professor, the male students have a really easy time going up to the male professors” (Mehta).

Another student at Brown University, a physics major named Natalie Love added that “having woman professors provides “some sort of assurance that there’s going to be a baseline understanding of the unique challenges that you face.” She additionally stated that “There’s also that difficulty … of forming a connection with the professor because male professors are just going to be more receptive to male students and communicate in a more similar way,”

Through the experiences and comments of female undergraduate students at Brown, it is evident that not having enough representation throughout their professors poses a problem for them and may even potentially drive them away from their current major, and even future goals/aspirations as a result. The experiences of these undergraduate students are not isolated, they are shared by undergraduate students across the country, including students at the University of Maryland.

Primary Research:

To conduct my secondary research, I made my survey available online through a unique link and made it available to share between everyone. I disseminated it through fellow University of Maryland students via class group chats, my fellow peers, word of mouth, and social media posts. Through my survey, I hoped to gather responses highlighting the effects of not having diversity in each student’s respective department in their major. I then tried to link that towards the lack of diversity towards it influencing their career and/or academic choices.

My initial expectation is that the experiences of males and females in their academic careers will differ based on the answers to their questions. Quite often, I have heard the same issue I described echoed by my peers in classes and have seen some of the issues I highlighted firsthand. In terms of hypothesis testing, I stated that the null hypothesis is that the means between males and females are different, and the alternate hypothesis would be that they are different. I then transform the categorical answers into numerical answers once I get enough survey responses to calculate the means.

Let’s look at the questions:

Question 1: What is Your Gender?

* Male
* Female
* Other: \_\_\_\_\_\_

Question 2: What is/was your major?

* Computer Science/Engineering
* Any Engineering Discipline
* Any other STEM majors
* Other

Question 3: I have had a high school teacher or any other influential figure in my life influence my college major and/or career ambitions.

* Strongly Agree
* Somewhat Agree
* Neutral
* Somewhat Disagree
* Strongly Disagree

Question 4: I have felt uneasy approaching any of my teachers in my classes because of their gender or have been made uncomfortable by comments from a teacher/professor of a different gender.

* All the time
* Frequently
* Sometimes
* Rarely
* Never

Question 5: The lack of gender representation in my school’s faculty/professors creates self-doubt within myself to pursue my studies or career goals.

* All the time
* Frequently
* Sometimes
* Rarely
* Never

Question 6: There is a clear and lack of female representation in my area of study’s faculty and/or professor population.

* Strongly Agree
* Somewhat Agree
* Neutral
* Somewhat Disagree
* Strongly Disagree

Question 7: I hear sexist remarks in a classroom setting (lectures, in academic buildings, office hours, study groups, etc.)

* All the time
* Frequently
* Sometimes
* Rarely
* Never

Question 8: How many female professors have you had so far in your MAJOR undergraduate coursework? This includes only classes that are listed as a part of your major.

* 0
* 1
* 2
* Other: \_\_

Question 9: I aspire to either be a professor one day or would consider one day being a professor at a university or college.

* Strongly Agree
* Somewhat Agree
* Neutral
* Somewhat Disagree
* Strongly Disagree

Question 10: If you can speak to or have any stories relating to any of the questions above, please feel free to elaborate below:

* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

This survey aims to gather information about the experiences and perceptions of students with regards to gender representation in their academic lives. The questions cover a range of topics, including the respondent's own gender, their major and career aspirations, their perceptions of gender representation in their school's faculty and in their area of study, and their experiences with sexism in the classroom. The answers to these questions could provide valuable insights into the ways in which gender influences the academic experiences of students, and how these experiences may differ depending on the respondent's gender, major, and other factors. By analyzing the responses to these questions, it may be possible to identify patterns and trends in the data, and to identify areas where there may be a need for greater support or intervention in order to create a more inclusive and equitable learning environment for all students.

I included the last option so anyone could openly (and anonymously) speak about any experiences they had relating to the survey or their general experiences in their undergraduate education.

Before analyzing the numerical data, a lot of the students that responded to the last question of the survey share the same sentiments and feelings as the Brown University students that were previously mentioned. Let’s take a look.

One male student admitted to his friends talking down on women and belittling them in a classroom setting. A female student stated that “I have frequently heard that pretty girls do not pursue STEM fields, or that they go to college to find husbands.” There were two other responses which shed a lot of light on the whole basis of my research.

An honest and open female respondent stated that “While I no longer study STEM, in my experience from when I was for about 4 years, it is very clear as a woman that women are not respected in the field and underrepresented. In those 4 years, only one of my professors was a woman and in many of those classes I would be one of few women. Often times, my issue was not with the professors because many were great, it was rather my peers who spoke over me, diminish my feelings, and wouldn’t allow me to effectively contribute in group settings. Many of the men that are in STEM fields create very hostile environments and I know from experience that it drives many women away.” While the professors not being an issue according to this respondent, more female professors would make fellow male classmates respect and not talk down on their female peers.

Another respondent that attended high school in Iran and now attends school at the University of Maryland stated that “I experienced no sexism in high school in Iran. Most of my science teachers were female. And, most girls my age were interested in studying science (including engineering) or medicine. The situation was reversed in US. Most science professors were male and I heard from female students that they didn’t want to study science because it was hard or they wanted to start a family and didn’t want to work as a scientist. My father was my strongest advocate for pursuing science and have a career.” This response also helps shed light on the difference between different countries and why the US lags behind other countries in terms of gender representation in STEM.

There has been a significant increase in the number of women studying STEM fields in Iran in recent years. According to data from the Iranian Ministry of Science, Research, and Technology, the number of women enrolled in STEM programs at Iranian universities has increased by more than 50% over the past decade. In 2020, women made up around 40% of students enrolled in STEM programs in Iran. This could be partially attributed to the number of females teaching STEM, like the respondent described.

The respondents for my survey were all in STEM majors due to the fact that the survey got disseminated to my classmates and peers who are all STEM majors. Therefore, there is no need to distinguish between respondents as I can categorize them all to be a STEM major. The sample size was too low to distinguish between computer science majors and all other STEM majors as well.

Analysis of Data:

All my analysis of this data is done using python under the Jupyter Notebook development environment. The code to reproduce my analysis can be found after the analysis of data.

Graphical user interface, application

Description automatically generated

This image displays the initial first 5 rows of my data. Let’s look at the split of genders that took this survey.

Chart, pie chart

Description automatically generated

An even split of respondents by gender, totaling to a total of 32 respondents.

Let’s look at a heatmap (or correlation matrix) of the questions:

\*For reference, a heatmap/correlation matrix is simply a table which displays the correlation coefficients for different variables. The matrix depicts the correlation between all the possible pairs of values in a table. It is a powerful tool to summarize a large dataset and to identify and visualize patterns in the given data. It contains cells with values ranging form 0.00-1.00.

Graphical user interface, chart, PowerPoint

Description automatically generated

The diagonal across the correlation matrix will always have a correlation of 1.00 because you are correlating the same question, so the significant observations lie in the other cells. Cells with high correlation have values around 0.70 or higher, and cells with moderate correlation have values around 0.50. As we can see Gender and Question 5 have quite a high correlation with a value of 0.68. This means that females and males are likely to gravitate towards a certain answer for Q5 (The lack of gender representation in my school’s faculty/professors creates self-doubt within myself to pursue my studies or career goals.). Responses to Question 4 and Question 5 are also moderately correlated.

Here is the correlation matrix for responses for just women:

Graphical user interface, application, PowerPoint

Description automatically generated

In this matrix, it is conclusive that Questions 4 and 7 are moderately correlated. This can mean that there is a link between hearing more sexist remarks in the classroom and feeling uncomfortable approaching professors for women.

Next, I converted all categorical responses into numerical data in order to take averages for both women and men. Answers from the survey were ranked on a 0-5 scale, with a response of 5 being “All the time” and 0 being “Never”. The results are as follows:

Text

Description automatically generated

From this table, the first observation is that males and females had very similar responses to questions 3 and 8 on average. This means that males and females at the University of Maryland have similar feelings in terms of having people influence their college major and aspiring to one day be a college professor. So, no differences in that regard.

The biggest differences are in Questions 4 and 5. Females responded to Question 4 with near “Rarely” on average, while males responded to this question with a mix of “Rarely” and “Never” on average so it is clear to see that females feel more uncomfortable in the classroom due to their professor’s gender more often than males.

For Question 5, females answered near “Rarely” on average, while males averaged near “Never” on average. The result of this analysis shows clear evidence that women feel self-doubt as a result of gender representation in their departments faculty and professors significantly more than men.

Code Used for Analysis:

*The reproducible python code used for analysis:*

*import pandas as pd*

*import matplotlib.pyplot as plt*

*import seaborn as sns*

*import pandas as pd*

*import numpy as np*

*import plotly.express as px*

*df = pd.read\_csv('Survey.csv', encoding='ISO-8859-1')*

*df.rename(columns={"Q1: What is Your Gender?": "Gender", "Q2: What is/was your major?": "Major",*

*"Q3: I have had a high school teacher or any other influential figure in my life influence my college major and/or career ambitions.": "Q3",*

*"Q4: I have felt uneasy approaching any of my teachers in my classes because of their gender or have been made uncomfortable by comments from a teacher/professor of a different gender.": "Q4",*

*"Q5: The lack of gender representation in my schoolâs faculty/professors creates self-doubt within myself to pursue my studies or career goals.": "Q5",*

*"Q6: There is a clear and lack of female representation in my area of studyâs faculty and/or professor population.": "Q6",*

*"Q7: I have heard sexist remarks in a classroom setting (lectures, in academic buildings, office hours, study groups, etc.)": "Q7",*

*"Q9: I aspire to either be a professor one day or would consider one day being a professor at a university or college.": "Q8"},inplace = True)*

*df = df.iloc[:,:-1]*

*df.head()*

*def label\_function(val):*

*return f'{val / 100 \* Len(df):.0f}\n{val:.0f}%'*

*fig, (ax1, ax2) = plt.subplots(ncols=2, figsize=(10, 5))*

*df.groupby('Gender').size().plot(kind='pie', autopct=label\_function, textprops={'fontsize': 20},ax=ax2)*

*from dython.nominal import associations*

*categorical\_correlation = associations(df, figsize=(10,10))*

*women\_df = df.loc[df['Gender'] == "Female"]*

*categorical\_correlation\_women = associations(women\_df, figsize=(10,10))*

*df['Q3'].replace(['Strongly Agree', 'Agree', 'Neutral', 'Disagree', 'Strongly Disagree'], [5,4,3,2,1], inplace=True)*

*df['Q4'].replace(['All the time', 'Frequently', 'Sometimes', 'Rarely', 'Never'], [5,4,3,2,1], inplace=True)*

*df['Q5'].replace(['All the time', 'Frequently', 'Sometimes', 'Rarely', 'Never'], [5,4,3,2,1], inplace=True)*

*df['Q6'].replace(['Strongly Agree', 'Agree', 'Neutral', 'Disagree', 'Strongly Disagree'], [5,4,3,2,1], inplace=True)*

*df['Q7'].replace(['All the time', 'Frequently', 'Sometimes', 'Rarely', 'Never'], [5,4,3,2,1], inplace=True)*

*df['Q8'].replace(['Strongly Agree', 'Somewhat Agree', 'Neutral', 'Somewhat Disagree', 'Strongly Disagree'], [5,4,3,2,1], inplace=True)*

*questions = ['Q3','Q4','Q5','Q6','Q7','Q8']*

*print(df.groupby('Gender')[questions].mean())*

Conclusion

In conclusion, it is important for universities to have more professors in STEM fields in order to attract and retain more female students. This is not only because it can create a more welcoming and inclusive environment for women, but also because having more females in STEM will help better populate the workforce. My own primary research has shown that many women feel uncomfortable not having a lot of female professors, and this can be a barrier to their success and retention in STEM programs. By increasing the number of female professors in STEM, universities can not only support the academic and career goals of their female students, but also contribute to the overall diversity and success of the STEM workforce.

The University of Maryland and other Universities across the United States should look to countries where there are large numbers of women in STEM fields as examples of how to increase female participation in these fields. For example, countries like Sweden and Finland have a high percentage of women in STEM, with over 40% of students in these fields being women. By emulating these countries’ successful strategies, universities in the United States can look to increase the number of women in STEM and create a more diverse and inclusive STEM workforce.

*Looking Forward*

If I had more time to further refine and add to my research, I would look at the number of active female professors in universities/colleges across the US and look at other variables like retention rates, graduation rates, and class demographics in each given school and try to draw more conclusions using that data.

I would also potentially analyze how other successful countries transformed the involvement of women within STEM and especially computer science (Armenia, China, other far east countries in Asia).

A couple of other minor improvements I can make with my current work would be to increase my sample size to students in non-STEM majors to see if there is not only a difference in genders, but also a difference in majors between different groups. By doing this, I would not only have a larger sample size which leads to more actionable and precise insights, but I would also bee able to draw more insights with data from more groups of students.

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