Bryant University

HONORS THESIS

SySTEMic Misogyny: Why Women Do Not Win Nobel Prizes at the Same Rate as Men

BY Olivia Valenti

ADVISOR • Judith McDonnell
EDITORIAL REVIEWER • Thomas Zammerel

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ABSTRACT

For too long, women have been left out of the narrative as pioneers in STEM fields. The purpose of this thesis is to evaluate the barriers to entry women face to achieve equitable recognition in STEM fields. Specifically looking at The Nobel Prize Organization, they have yet to transform their processes to allow women to overcome gender socialization and attain equal levels of success like men. Misogyny, for the purpose of this thesis, is categorized as a prejudice against the structural advancement of women, and the individual, and institutional ways gender bias is perpetuated through STEM. Through IRB approved interviews of women in STEM, and a culmination of diverse research and analysis globally, the findings from this thesis indicate a strong bias against women in the Nobel Prize process which is a pro-longed side-effect of gender socialization, and gender roles negatively influencing women's career advancement leading to a divergence from STEM early on in womanhood.

INTRODUCTION

This thesis investigates gender socialization and its effect on formal processes by institutions rewarding scientific achievements like the Nobel Prize Organization. The research presented in this thesis examines how gender norms, institutional barriers to entry, misogyny and lack of support and mentorship throughout various stages of women's lives pushes women out of STEM fields. This results in low retention of women in STEM, equity and mass representation gaps, and recognition and achievement disparities between men and women later on in life. Collectively, through research and preliminary interviews, this thesis presents evident correlations between gender socialization and sexism and its effect on equality and achievement in STEM recognition processes like that of the Nobel Prize Organization. This research will uncover important factors that influence why so few women are in contention for Nobel Prizes in STEM fields, and the processes that have failed to overcome discriminatory barriers towards women.

PLANNED METHODOLOGY

This is a traditional research thesis utilizing a systematic investigation of institutional misogyny to answer a series of research questions outlined below:

How does socialization at different stages of a woman's life impact their decision to pursue degrees and careers in STEM fields?

Why are women not recognized or awarded Nobel Prizes at the same rate as men?

How are women impacted compared to men by the Nobel Prize fielding process, and what factors lead to this discrepancy?

How do biases, stereotypes and institutional discrimination limit the opportunities for women to succeed in STEM?

After collecting academic and scholarly research on women in STEM and the Nobel Prize Organization through library databases such as EBSCO, multiple women at different stages of their STEM careers were interviewed. This helped to understand how socialization and misogyny has impacted women's decisions to go on to pursue careers in STEM, or majors in STEM. This provided real-life perspective and drew connections between identity formation and overall achievement later in life.

A research-based approach was justified because this thesis leans into already established research to uncover the root of long-standing problems for women in STEM. This thesis does not have a goal to solve misogyny, but uncover why it exists, and how it has been unconsciously perpetuated in STEM fields through the creation of processes and awards that are catered to male recipients. To complete this research, chronological data was used to interpret any changes, or lack thereof, to processes throughout the establishment of the Nobel Prize Organization.

LIMITATIONS

Due to the time frame in which interviews were conducted, there were several limitations that hindered the research process. Since interviews were conducted at the height of COVID-19, all interviews were done online. It was difficult to secure participants having a limited network of STEM professionals, which resulted in a narrow scope of participants. This could potentially lead to skewed data since the sample pool was selected from mostly Bryant community members, where only 3% of the student population majors in STEM (US News). Furthermore, having a qualitative research method, quality over quantity was essential to measure the personal and emotional experiences of participants. Unlike a survey, the goal of the interviews is to center the narrative of participants and draw connections from their stories and experiences. This process takes a substantial amount of time, and each interview conducted surpassed an hour. This made the number of participants in the study limited due to the amount of time allocated to preliminary research goals.

LITERATURE REVIEW

In order to successfully integrate the interview findings with research, a literature review was conducted to evaluate the current state for girls and women developing in STEM.

Dasgupta's study discusses the foundation of my thesis by examining how male stereotypes, parental expectations of their daughters, peer norms, and interest in STEM plays a role in whether or not girls pursue degrees or careers in STEM at different stages of life. The study specifically focuses on the childhood and adolescent years, mid-adulthood, and adulthood. The study provides in depth information on socialization before concluding that in early-adulthood, girls avoid STEM majors because they are vastly outnumbered by male peers, and have few, to no, female role models to look up to when pursuing a degree. Further into life, around mid-adulthood, women face gender bias and discrimination during the hiring and promotional process as well as not inclusive work environments, women struggle to balance work, life and family, face biased evaluations of their work compared to their male peers, and often do not return to work after life-related pauses (ie: having a child) which lowers the retention of women in STEM (Dasgupta and Stout, 2014).

Since 1901, 688 individuals have been awarded Nobel Prizes in physics, economics, chemistry, and medicine- but only 20 recipients have been women. Looking at new ways to determine gender bias in the Nobel Prize Process, Gender Bias in Nobel Prizes uses data driven technology, known as the Bayesian hierarchical model in correlation with historical data from different scientific fields to quantify gender bias. Their ultimate goal was to determine if women earn Nobel Prizes less than the gender ratio proposes. The findings conclude with 96% probability that women are under-represented in STEM across all disciplines studied. Overall findings suggest that bias against women is even more prevalent than the model used presents, showing that women are less likely to be awarded prizes, strongly disfavored, and often counted out earlier in their career when gender ratios are more balanced (Lunnemann et al., 2018).

A closer look at discrimination in the Nobel Prize process and its relation to socialization was investigated by Professors and Doctors contributing to The Justice forum. The contributors make it clear that gender parity in Nobel Prize awards has only happened once in 2011, when out of twelve recipients, five were won by women. One researcher pointed out that one of the major flaws to the Nobel Prize fielding process is that it is not clear if the prize is awarded for a specific discovery in the field, or for lifetime achievement. Due to candidates and their achievements often being disputed by the committee, awardees are selected based on their publication record, or based on their leadership in labs, like serving as director when a large number of achievements are outputted during their tenure. Women are seen as new to the field of science because of the significant barriers to entry they have faced in recent decades. Knowing this, women have had little to no opportunities to manage large labs like their male peers and have been shown to have significantly more family responsibilities than men, limiting their chances of being awarded a prize. The researchers also look into the committee, and the nominators. Nominators, whether previous awardees, members of the Swedish Committee, or well-known academics, have an extensive network of colleagues in the field for being established and successful individuals themselves. Having said that, nominees often come from the committee's network, or from institutions they affiliate with. They use the Nobel Prize as an opportunity to extend their influence and highlight the powerful renown of their institutions. The researchers bring to light that it goes without saying the Nobel Prize

process is not excluded from persisting gender bias. This has led to many women's accomplishments being less visible than their male peers, despite progress in recent years. Women also face slower promotions in the field, and their work and success on projects often gets overshadowed by male collaborators who take the recognition. Lastly, their research highlights the necessity for the Nobel Prize Organization, among others, to quickly implement policy interventions that combat sexism, which has made little progress globally in all disciplines (Hackett et al.).

Looking at the effects of socialization on young adolescent girls, a study found that middle school girls who were surrounded by male peers exhibiting explicit gender/STEM stereotypes negatively impacted the intention of girls later seeking to pursue STEM majors. However, the same study found the girls surrounded by other female peers in science classrooms with positive attitudes towards STEM, increased the number of girls seeking STEM majors. The study's ultimate take away was that peer influence is a significant source of feedback for whether or not girls pursue STEM degrees. By examining the influences, both positive and negative, on young girls where they learn fundamental skills, we can see how socialization by their peers at the first stage of development impacts their choices later in life (Riegle-Crumb and Morton, 2017).

Carol Dweck, a psychologist at Stanford University, emphasized the difference between a growth, and fixed mindset in Chapter 2. A growth mindset leads to persistence in the face of adversity, while a fixed mindset results in a loss of confidence when things don't come easy. A person with a growth mindset focuses on the power of effort, and in the face of challenges, has increased confidence in their ability to take on what's ahead of them. In the culture of STEM, math is viewed as fixed. In a study done tracking the grades of junior high school students over a two-year period found that students with a growth mindset out performed those with a fixed mindset. Whether or not grades would improve in students was dependent on their motivational framework. In a second study done on 7th graders, researchers sought to understand if teachers could teach that intelligence is malleable (ie: being smart is a choice). Prior to the study, grades in most students were declining, but once students were taught that intelligence was not fixed, and that gender roles influence what is seen as fixed, the outcome

reversed and students' grades began to improve. Dweck concluded that in STEM, growth mindsets could protect women from the influence of stereotypes, while fixed mindsets can lower self-confidence, increase the persistence of stereotypes, and disengage women from STEM. Chapter 6 focused on the influence of department culture on women's success in STEM. Knowing that women are less likely to pursue STEM, a four-year study followed women pursuing computer science majors. The study followed women from their first semester to graduation, or when they departed from the major. Researchers concluded that women are two times more likely to leave the major of computer science compared to men. Department culture influences the expectations and values that guide students, faculty and staff inside, and outside the classroom. The department culture of computer science is by default, male centric- and alienates women from persisting through the major. Studies show that even when women have similar talent and grades as their male peers, they have lower self-confidence and lose steam by their second and third semesters in the major. Chapter 6 also looked into the relationship between computers and men and women throughout their lives that affect computer science degrees later in life. Studies show that men have a different experience with computers, and are more likely to have exposure and experiences with technology early on in their lives compared to women. ¾ of men studied indicated an intense attraction to computers at an early age compared to only ¼ of women. "Geek" stereotypes influence who is seen as a good fit to belong in computer science majors. ⅔ of women and ⅓ of men indicated that the "geek" stereotype didn't apply to them. This results in women more than men questioning if they belong in the major, which can also be traced back to men's early attraction to computers that women didn't have. The predominantly male environment, view of computer science as "hacking", and "geek" stereotypes deter women from pursuing computer science degrees. By implementing a broader culture of inclusion, women will have more opportunities to reach par with their male peers. Historically black colleges have done this right- producing half of all African American physics degree holders, and encouraging a female friendly environment by providing a path towards degrees in STEM even for students not prepared to enter the major, but show a general interest. Chapter 7 focused on junior and tenured faculty satisfaction by analyzing the results of the COACHE study. Female faculty are underrepresented in almost all STEM areas, and are less satisfied with all 10 measures of

the study compared to men. The study found that female faculty in STEM are less satisfied specifically with how they fit into their departments, opportunities to work with senior faculty, and the lack of support for work life balance. Junior faculty are the most at risk of leaving early on in their careers due to the lack of sense of belonging in their departments. In order to bridge this gap, colleges must provide mentorship programs and implement proper work life opportunities so women can retain their roles in STEM and have equal growth opportunities to their male colleagues (Hill, Corbett, & St. Rose, 2019).

A similar study looked at socialization of peers and families on young girls, and the effects on the number of women in STEM professions, the number of adolescents engaged in STEM focused material, and the number of females enrolled in STEM programs. Researchers focus on socialization's effect on this age range because studies have shown that females lose interest in STEM between the ages of 9-12. While women have been entering STEM at higher rates than ever before, combating social constructs that prevent leveraging girls into STEM need to be completely transformed. The study concludes that the marginalization of women in STEM can only be closed if society wide we provide "continued STEM experiences, professional women role models, build positivity, and foster curiosity about the potential of STEM applications and/or careers" (Reinking and Martin, 2018).

The article "A moment for women in STEM?" summarizes a consensus report on COVID-19's effect on women in STEM, with a sample of 733 tenured, or tenured track faculty, and 170 non-tenured faculties. The report found disproportionate issues facing women compared to men. Women's caregiving duties during the pandemic has increased, while their productivity at work has decreased. The report stresses the importance of correcting, funding, and implementing policies for women, as colleges and universities nationwide are at risk of losing valuable professors. There needs to be a switch from individual agency to institutional changes to support the advancement of women in STEM. One of the major findings of the study was that women faculty and staff have lost their work/life boundary which has effects such as lower overall productivity, decreased effectiveness, poorer social interactions with peers and students, and adverse effects on teaching and research. 90% of female faculty studies indicated they are handling the needs of their children, with only 9% sharing the

responsibility with a significant other. Furthermore, ⅔ of those studies indicated a decline in their overall well-being and psychological well-being. Compared to tenured track faculty, non-tenured track faculty worried more about the effects of the pandemic on their teaching, advocating for more useful technology, and teaching and grading support. Most faculty studied identified that their university's only attempt at easing faculty and staff concerns was offering remote work, stopping tenure track clocks, and offering the ability to choose the mode of teaching they prefer. Some schools, however, had no clear plans on how to help professors, and very few offered childcare needs. Participants in the study indicated that their schools need to acknowledge the decrease in productivity as a result of COVID-19, and implement positive changes to mitigate faculty and staff concerns. At the beginning of COVID, many faculty gave a positive rating to their administrators for their swift action handling the crisis, but as the pandemic went on, faculty began to feel left out of important decision making that shapes teaching, learning, and their future career growth opportunities at their institutions. The report found that while COVID disruptors disproportionately affect women, there is a stronger negative effect on women of color compared to men, and a negative correlation to women's support systems who are already isolated in their disciplines. Before COVID, women's participation in STEM was increasing, and women's leadership at schools with less prestige and fewer resources was on the rise. In order to see impactful change and correct the institutional effects of COVID-19 on women in STEM, it is vital to address decision making needs and close gender gaps through institutional policy like that done at Umass Amherst (Flaherty, 2021).

EARLY CHILDHOOD AND GENDER ROLE INTERNALIZATION

At early stages of development, gender socialization begins to segregate opportunities for young boys and girls. This is something called the leaky pipeline, where women begin gravitating away from STEM at different stages of their life. Studies have shown women avoid STEM majors or leave in emerging adulthood which has been attributed to the inability for young girls interested in STEM to find female role models to look up to and emulate.

In early childhood, gender roles and stereotypes steer girls to be communally oriented. Girls are socialized with a focus on interpersonal skills and relationship development, while conversely, male stereotypes steer boys to be autonomous, acquire skills and competence, explore, and gravitate boys to activities that focus on financial gain and showing power and status. As young as six years old, these stereotypes begin to form, and by age ten, research shows girls like math less than reading, and later in adolescence, begin to perform worse in STEM courses.

While both men and women have internalized stereotypes such as "women don't like math and aren't good at science"- researchers have debunked these common perceptions of women's intelligence. Mary Feeney, a Professor of Ethics at the University of Arizona said when analyzing research that "Studies show that girls and women avoid Stem education not because of their cognitive inability, but because of early exposure and experience with Stem, educational policy, cultural context, stereotypes and a lack of exposure to role models" (2018). The results of a Microsoft study found that when girls have a mentor or role model to look up to, their interest in STEM fields doubled. This research indicates that before test performance differences begin to appear between boys and girls, children already have internalized math stereotypes.

PARENTAL AND PEER INFLUENCE

Two factors in development that widen the gap of interest in STEM is parental and peer influence. Research has shown that boys and girls are raised to conform to the male and female gender roles set in society. Parents influence children through their advice, the resources they provide like toys available, and exposure to experiences and activities. Parents who support children in the exploration of STEM have children that are more likely to participate in STEM courses later in life. Furthermore, parents who believe their children are good at math and support their competencies increase their child's confidence in their capabilities and predict a higher performance in math in school. Conversely, if parents believe their child is not good at a particular STEM subject and do not enforce support, there is a negative correlation to the child's performance in the classroom. Research on gender roles and

women's achievement related decisions found that parents assign gender stereotypes to math and science which influences children's abilities and interests. Mothers more than fathers in early adolescence influence the motivation of girls to continue to pursue science and math. However, mothers more than fathers apply gender stereotypes about STEM fields which can have a negative influence on young girls' perceptions of STEM.

Research shows that girls are more likely to take math and science courses if other female friends performed well the previous year. This led researchers to try to understand the impact peers have on sending inclusionary and exclusionary messages in the classroom. A 2017 study found that girls exposed to a higher number of 8th grade male peers displaying explicit gender/STEM stereotypes "significantly, and negatively predicted girls' future intentions to pursue a computer science/engineering major" (Riegle-Crumb and Morton, 2017). Contrastly, the same study found that when girls are exposed to a higher number of confident female peers in their science classes, their future career aspirations in STEM were positively influenced. This means that peers play a vital role in whether or not girls will pursue non-traditional STEM fields.

PH. D PROGRAMS AND ELITE ACADEMIC INSTITUTIONS

At the next phase of development, studies have analyzed the confidence levels and retention rates of doctoral students. In a 2006 study done by the Royal Society of Chemistry in London, "over 70% of 1st year women students indicated that they planned a career in research but revisiting the same group by the time they reached the 3rd year, only 37% were found to be pursuing that aim in comparison to 59% of male students" (Modgil, Shweta, et al., 2017). Researchers have long attributed this explanation to the lack of female role models in research and STEM, and women struggling to find mentors for themselves- this is further supported by research showing women scientists in chemistry exhibit lower self-confidence than their male peers and have a much harder time securing a career than their male colleagues. Even when women have the same experience, age, and qualifications as their male peers, studies confirm

that men are 2.5 times more likely to reach full Professor status in STEM compared to women.

Looking at Ph.D. program representation, "The Prestige Gap" study found that men are overrepresented in elite Ph.D. programs. One of the main reasons for this is that women self-select out for three main reasons; 1) they believe their abilities are inadequate compared to their male peers, 2) the environment of the program is unfriendly and unwelcoming to women, 3) there is a culture of a fear of failure that disproportionality affects women in STEM compared to men preventing career advancement. This leads to persistent gaps in elite Ph.D. program representation for men and women, "Women earn about 18% of PhDs in physics, which is an increase from 1975 when women earned 5% of PhDs in physics" (Feeney, 2018). Tying in the Nobel Prize, we know they are typically awarded to full professors at prestigious academic institutions which means it's important to understand structural barriers to entry for women. Research by UNESCO found that only 30 percent of the world's researchers are women, and there has been a slow push to leverage women into STEM despite women being largest untapped human capital in the world.

Colleges and universities in the U.S. have more diverse faculty and staff entering the workforce, but systemic barriers to promotion for women and minorities in higher education prevent equitable opportunities for growth and development. There are fewer tenure-track positions filled by women and minorities, which has led to a lack of job security and autonomy that lends women and minorities more freedom, status and time to pursue research with the same equity as their male peers, who have more work/life opportunities in the public sphere. The people awarded Nobel prizes are typically of senior scientist status, which means they are being awarded for work from much earlier in their careers. Knowing the institutional barriers that push women out of STEM before they reach seniority may factor who is seen as important enough to receive a prize, "In the U.S. in 2010, white women constituted only 18 percent of the engineering and science workforce, with black and Hispanic men and women making up less than 4 percent each" (Mehta, 2017). Faculty are reluctant to support women through their PhD programs because women are more likely than men to get married or start a family during their research tenure that halts the project and research associated with it. This

has been disputed due to the lack of work/life balance given to women looking to balance both a family and research career path.

SUBCONCIOUS GENDER BIAS IN FACULTY

To get a better understanding of subtle gender bias and its effects on women's development, a study titled "Nobel Nominations in Science: Constraints of the Fairer Sex" analyzed gender bias in faculty members of science. The findings of the study showed that both men and women faculty at the subconscious level held a bias against women. The study asked "one hundred Professors of Biology, Chemistry and Physics at 6 universities in the United States to evaluate CVs of 2 made up College students, with a male candidate named John, and female candidate named Jennifer for the job of laboratory manager. Despite both students having identical credentials, the Professors agreed to offer $3,730 less per year to Jennifer than the other student named John and showed more willingness to mentor John in comparison to Jennifer" (Modgil, Shweta, et al., 2017). This same subconscious bias is evident in the Nobel Prize fielding process.

Using a predictive model, researchers from the Bhor Institute in Copenhagen found with more than 96% probability that the gender distribution of the Nobel Prizes held a gender bias. When women avoid the leaky pipeline and become established full-time professors, or full status scientists, they do not have equal opportunity to become Nobel laureates. It is evident that this divergence occurs at "multiple earlier stages in the careers of potential Nobel laureates- which means there is not an equal possibility for both genders to be nominated for a Nobel Prize" (Lunnemann et al., 2018).

ACADEMIC RECOGNITION AND THE MATILDA EFFECT

Gender stereotypes persist in science fields when it comes to recognition, respect, and accomplishments. The use of surnames is much more common with male scientists, while for women, people are more likely to use their first names. This is problematic because studies show the use of surnames significantly impacts who is seen as distinguished in written work. One study found that calling "scientists by their last names led people to view them as 14%

more deserving of a National Science Foundation career award". Women more than men are judged based on personal information or physical appearance which deters women from submitting written work or being judged as equitable scholars in their fields.

It takes women twice as long as men to move through the peer review process (Feeney, 2018), and this is because women are not only underrepresented throughout the entire editorship process, but implicit bias plagues research findings and recognition for work in STEM. There is a gender gap in recognition, award winning and citation use, "… men cite their own papers 56% more than women do, and women's research is less likely to be cited by other people and their ideas are more likely to be attributed to men" (Feeney, 2018). This idea is known as the Matilda Effect; where women's work is underscored or associated with a man without due recognition of her own accomplishments. These barriers to women's written publications works against the promotion of women's work and research.

MARIE CURIE

Madame Curie, the first person ever to win two Nobel Prizes, and the first woman to win a Nobel Prize, won the Nobel Prize in physics in 1903 and chemistry in 1911.

Marie Curie is a prime example of the uphill battle women face for recognition in comparison to their male counterparts. Madame Curie worked on par with her husband Pierre Curie, but the French Academy of Science still did not include her name in the 1902 Nobel nomination until a woman Nobel Committee member told Marie Curie's husband. He, in turn, wrote to the Nobel Committee saying, "A Nobel Prize for research in radioactivity that failed to acknowledge Marie's pivotal role would be a travesty" (Agarwal, 2018) which then turned their initial denial of Madame Curie around. It took until 1962 for Yvonne Choquet-Bruhat, a former student of Marie Curie, to become the first woman elected to the FAS, the same academy that initially denied Marie Curie a nomination.

ACADEMIC INSTITUTION REPRESENTATION

A study done on 63 academies around the world found that they consisted of only 12% women on average. The French Academy of Science, which voted against Marie Curie's membership in 1910, has under ~8% women. The Royal Swedish Academy of Sciences, whose members vote to decide the Nobel Prize recipients in physics, chemistry and economics, with over 600 Swedish and foreign members, has under 13% women (Agarwal, 2018). In 2018, the Nobel Committee for Physics, Chemistry, and Medicine includes 6 members of which 5 were men.

Analyzing something called the masking effect looks into how work by women either remains "shielded by their husbands working in the same field or by other male colleagues who are well recognized by being socially well networked in the field" (Modgil, Shweta, et al., 2017). Since the inception of the prize, all but four STEM related Nobel prizes won by women were shared with men.

Francis Crick and James Watson were two Nobel Prize–winning discoverers who are credited for finding the structure of DNA. However, none of their work would have been possible without the data collected by Rosalind Franklin. Rosalind Franklin was a scientist "whose data was shared with the prize-winners without her permission, and she was never nominated for the prize". Similarly, Esther Lederberg was overlooked for the 1958 Nobel Prize for replica plating, even though she invented the laboratory technique. Her husband not only won the shared Nobel Prize, but Esther Lederberg was not even nominated for the prize alongside him- despite publishing many papers together, during his acceptance speech, he failed to acknowledge his wife's contributions once.

STATUTES GOVERNING THE PRIZE

Since the inception of the Nobel Prize in 1901 to 2020, of the 934 awarded Nobel prizes only 58 have been awarded to women (Madame Curie twice) while 876 have been awarded to men.

The Nobel Prize Organization choses only three winners per category and keeps deliberations private for half of a century. This "reinforce the vision of scientists being predominantly male, white and older. and being based on an archaic "great man" model of science, which fails to acknowledge the collaborative foundation of scientific knowledge…[this] which makes sense given 97 per cent of the science Nobel prize winners have been men" (Fenney, 2018). In Nobel Prize winning research and discoveries, women in STEM have been consistently overlooked. Due to the limit of winners imposed by the Nobel prize committee, the majority of people who contribute to the overall scientific discovery go unnoticed. This means the $1 million dollar prize money, the recognition, and reputation appraisal only goes to a select few individuals, perpetuating the idea that science is an individual field and not collaborative nature which prevents due recognition to all contributors. For instance, in 2017, the physics Nobel Prize was awarded to three white men, when the project involved thousands of diverse engineers and scientists. Bias within the Nobel Prize Organization cannot be corrected until the statues and process for fielding Nobel nominees gets addressed.

Women and minorities from developing countries face an even bigger set of hurdles. Looking at the geographical distribution of awards, Nobel prizes are primarily awarded to scientists in European countries and the United States- which means the type of science awarded, requires money and university support for research, which is extremely difficult for scientists from nations struggling with the legacy of colonialism. Historically, the Nobel Prize Organization has disproportionally represented contributions of Western science, and equal opportunities for all women, globally, is not possible without acknowledging the lack of representation of non-Western countries.

INTERVIEW FINDINGS

The demographic of the study was ten self-identified women who ranged in age and experience. This was to ensure data was collected at each phase of the leaky pipeline or when women typically begin separating from STEM. This is a qualitative research paper that focuses on centering respondent's narrative and giving women the opportunity to speak for themselves about their lived experiences. The goal in interviewing women in STEM was to

uncover how power dynamics and gender roles at the professional, personal, and interpersonal level play a role in shaping whether or not an individual's career goals were attained, or hindered due to gender socialization, and institutional and structural misogyny.

Key Findings:

- 100% of participants had a female role model at some point in their STEM development- many participants noted that a strong female mentor drove them to pursue their passions in STEM. This suggests the importance of powerful women mentors at every stage of a woman's academic and professional career. Having women to look up to in STEM helps retain the number of women persevering through the leaky pipeline, and prevent gender role internalization in adolescence. One participant said having a woman role model in STEM allows for girls to have an "if she can do it, so can I" mindset.
- Most participants feel supported by their Science and Technology department, but not by their institutions broadly- citing lack of funding, lack of resources, and lack of representation for the main losses in their institutions science programs.
- 83% of participants had experienced either covert or overt gender bias as some point in their STEM careers- the outliers being underclassmen STEM majors who have not had the academic freedom or exploratory opportunities to take STEM classes that are typically required of upperclassmen.
- All students agreed that the strongest professors in the Science and Technology department are women, and noted that from their personal experiences, women have more inclusive classroom practices. Students indicated that they are less likely to ask questions or advocate for themselves in groups that are predominately men, or in STEM classes taught by male faculty.
- Some participants could cite specific examples of gender bias with male faculty, including two participants having filed a complaint with their department. One participant indicated that her confidence had gone so down during her underclassmen years as a STEM major, she retook some of her core classes as an upperclassman.

It is important to note that these are personal experiences in STEM, and not a complete representation of STEM institutions nationwide. The use of personal anecdotes was

foundational in creating recommendations that can be applied universally, to all women, at institutions globally. The findings from the interviews conducted suggest a strong presence of gender role internalization in all participants. Regardless of age or gender, all participants had referenced or noted their gender as a barrier to advancing in STEM or moving up in their academic career. It was evident that age and exposure to experiences in STEM, however, played a significant role in whether or not students or STEM professionals felt supported, or isolated by their occupation or academic institutions. Furthermore, the major finding of this research indicates one of the strongest safeguards against the leaky pipeline is for women in STEM to have strong female role models to look up to and inspire them.

RECOMMENDATIONS

It is essential to support institutional change at every stage of the leaky pipeline. In order to advance women in STEM and change the culture of gender roles in society, structural change must be supported from the top down, and bottom up at institutions globally. Utilizing the data collected from participants and preliminary research, the following recommendations were created to accelerate cultural changes at the institutional level.

1. At every level of the leaky pipeline, mentoring must be a priority. From high school to post-secondary opportunities, colleges and universities need to dedicate time and resources to creating STEM pipelines for women. Once women enter their institutions, mentoring must be consistent and embedded in the development of students. Creating "Women in STEM" organizations, for instance, where underclassmen and upperclassmen can mentor and inspire one and other, can build confidence in women to pursue STEM. Furthermore, faculty and staff must be dedicated to supporting junior, and tenure-track women faculty by creating mentorship programs at the departmental level that fosters professional development, and retaining women at the top level of STEM at their respected institutions.
2. Historically black colleges and universities continue to develop strong pipelines for women and minority graduates in STEM majors. This has been largely attributed to a method of reverse recruiting that supports programming and STEM initiatives on

campus, even for students who have not declared STEM as an intended path of study. For instance, this method of recruiting could work if young girls in high school had exposure to STEM related activities and enjoyed them, but failed to enter STEM due to gender stereotypes, or other interests pushing them away from the field. Reverse recruiting can draw women back to STEM if the proper time and money is allocated to STEM programming and mentorship. This method of recruiting students once they are enrolled onto campus can regenerate an interest or passion for STEM, resulting in not only more women pursuing STEM degrees, but more women gaining exposure to skills and competencies in STEM disciplines.

3. It is fundamental at early stages of development to teach children that intellectual skills can be acquired. Knowing that gender socialization causes young girls and boys to view their brilliance differently, it is vital to implement a curriculum that teaches young girls that their performance in math and science courses is not fixed. Due to cultural representations of science and math aligning with male stereotypes, it is imperative that young girls are taught to have growth mindsets. In a second study done on 7th graders, researchers sought to understand if teachers could teach that intelligence is malleable (ie: being smart is a choice). Prior to the study, grades in most students were declining, but once students were taught that intelligence was not fixed, and that gender roles influence what is seen as fixed, the outcome reversed and students' grades began to improve (Hill, Corbett, & St. Rose, 2019). Unlike fixed mindsets, growth mindsets could protect women from the influence of stereotypes and push them through barriers of the leaky pipeline.
4. Supporting the work/life balance of women faculty will be essential in order to keep women entering STEM at the same rates as pre-pandemic. In a study done on the effects of COVID-19 on women faculty, 90% of female faculty indicated they are handling the needs of their children, with only 9% sharing the responsibility with a significant other. The same study found that ⅔ of women faculty indicated a decline in their overall well-being and psychological well-being. One of the major findings of the study was that women faculty and staff have lost their work/life boundary which has effects such as lower overall productivity, decreased effectiveness, poorer social

interactions with peers and students, and adverse effects on teaching and research. This emphasizes the importance of correcting, funding, and implementing policies for women, as colleges and universities nationwide are at risk of losing valuable professors post-pandemic.

These recommendations can be implemented into short term and long-term initiatives to support the inclusivity of women at the top level of institutions globally. Supporting incremental changes to representation up the leaky pipeline will eventually lead to changes in the fielding process of women Nobel laureates as the narrative and culture around women's success in STEM shifts, and representation increases.

APENDICES

APPENDIX A – INTERVIEW TRANSCRIPTS

Interviewer: Via Valenti

Interviewee: Upperclassman STEM Major

Date: March 5th, 2021, 9:30am

Interviewer: What's your major/ was your major?

Interviewee: General Biology with a Concentration in Human Resource Management

Interviewer: Who are your role models in STEM?

Interviewee: I always knew I liked science, but a 9th grade biology teacher, was a successful woman in STEM I looked up to as a role model.

Interviewer: How were you encouraged to get into STEM?

Interviewee: Always liked science and anatomy, and a 9th grade professor helped build this passion. I also always liked business, but it was not where my strengths are.

Interviewer: Who are your role models in STEM?

Interviewee: I always knew I liked science, but a 9th grade biology teacher, was a successful woman in STEM I looked up to as a role model.

Interviewer: Do you feel supported by Bryant in your STEM classes?

Interviewee: To an extent, the department chair- who is a woman, is a successful woman in STEM and helps guide students from their freshman year on. As a whole, Bryant feels like a business school, specifically the first two years since most science classes you typically take as an upperclassman.

Interviewer: How have your classes at Bryant shaped your future career aspirations?

Interviewee: Came in as pre-health biology major and changed to general biology because classes were more obtainable- got guidance from Kirsten Hoakness the department head. After taking an anatomy class (taught by a woman professor who was a Physician's Assistant) it influenced a career path change and a major change.

Interviewer: How have your classes at Bryant shaped your future career aspirations?
Interviewee: Came in as pre-health biology major and changed to general biology because classes were more obtainable- got guidance from Kirsten Hoakness the department head. After taking an anatomy class (taught by a woman professor who was a Physician's Assistant) it influenced a career path change and a major change.

Interviewer: Do you think Bryant is inclusive of women in their STEM resources and curriculum?
Interviewee: No, because even though there are many women in the science department, male professors have a harder time including women in the class, as well as incorporating women faculty members- one came into the lab with female professor and tried to mansplain organic chemistry even though the professor was an organic chemist herself.

Interviewer: What was the gender breakdown of most of your Bryant STEM classes?
Interviewee: Gender breakdown is typically 50/50, but labs sometimes have more women.

Interviewer: Do you feel comfortable working in a group with women and men?
Interviewee: More with women, because men don’t delegate “important” work to women - women can relate more and can delegate to skills and ability more so than men in group work from experience.

Interviewer: Do you feel confident in your ability to pursue STEM post grad?
Interviewee: Yes, I do, I feel like even though science is a small department, grad school applications show Bryant covers all the bases.

Interviewer: What has been your biggest obstacle being a woman pursuing STEM?
Interviewee: Personal biases- with male professors it's more nerve wracking to ask questions, and I'm less likely to advocate for myself. I also wouldn't ask for letters of recommendation from male professors which limits role model reach. As a freshman and sophomore, I had so much less confidence in myself to ask questions- afraid to speak in class and afraid to go to office hours, specifically with male professors. Women professors are more likely to explain and say, "sorry I didn't make that clear enough" where male professors are more likely to say, "so you weren't listening". When I realized I was supposed to ask questions and got to harder classes, I gained competence and confidence in my ability to advocate for myself.

Interviewer: Do you feel like you have equal opportunities to succeed in STEM compared to your male peers?
Interviewee: Not equal, especially with intersecting identities as a black woman and a woman in STEM.

Interviewer: Have you experienced gender bias in your STEM classes/ STEM work?
Interviewee: No outward discrimination, but professors' responses→ situation where anytime a woman would ask a question a professor would be annoyed, but when a male in the class would ask the same question there would be a more engaged response.

Interviewer: Have you felt negative stereotypes towards you as a woman in STEM?
Interviewee: No, but I work in the science department so I have a little bit more respect and I am established within the department— so it could be specifically because of that.

Interviewer: What can Bryant do to be more inclusive to, and advocate for women in STEM?
Interviewee: There needs to be more funding dedicated to growing the department. Everything still feels like a business school and Bryant is oriented that way. That makes a lot of the way Bryant is set up to be male centric (ie: socially and culturally, men= business, inherently male focused before women even enter). There should be consistent four years of

STEM curriculum because the way Bryant is set up is not helpful for long term career advancement. There are very few mentors and role models in STEM, and there is not enough STEM focused academic advisors, faculty/staff, and AMICA Center liaisons. There must be an active push to employ more women in the science department, so women feel empowered to stay a STEM major all four years.

Interviewer: Via Valenti
Interviewee: Alumni STEM Major, Masters in Exercise Science
Date: March 5th, 2021, 9:30am

Interviewer: What's your major/ was your major?
Interviewee: General Biology with a Concentration in Psychology
Masters in Exercise Science and Sports Science

Interviewer: Who are your role models in STEM?
Interviewee: Looked up to more athletes, D1 Athlete at Bryant
When she was 10 years old and was in 4th grade her female swim coach was going through the Olympic Trials. She was the biggest influence in her life and helped her figure out what she wanted to do after swimming. She also looked up to Missy Franklin and acknowledged she wouldn't have pursed STEM if it wasn't for her swim coach- all of the academic success she had was connected to athletic success.

Interviewer: How were you encouraged to get into STEM?
Interviewee: Always liked science and anatomy, and a 9th grade professor helped build this passion. I also always liked business, but it was not where my strengths are.

Interviewer: Who are your role models in STEM?
Interviewee: I always knew I liked science, but a 9th grade biology teacher, was a successful woman in STEM I looked up to as a role model.

Interviewer: Do you feel supported by Bryant in your STEM classes?
Interviewee: Didn't feel discriminated against because of gender, some classes were outnumbered by women. However, as a biology major as a whole, there is a general lack of support from the University.

Interviewer: How have your classes at Bryant shaped your future career aspirations?
Interviewee: Career aspirations remained consistent, a huge part of that was Professor Mott and Professor Hoakness who spoke to freshman and guided science majors through their courses. She thought about switching career paths because she was having a difficult time in some classes that were taught by men, even though she tried to avoid them she couldn't.

Interviewer: Do you feel like men and women faculty treated you differently?
Interviewee: The strongest professors of her Bryant career were women; male professors always had the most conflict. From freshman to senior year, she retook a few classes to get the GPA boost for classes she wasn't confident in because she was intimidated to ask questions and advocate for herself.

Interviewer: Do you feel confident in your ability to pursue STEM post grad?
Interviewee: Yes, I was well prepared, and the cross disciplines made her a more well-rounded candidate.

Interviewer: What has been your biggest obstacle being a woman pursuing STEM?
Interviewee: The job search came with the most obstacles. Looking for jobs as a cognitive performance coach which requires her to work with military personnel. She questions if they ask, "why is this 23-year-old girl qualified to lead these soldiers?". She's also experienced backhanded comments about intelligence that she didn't understand the implications of until she graduated.

Interviewer: Do you feel like you have equal opportunities to succeed in STEM compared to your male peers?

Interviewee: Not equal; there was a time where there was a group of women sitting in the front row of a class when one woman asked a question, the professor made an off handed comment about it being a stupid question, but when a male classmate asked a similar question, he answered it. It made her think in that moment "why ask questions if I am not going to get the same respect?". As a result, women in the class wrote a letter to the department head and ensured proper accountability.

Interviewer: What are the biggest cultural differences between Bryant and Post-Grad?
Interviewee: Classes in her master's program are 50/50 male/female which was new. This is because her program is so specialized that she has a lot of commonalities with her peers which is different from Bryant. 50-60% of people in her program have fellowships, but male classmates don't speak up when they have experience since it is more hands on, they are not as comfortable speaking compared to the women in the class.

Interviewer: What can Bryant do to be more inclusive to, and advocate for women in STEM?
Interviewee: Encourage the science department to set up female mentorship programs. "If she can do it so can I". Seeing women in PA helped her confidence throughout undergrad.

Interviewer: Via Valenti
Interviewee: Elite Academic Institution, STEM Professor
Date: March 8th, 2021, 9:30am

Interviewer: What's your major/ was your major?
Interviewee: Geology and Geo Physics
Masters in Geo Physics

Interviewer: Who are your role models in STEM?
Interviewee: Growing up, her mother was a physicist, so she had a strong woman to look up to in STEM.

Interviewer: How were you encouraged to get into STEM?
Interviewee: Went to college as a music major, didn't turn out well, so she took a geology course and got interested in STEM her sophomore year in college, was inspired by "The Undersea World of Jacques Cousteau"→ sophomore year committed to pursue STEM.

Interviewer: Did you feel supported by your college in your STEM classes?
Interviewee:

Interviewer: Do you feel like men and women faculty treated you differently?
Interviewee: She mostly had male faculty as an undergraduate, and she actually had no women professors in STEM as an undergraduate. When she got to grad school, one of her co-advisors was a woman.

Interviewer: Did you feel confident in your ability to pursue STEM post grad?
Interviewee: v in ability. She wasn't sure she wanted to continue in STEM, but she went directly into a Ph.D program. Every Spring, she had a deal with herself that if she enjoyed what she was doing and liked it, she'd keep doing it but it took until the end of her Ph.D program to know she wanted to continue a career in STEM. She was deciding between a job and grad school and wasn't sure grad school had the dimensions she was looking for about giving back to society.

Interviewer: What has been your biggest obstacle being a woman pursuing STEM?
Interviewee: Don't know how much being a woman has played a role in how much people value her work. There have been times where there was an idea that people didn't take as serious, or comments on papers and proposals where she would think "would that come from a paper from a man? Also extremely underrepresented, only 25% women, with a small number of minorities.

Interviewer: Do you feel like you have equal opportunities to succeed in STEM compared to your male peers?

Interviewee: Yes and no. Remarkably lucky with colleagues in department. Vast majority of people she works with are men, individually who she works with there is a lot of support, and she doesn't feel underrepresented. The department is made up of 22% women, and her every day lived experience is great. Her institution more broadly is supportive, but there are moments where ideas are respected but faps in terms of how men and women perceive merit room full of women would be a different conversation.

Interviewer: What can people and institutions do to be more inclusive to, and advocate for women in STEM?

Interviewee: Make sure women in STEM have a strong mentoring system. She benefited from people who have stepped up and been strong mentors. Science is hierarchal- if a mentor knows how the system works and has power and prestige- they can help others. We need to make sure women don't take on too much service work because people rarely value that women also cannot do more than their share. Childcare is also huge→ women need a better work life balance, need to be able to conduct business that makes it easier for women in small businesses.

Interviewer: Via Valenti
Interviewee: Upperclassman STEM Major
Date: March 21st, 2021, 9:30am

Interviewer: What's your major/ was your major?

Interviewee: Environmental Science, Minor in Global Supply Chain and Sociology

Interviewer: Who are your role models in STEM?

Interviewee: Gained appreciation for environment from grandmother, used to collect butterflies.

Interviewer: How were you encouraged to get into STEM?

Interviewee: Family traveled our West, went to national parks, and went to glacier national park and the park ranger said "when you come visit with you kids this glacier won't be here anymore"

Interviewer: Do you feel supported by Bryant in your STEM classes?

Interviewee: Within the science department, yes, but at the university level- no. Was supposed to take a ton of classes for my major that were never offered and I don't feel like I'm getting the value out of my major that I should. Most classes at Bryant fixated around business-"most of you are not science majors".

Interviewer: How have your classes at Bryant shaped your future career aspirations?

Interviewee: Dan McNally's class, and him as a professor made me want to do Environmental Science, but he helped support and guide me. I plan on going to grad school for sustainability science, or sustainable development. Was pushed by Bryant to take on the intersection of business and science→ corporate sustainability.

Interviewer: Do you think Bryant is inclusive of women in their STEM resources and curriculum?

Interviewee: I think so, Professor Hoakness and Mott make women feel included. Haven't felt exclusion, or inequity.

Interviewer: What was the gender breakdown of most of your Bryant STEM classes?

Interviewee: Most of my science classes have been a pretty even split- sometimes even more female leaning. All science majors working on honors projects are women.

Interviewer: Do you feel comfortable working in a group with women and men?

Interviewee: I feel comfortable working in both. Usually it doesn't matter, but I am more comfortable talking and asking questions when I work with other women compared to men.

Interviewer: Do you feel confident in your ability to pursue STEM post grad?
Interviewee: Yes, I do- but I feel like I do because I have a more well-rounded perspective from having the business piece integrated- but Bryant did not prepare me well enough for the base level science classes (lack of class offerings).

Interviewer: What has been your biggest obstacle being a woman pursuing STEM?
Interviewee: At my internship- it's me, and one other woman, and the rest are all males. It was my first real world experience understanding how male dominated STEM is, it also makes me a little uncomfortable because its' hard to interact with men on the team—ordering quarter zips, male on team said, "we're not going to ask about your size since that might be a touchy subject", first day and they said "thank god you finally hired a female".

Interviewer: Do you feel like you have equal opportunities to succeed in STEM compared to your male peers?
Interviewee: Right now, yes, and society is pushing for women in STEM→ I feel like opportunities for women in STEM are growing.

Interviewer: Have you experienced gender bias in your STEM classes/ STEM work?
Interviewee: Not in STEM specifically, but I have experienced gender bias in other aspects of my life and identity.

Interviewer: What can Bryant do to be more inclusive to, and advocate for women in STEM?

Interviewee: One thing that bothers me about the speakers we've had at Bryant is that they are always business related and not STEM related. More STEM representation across campus is needed, and it needs to be integrated across more departments like the career center, and honors program.

Interviewer: Via Valenti

Interviewee: Underclassmen STEM Major

Date: March 21st, 2021, 9:30am

Interviewer: What's your major/ was your major?

Interviewee: Major: Biology, Minor: Undeclared

Interviewer: Who are your role models in STEM?

Interviewee: Mom social worker, sister in Arts, Dad accountant, played a lot of sports growing up→ used to see a sports medicine doctor→ shadowed him, met a PA school student from Bryant (women)→ wanted to be like her

Interviewer: How were you encouraged to get into STEM?

Interviewee: In 8th grade, knew she was going to pursue STEM- always wanted to go into STEM- decided she wanted to go to PA school, took two sciences in high school to get.

Interviewer: Do you feel supported by Bryant in your STEM classes?

Interviewee: Bio and chem class predominantly girls, takes classes with her friends

Interviewer: How have your classes at Bryant shaped your future career aspirations?

Interviewee: Haven't played a major role, still have a lot of classes to take, feels like some of the classes are unhelpful and not specific to specialization in the future

Interviewer: Do you think Bryant is inclusive of women in their STEM resources and curriculum?

Interviewee: Pretty balanced so far in classes, Professors try to make classroom a safe community→ Professor Hoakness helped be supportive and guide her- makes STEM fun.

Interviewer: What was the gender breakdown of most of your Bryant STEM classes?

Interviewee: Mostly split, but a few more women, lab less men.

Interviewer: Do you feel comfortable working in a group with women and men?

Interviewee: Prefers to work with women, a lot of men in STEM passively assign work to men.

Interviewer: Do you feel confident in your ability to pursue STEM post grad?

Interviewee: Feels prepared so far→ Bryant PA school is goal, doesn't know if Bryant will be able to help her get hours

Interviewer: What has been your biggest obstacle being a woman pursuing STEM?

Interviewee: Male professors expect you know information even if you've never been exposed to it→ even if he hasn't taught it→ women professors teach a little mote inclusively.

Interviewer: Do you feel like you have equal opportunities to succeed in STEM compared to your male peers?

Interviewee: Pretty even right now, so early on in career in STEM—not far enough into career path.

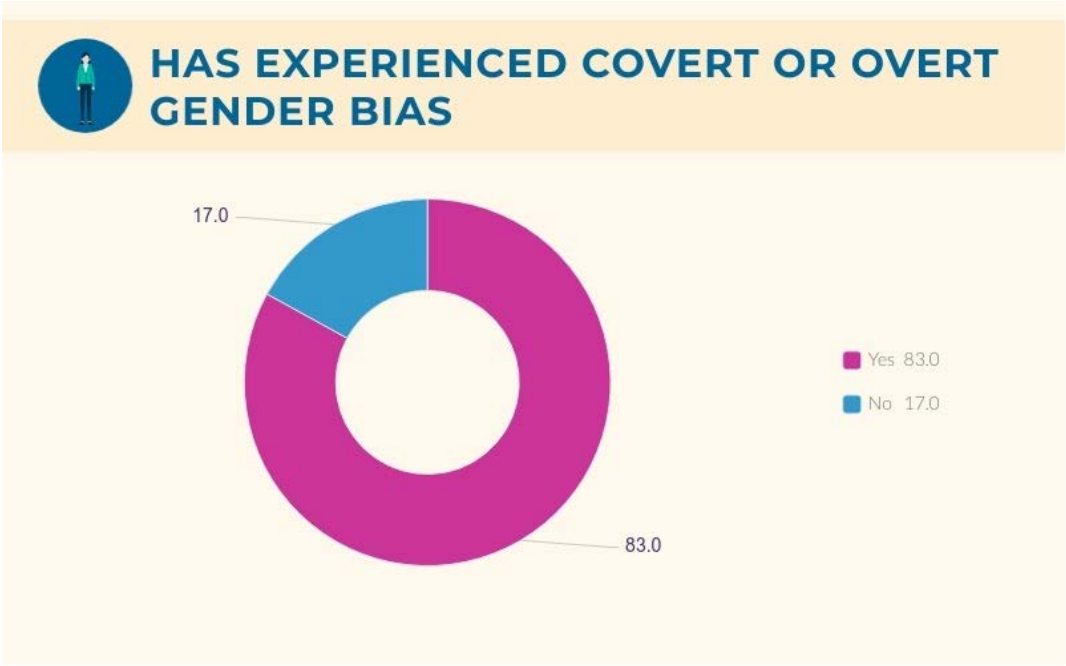
Interviewer: Have you experienced gender bias in your STEM classes/ STEM work?

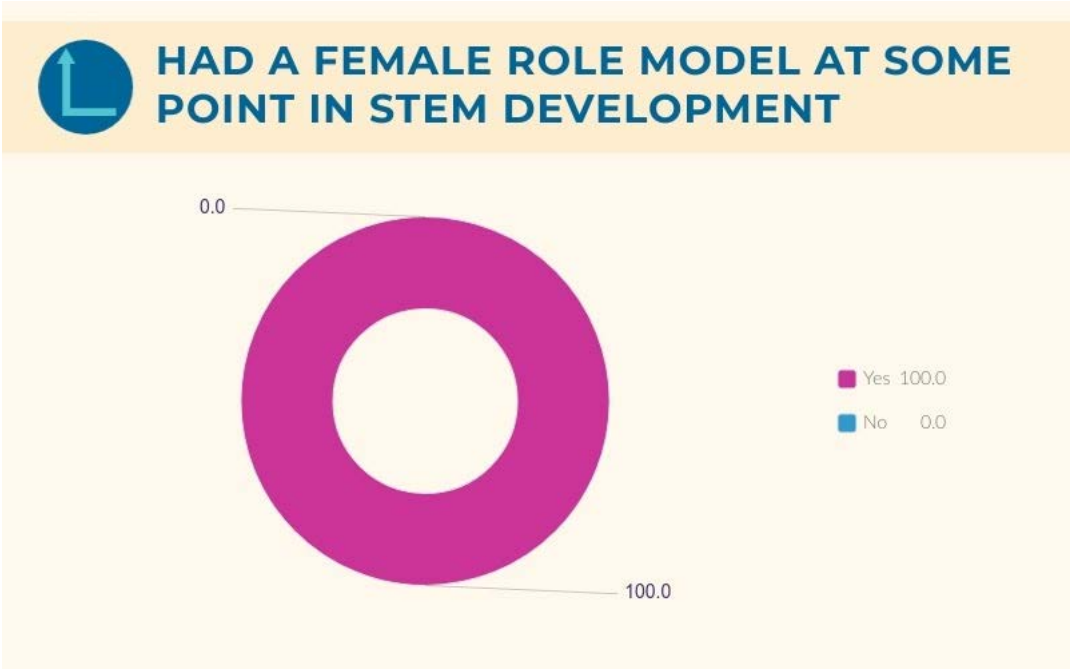
Interviewee: Haven't experienced any gender bias or subconscious bias that she can think of yet.

Interviewer: What can Bryant do to be more inclusive to, and advocate for women in STEM?

Interviewee: PA program was a big part of why she came to Bryant→ biology department needs more students and stronger marketing… peer mentors would be helpful→ older students who already went through classes to help navigate courses and feel supported

Appendix B – Key Interview Findings





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