



Gender Discrimination in STEM Education

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Abstract. Education equality is a worldwide problem that has existed for a long time. Women in science, technology, engineering and math (STEM) fields need special attention because they are at a disadvantage in STEM education. In this article, the manifestation of gender discrimination against women in STEM education will be presented and the causes will be discussed. Women who are willing to major in STEM, they cannot get as equal chances as men can in getting access to STEM education. And the exceptions from society and family are different. Besides, for women who are majoring in STEM, it is hard for them to be as competitive as men in academic achievement because of lower self-efficacy caused by gender stereotypes. Based on the two phenomena, the disadvantages of women will be discussed in detail. Women are disadvantaged in STEM education because they cannot get enough returns and a sense of gain, and gender stereotypes also decrease women's interest in enrolling in STEM education.

Keywords: gender difference · gender discrimination · STEM education

1 Introduction

In the early 1920s, many countries realized the idea that it is necessary to enhance the innovative spirit of the people if a country wants to improve its economic level. Therefore, the rise of STEM education has played a vital role in the cultivation of innovative talents in the United States. It has also promoted the development of the American economy to a certain extent. Under a series of publicity, STEM education has been gradually introduced into schools in many countries, which has expanded the scope of STEM education beneficiaries. Although the original intention of STEM education is to motivate all students to participate in the study of science and technology disciplines, previous research by scholars has found that in the process of STEM education, gender differentiation in textbooks is caused by gender stereotypes and participation caused by different treatment of men and women have appeared. The problem of gender imbalance in STEM education occurs. Especially in higher education, the problem of gender disparity is more prominent. The unbalanced gender ratio in STEM education not only

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hinders the development potential of female students, affects the educational development level of STEM education, but also violates the principle of equality respected by society. Since previous scholars have not systematically reviewed the issue of gender imbalance in STEM education, this paper will reveal the causes of gender discrimination in STEM education by reviewing gender differences in STEM education access and gender differences in STEM academic achievement this article as well as the disadvantaged position of women in STEM education and pointing out some possible solutions.

2 Gender Differences in STEM Education Access

2.1 Proportion of Girls and Boys in Receiving STEM Education

The unbalanced proportion of female students and male students in STEM education reflects the problem of “gender segregation”, which has a negative impact on the idea of promoting gender equality in society. As a comprehensive field of study including science, technology, engineering and mathematics, STEM education has its origins as early as 1986. At the beginning of the period, the United States wanted to encourage students to participate more in the study of science and technology subjects as well as improve the quality of school education and the cultivation of scientific and technological talents. The National Science Board (NSB) released the report “Undergraduate Science, Mathematics and Engineering Education” [1]. STEM education was carried out in schools until 2005, which has led society to pay more attention to the disadvantaged groups in traditional education, such as women, Latino science learning, especially the interest of some disadvantaged groups in STEM learning, including proficiency related to learning ability, etc. However, in the implementation of STEM education, the problem of the proportion of male and female students participating in STEM education has been exposed year by year due to the “gender segregation”. The unequal of male and female participation in STEM education is not only reflected by research data in the United States, but also reflected in a survey of gender differences in Indian 15–60-year-old individuals who choose to study majors in high school: About 40% of male students will choose to join Science Professional study, and only about 30% of female students will choose to study in the field of science. The data shows that in the age range of 15–60, the overall number of male students willing to study Science and Technology is higher than the number of female students willing to participate in Science and Technology. On contrary, the number of women willing to study Arts was about twice as high as that of men across all age groups studied. Therefore, these data also reflect the disadvantaged position of women in the field of STEM teaching. Women and men have different divisions of labor in society [2]. Most people have stereotyped thinking about the role of the social division of labor, which may lead to the problem of gender imbalance in participating in STEM education. The problem of gender discrimination in STEM education will eventually cause problems such as the imbalance of male and female employment ratio in society.

2.2 The Impact of Family Education Expectation on Gender Difference in STEM Education Opportunity

Parents’ education and expectations for boys and girls in STEM learning will lead to form a gender segregation problem in STEM education. This ultimately manifests a result of

an imbalance in the number of boys and girls participating in STEM education. Because parents are influenced by society's general prejudice which is against women, they teach boys and girls different educational philosophies. This social bias of discriminating education is almost inevitable, unless parents are highly educated and possess the ability to discern right from wrong to suppress expectations of differential outcomes for boys and girls in STEM learning. As consequence, parents affected by social factors do not give girls more expectations. Since children's life circle is limited to school, family and community, these three environments have become the main factors affecting their interest in STEM learning [3]. In a study of factors influencing the development of students' STEM career interests, it was found that parents had the greatest influence, accounting for 36% of the four influencing factors studied. The second is the influence of teachers on children, which accounts for 32% of all influencing factors [4]. Therefore, family prejudice against girls in STEM learning will greatly affect girls' interest in STEM learning, which further affects their motivation for STEM learning. In the end, they choose to avoid STEM education because they have no external recognition and self-confidence in STEM learning. But for boys, parents will give them greater expectations, so they have greater motivation to learn STEM, and more boys will choose to participate in STEM learning for them. Therefore, the difference in parents' expectations for boys and girls results in an unbalanced opportunity for boys and girls participating in STEM education.

2.3 The Impact of Social Expectation on Gender Difference in STEM Education Opportunity

The difference in STEM education opportunities for boys and girls is also due to differences in society's expectations of men and women. Because men and women have different physical and mental development patterns, society labels men and women in STEM education, which consolidates the formation of gender segregation. Many people empirically believe that boys develop faster bodies and brains than women during puberty, so society has developed the notion that boys are more suitable for participating in STEM learning than girls. However, in a study comparing the spiritual intelligence of male and female students, the average mental intelligence level of boys was 16.11, while the average spiritual intelligence level of girls was 18.13 [5]. The results of this experiment are a big blow to people's empirical conclusions. Therefore, it is false that boys are better suited to participate in STEM learning than girls. However, this misconception has largely attacked adolescent girls' recognition of their own learning ability, so they will choose other majors to study except STEM. In short, the differences in social expectations for male and female students eventually led to the formation of gender segregation in STEM education and the imbalance of participation in STEM education.

3 Gender Differences in STEM Academic Achievement

3.1 Difference in Enrollment in STEM Higher Degrees

It is normal for women and men to differ in their STEM higher degrees. The specific manifestations are women are less likely to pursue higher degrees in STEM. According

to a survey done by the US government, women achieve fewer degrees than men do in STEM fields [6]. It can be inferred that there may be some impacts that preclude women from stepping into STEM higher degrees.

An important issue is gender stereotypes. Stereotypes like women performing worse than men in mathematics and science, women should not major in STEM, and women do not fit careers in the STEM domains, are still common today. In a survey of 209 undergraduate students, data showed that 52% of them believed that young men outperformed women in STEM, while 47.5% of non-STEM students felt the same [7]. Gender stereotypes have negative impacts on women who are interested in STEM. A survey shows that women think that supports from parents are significant for them when deciding whether to enroll in the STEM domain or not [8]. If women's parents have strong stereotypes about their children and believe women are not born for STEM, they may reject to support their daughters to encourage them to enroll in STEM higher education. The situations are the same in schools when teachers think men are the potential in STEM. The actuality that parents and teachers are unwilling to support women to step into the STEM domains is discrimination caused by gender stereotypes.

Discrimination can lower women's self-efficacy, and can also lower the possibility that women enroll in STEM higher degrees. Self-efficacy, according to research, means the belief in their ability to succeed [9]. Self-efficacy will decrease if women show doubts about themselves more often rather than show trust. Self-efficacy has strong connections with women's academic performances. It turns out that self-efficacy has a lot to do with students' perseverance to complete their degrees. The higher the self-efficacy is, the students are more likely to persist to get degrees in STEM [10]. With low self-efficacy, women will doubt themselves that whether they are qualified for STEM or not. Women will also feel that they can hardly succeed in the STEM domain as a female, which is not good for their future careers. Lower the self-efficacy is, women are less likely to enroll in higher degrees because the continued effects of stereotypes in college.

Actions should be taken to encourage more women to enroll in STEM higher degrees. Women's continuous vacancy in STEM may intensify the stereotypes about women's disabilities in the STEM domains. Parents and teachers should be reminded not to stifle women's enthusiasm for STEM.

3.2 Difference in Participation in STEM Competitions

Women and men have a different status in STEM competitions. For example, in the International Chemistry Olympiad, International Physics Olympiad, and International Biology Olympiad from 2008 to 2017, every single year there were more men than women in the teams from the US and other countries. The participation rate of women in the International Mathematics Olympiad in 2020 is 10%, and these female competitors won fewer medals than the man did [11]. Through those data, it can be easily found that women have a low participation rate in STEM competitions and are in a disadvantage when competing in STEM competitions with men.

Because fewer female competitors are included in competitions than male competitors are, women may not be as competitive as men. Thus, it is understandable that there will be lower possibilities for women to catch up with men in overall performance. And women are more likely to give up competing than men if they lose the competition once

[12]. Meanwhile, women expect more rewards after competing [13]. If women lose a STEM competition once, and cannot get the reward they expect, they will be less likely to enroll in the same competition. Without persistence in participating in the same competitions, women are less likely to learn from their experience which can help them to improve their performances in the competition next year.

Participating in STEM competitions is also related to self-efficacy. There are always more men than women in those competitions and men perform better than women. And women's continuous disadvantages in those competitions may intensify the stereotypes in their hearts that STEM is not the domain of women. They may feel they are less likely to succeed than men in those competitions, and it is not worth paying so much attention and energy to things that can hardly be reached. They can also find from the results each year that female competitors can hardly achieve their goals to get higher degrees and win a medal. This reality can also lower women's self-efficacy. They will be discouraged by both the disadvantages of women in STEM competitions and the negative thoughts. With the effects of stereotypes and discouraging results, women's confidence will decrease and their self-efficacy will be lowered. With lower self-efficacy, it will be harder for women to get ideal results, which will lead to a vicious circle.

More women should be involved in the STEM competition. Participating in competitions can improve women's performances in STEM and winning medals is encouraging for women. To eliminate the inequality created by the imbalance in the number of male and female competitors, having a group of women and coming up with one more problem in the competition but the same level as the men can solve the problem of sexuality. Without the stress of competing with men, there might be more women participating in STEM competitions.

3.3 Different Pursuits for Career Path Based on a STEM Major

Compared with men, fewer women work in the STEM domains after graduating from STEM majors. This statement can be proved by research done in 2016. According to the study, 20.8% of female STEM graduates expect to be in STEM within 5 years, compared to 30.3% of males [14]. Women's willingness for working in the STEM domains is related to both outside ingredients and inside ingredients. Outside ingredients are treatments in workforce such as payment and promotion, while inside ingredients are women's willingness to carry family responsibilities such as pregnancy and baby-caring.

Treatments for women in STEM workforces have strong connections with gender stereotypes. The typical gender stereotypes that women are less gifted than men in STEM may be shown in workforce in different ways. Because of the gender stereotypes that consider women as the weak and the potential lying-in women who will resign for children in the future, women will be treated unequally in the STEM workforce. All of the unequal treatment of women can be considered gender discrimination. These discriminations make women at disadvantage in STEM domains, which may preclude women from enrolling in the STEM workforce. And most the STEM workplaces are still dominated by men. It is hard for women to put their feet in those workplaces if they are considered traditional women in stereotypes. Without basic understanding and respect, it is understandable that women who graduate from STEM majors are unwilling to choose STEM careers.

Family responsibilities preclude women from pursuing careers in STEM domains. Traditionally, women are expected to hold the responsibility for pregnancy and child birth, and many women are willing to carry out their family responsibilities. In research, 53.9% of women who have already gotten a bachelor's degree expected to marry before age 25 and 92.4% of them expected to have one or more children [15]. Compared with men, women have more roles in the family as mothers and housekeepers. The more roles women have, the harder it is for them to balance family responsibilities and jobs [10]. Affected by family responsibilities, women have less energy for STEM work. And as mentioned in this article, parents' supports are significant for women to make career choices. Without support, the possibility of women being willing to enroll in the STEM workforce will be decreased.

4 The Disadvantaged Position of Women in STEM Education

4.1 Low Interest in STEM Study

Women's lack of interest mainly comes from gender stereotypes. The prejudice that men are innately more competent and interested in science is a common cultural stereotype, and while most individuals consciously reject it, implicit association studies support the stereotype's persistence across age, race/ethnicity, gender, and country [16]. There is a common and interesting phenomenon. Almost all of the images on the covers of certain children's science and math books are of boys. Of all the pictures of scientists and explorers in the encyclopedia, not a single one of them is a woman. Children's stereotypes may be formed from childhood. The lack of role models gives women a signal that they don't belong in the field. Due to the influence of the notion on the whole society, women tend to have a self-consciousness that they are not as talented as men in STEM. However, most people are realistic. Women are more inclined to spend time and energy on things that they have advantages. Women's interest in STEM is hampered by ambiguous self-awareness.

In addition, parenting styles also hinder women from learning STEM subjects because of the influence of stereotypes. While the student's own interests were the most important factor in deciding on a major, the researchers highlighted that this required prior understanding of the field [17]. If a pupil has never been exposed to a subject, he or she will not acquire any interest in it. For girls, parents may think that they are more suitable for some literary and artistic subjects. Most parents know that women are in a dominant position in STEM subjects, and they don't want their daughters to take such risks. This is one of the reasons why parents deliberately avoid raising their daughters to study STEM subjects. In childhood training, there will be more emphasis on these subjects that the public thinks are more suitable for women. Parents of boys tend to focus on mathematics and science for their children's enlightenment education. Women have little exposure to STEM-related subjects during childhood, making it difficult to develop interest.

4.2 Low Sense of Gain in STEM Subjects

Women have a low sense of acquisition in STEM. Women received less encouragement and understanding in STEM subjects than men, leading to poor motivation. The pressure

of the learning environment has a certain influence on this phenomenon. It is well known that the STEM field has always been male-dominated. If a person is in an environment with more of the same kind of people will undoubtedly be more encouraged, while in a solitary environment will feel uncomfortable. Even female mentors in STEM fields are in the minority. However, female mentors in the STEM field also face the embarrassment of stereotypes. While male teachers do not place much importance on female students learning STEM subjects. Reducing women's sense of belonging to the research environment.

Sexism is pervasive in academia, especially in STEM fields, where the majority of people are prejudiced against women. According to Moss's research, faculty participants rated the male applicant as significantly more competent and hireable than the (identical) female applicant [18]. Most professors are reluctant to admit female students. And it's not just that the mood swings of women's special biological periods can affect academic research. It is also because women are far less physically strong than men of the same age when performing some experimental activities, which is a vital part of STEM. Teachers' discrimination against female students is not only reflected in the rate of hire, but also in the attitude of encouragement. Assuming the male is not gifted in STEM, teachers will simply think it is the men's personal problem. However, when a woman is not gifted in STEM, teachers tend to conclude that women as a whole are not gifted in STEM. Another possibility is that a female student showed excellent academic performance in STEM, and most teachers would only regard it as the result of hard work rather than talent. These conclusions frequently strike women, then women will show a lack of desire to master STEM subjects.

4.3 Lower Educational Return of Women in STEM Education

Low educational return is reflected in women's employment. Women who choose STEM fields will always have difficulties in future employment. Not only because of gender discrimination in this field, but also because of women's own family responsibilities. Fears about future prospects prevent women from pursuing higher-level STEM education.

The STEM industry has always been dominated by men, leading to a vicious circle. People often associate STEM jobs with masculinity. Stereotypes that women are less capable of working are still prevalent in STEM jobs. Women with a STEM degree are less likely than their male counterparts to work in a STEM occupation; they are more likely to work in education or healthcare [16]. Women are lacking role models in this industry. It is also because women have heavier household responsibilities, they spend less time at work than men. Companies will deduct women's salaries to a certain extent. This circumstance erodes women's confidence in entering STEM disciplines and limits their potential in those fields.

Women are often regarded as caregivers in a family, while the main source of income for the family comes from men. Women are not only more willing than men to make occupational sacrifices for the sake of their families, but they also prefer work-centered lifestyles at lower rates than their male counterparts [19]. Men will choose STEM-related jobs because they often offer a high salary. Women, on the other hand, select careers that allow them to balance work and family responsibilities. STEM-related jobs are extremely time- and energy-intensive. This affects many women's employment choices.

However, STEM fields are rapidly changing and require a substantial time commitment and continuous development of expertise to remain both productive and competitive [20]. This also means that women will face difficulties returning to work after their reproductive years. During women's maternity leave, the changing nature of information in STEM fields makes it difficult for them to return to work. Even if they return to work, they will encounter career bottlenecks where promotion is difficult. As a result, they are at a disadvantage in comparison to their male counterparts in the same field.

5 Conclusion

There is indeed gender discrimination in STEM education and gender stereotypes play an important role in this process. Under the situation that there are already fewer women who are willing to step into STEM, women still cannot get equal chances for enrolling in STEM education due to the expectations from family and society. Under the effects of gender stereotypes, people believe that men can do better in the STEM domain compared to women, which can preclude women from participating in STEM education and women will doubt their ability in learning STEM subjects. Women who are already in the STEM domain, are less likely to get as many achievements as men do and less likely to continue working in the STEM domains since the stereotypes make their parents unwilling to offer support and their colleagues will treat them differently. Furthermore, gender stereotypes can lower women's interest in STEM study, and will also make women less motivated. Since women are expected to undertake the family responsibility, they are more likely to give up their STEM careers, which makes women get fewer returns. According to those phenomena, women are indeed at disadvantage in STEM education. Future studies will focus on how to solve the discrimination problems in STEM education. This research can be used for helping to increase women's effectiveness in STEM education, and can provide a theoretical foundation for policy support that can improve women's plight.

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