

Honors Program

Alicia Underwood

*Reasons Behind the Determent of Women
in STEM Disciplines*

Accounting

03 May 2013

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Alicia Underwood

Honors Thesis

Bemidji State University

Colleen Livingston, Advisor

April 2013

Abstract

In the last two to three decades, women have started to become more prominent in the Science, Technology, Engineering, and Mathematics (STEM) fields. In disciplines notably dominated by their male counterparts, female advancements have started to become noticeable. However evident their contributions may be, a very apparent gender gap still exists. Few have answers as to why this remains true when women are deemed equal to men in today's society. More women may be entering the STEM world, but progress and retention still pose a struggle and have many researchers puzzled. Some claim that middle and high school preparation and curriculum is the pivotal point in a young girl's life while others tend to focus more on the societal influences and stereotypes our nation has yet to overcome. Although the United States of America prides itself on upholding many types of equality, this study will argue that the gender inequalities in STEM fields are keeping this society from functioning in a way that truly represents and fosters advancements for both men and women equally. Until the United States can accept this issue as problematic, it has no chance of remedying it. This examination looks at three key aspects influencing a lack of women with STEM aspirations. The hope for this thesis is a better and brighter future for women pursuing STEM careers.

Keywords: Women in STEM, gender gap, retention, stereotypes

THE DETERMENT OF WOMEN IN STEM

Reasons Behind the Determent of Women in STEM Disciplines

Recent research shows that more women have been taking on the challenge of entering some of the most male dominated fields, including Science, Technology, Engineering, and Mathematics (STEM). However, much of that progress has stalled and the gender gap is still prominent. In a study conducted by Yingyi Ma entitled “Gender Differences in the Paths Leading to a STEM Baccalaureate,” she states, “In this increasingly technologically advanced world, women’s underrepresentation in STEM is widely considered as one of the bottleneck issues facing women’s advancement into leadership positions” (2011). If the United States wants to continue to be globally competitive, it needs topnotch employees in its STEM jobs. For that to be possible in the twenty-first century, the U.S. needs to start relying on more than just half of the population. By examining educational factors, social environments, and societal influences, this paper increases the insight on the struggles women face before and after entering STEM disciplines. From there, the possibilities to remedy this problem start showing themselves. This thesis was written in hopes that one day, no one will know of a gender gap. In the next two sections, this paper will discuss some of the literature used for this research and the conclusions made with that research.

Literature Review

Statistics

In one report used to discuss recent statistics regarding women versus men in STEM areas, Beede et al. (2010) conclude that women are underrepresented in both STEM jobs and STEM undergraduate degrees and have been consistently over the last decade. The report is titled “Women in STEM: A Gender Gap to Innovation,” which is perfectly suited for this thesis. It is very important to give the reader a brief background on recent data in order for this paper to

THE DETERMENT OF WOMEN IN STEM

be meaningful. Without an actual sense of how outnumbered women are in the Science, Technology, Engineering, and Mathematics fields, the reader would just be reading an account of self-conscious women. By having the statistics, the reader will know that this is an issue that needs to be resolved.

Education

In order for females to know and understand what STEM fields can offer both them and society, preparation in middle school and high school years is pivotal. In 2011, Casey A. Shapiro and Linda J. Sax pool their knowledge and expertise when writing “Major Selection and Persistence for Women in STEM,” a paper dedicated to exposing influences that contribute to women’s selection of and persistence in STEM majors. Sax is a professor of education at UCLA’s Graduate School of Education and Information Studies and examines gender differences in college student development. She has done extensive research in higher education gender issues.

The co-authors use data, studies, scholarly papers, and more to summarize common factors that lead women toward or away from STEM disciplines in college. While touching on some forces beyond the classroom, the focus lies on issues institutional researchers have an opportunity to overcome. Their paper determines that the role of educational settings in women’s pursuit of STEM, middle and high school preparation and curriculum, culture and pedagogy in college-level STEM, and interactions with teachers and faculty all affect a woman’s decision of whether or not to pursue STEM beyond high school (Shapiro and Sax, 2011).

These findings were vital to this paper’s research because it stressed the importance of encouragement of women at a young age. Securing women once in the STEM fields may be a larger issue, but without women wanting to enter those disciplines, there will be no one to retain.

THE DETERMENT OF WOMEN IN STEM

The solutions to women feeling too discouraged to pursue their STEM aspirations may simply be a combination of proper preparation in middle and high school, offering suitable resources and opportunities, and providing young females with women role models. The information contained in this paper may be the jump start researchers need to solve this issue.

Social Environment

One working definition of a social environment is the immediate physical and social setting in which people live or in which something happens or develops; it includes the culture that the individual was educated or lives in, and the people and institutions with whom they interact. Therefore, the examination of family and peers falls into this section.

The people in one's family inarguably influence his/her future, as do family aspirations. Many women want to have a family and children at some point in their lives, and those ambitions may deter women from a career path that has been deemed both unwomanly and time-consuming. Most published papers and articles about women in STEM disciplines talk about these factors. However, "family" can be a very broad term. In today's world, many people may influence a person and his/her future: friends, peers, classmates, roommates, etc.

The main source for family influences is entitled "Cohort Changes in the Relationship Between Adolescents' Family Attitude, STEM Intentions and Attainment" and was written by Stephanie W. Burge and published this year. It is a study that examines cohort change in the effect of adolescents' family attitudes – the importance they attach to future marriage and parenthood – on their intentions to major in a STEM discipline and attainment of STEM bachelor's degrees. She used national studies to gather her information and found that women who placed a high priority on family had lower STEM attainments than similarly family-oriented men, even after expressing STEM intentions.

THE DETERMENT OF WOMEN IN STEM

While this thesis covers both family influences and family aspirations, it also discusses the importance of one's surroundings and the people in one's life. Biases exist among both men and women toward females in STEM careers. Nonetheless, men's biases toward women are more known and prominent. This thesis examines two papers discussing the effects a female environment has on a woman's interest in STEM fields and her self-confidence about her abilities.

"It's Different for Girls: The influence of schools" was written in 2012 by Priya Kantaria and published by the Institute of Physics. Its findings are remarkable, stating that "girls were almost two and a half times more likely to go on to do A-level physics if they came from a girls' school rather than a co-ed school" (Kantaria, 2012). It shows that when surrounded by people in similar situations, bonds form and encouragement from peers starts to take place, creating a positive learning environment. If encouraged in the right manner, girls are able to see that science can be fun for women, too.

The second paper was written by Katalin Szelényi and Karen Kurotsuchi Inkelas. "The Role of Living Learning Programs in Women's Plans to Attend Graduate School in STEM Fields" observes the role living-learning (L/L) programs at the undergraduate level play in a woman's plans to pursue STEM fields at a graduate level (Szelényi & Inkelas, 2011). This study uses data drawn from the 2004-2007 National Study of Living Learning Programs, a multi-institutional longitudinal study of undergraduate students. The focus of the study was on the effectiveness of L/L programs in facilitating successful outcomes for women in STEM fields. "Specifically, participation in women-only STEM L/L programs was consistently associated with women's plans to attend graduate school in a STEM field, when compared to coeducational L/L programs, non-STEM L/L programs, and traditional residence halls" (Szelényi & Inkelas,

THE DETERMENT OF WOMEN IN STEM

2011, p. 350). In 64.5% of the cases examined, the study was able to correctly predict student's plans to pursue STEM graduate education (Szelényi & Inkelas, 2011).

Couple this data with the first analytical point. If women are provided with the proper tools early enough and are then encouraged by their family and peers, recruitment into STEM disciplines would be nearly effortless. This topic, as well as the first one, helps provide insight on how to properly recruit and retain women into the STEM disciplines. Thus, for this research, it helped provide a solution to the discouragement of women.

Society

Another important study of women's underrepresentation in STEM fields is "Why So Few?" written by Catherine Hill, Christianne Corbett, and Andresse St. Rose and published by the American Association of University Women. This paper is 134 pages long and contains data, graphs, and in-depth analyses of multiple theories and proven reasons as to why men continue to outnumber women in STEM fields. This paper has findings to support all three areas of this paper's research. However, it is most helpful in the societal aspect of this exploration. Four of its ten chapters include "Beliefs about Intelligence," "Stereotypes," "Implicit Bias," and "Workplace Bias" (Hill et al., 2010). It notes that stereotypes do exist about girls not being as capable in math and science as boys, despite the considerable gains in participation and performance in these areas (Hill et al., 2010). If women start to believe those stereotypes, it will very likely have detrimental effects on not only their ability to perform but also on their decision whether or not to pursue STEM as a potential career.

The chapter on implicit bias discusses that even individuals who consciously refute gender and science stereotypes can still hold that belief at an unconscious level. However, it is not the only bias that exists. "Why So Few?" states that "People tend to view women in

THE DETERMENT OF WOMEN IN STEM

‘masculine’ fields, such as most STEM fields, as either competent or likeable but not both” (Hill et al., 2010). This is the opening sentence of the Workplace Bias chapter. It discusses a follow-up study conducted by Madeline Heilman, an organizational psychologist at New York University, and her colleagues. They conducted three experiments involving women in male-type jobs. This is what Heilman said about her results: “whereas there are many things that lead an individual to be disliked, including obnoxious behavior, arrogance, stubbornness, and pettiness, it is only women, not men, for whom a unique propensity toward dislike is created by success in a nontraditional work situation” (Hill et al., 2010). A woman’s success should not impede her upward mobility in male-dominated fields, especially when they have proven themselves capable of moving ahead in their careers.

Stereotypes are not the only influence in society, as this section has discussed. Many societal factors influence women every day in every aspect of their lives. Examining some of these factors aided the examination of the thesis topic. The societal focus also helped explain why the first two analytical topics exist. Without stereotypes and biases, people would accept the fact that women are just as capable as men in attaining STEM degrees and pursuing careers in those fields.

Discussion

Statistics

For this paper to resonate, people must be made aware that a gender gap does still exist. The easiest way to do so is to present some data. In a report written by Gerhard Sonnert, Mary Frank Fox, and Kristen Adkins, all collegiate faculty, they examine the determinants of outcomes for women in science and engineering. Their study “Undergraduate Women in Science and Engineering: Effects of Faculty, Fields, and Institutions Over Time” found that although women

THE DETERMENT OF WOMEN IN STEM

have been entering the science and engineering fields in growing numbers over the past two decades, “Women are still relatively rare among majors and degree holders outside the social, behavioral, and life sciences” (Sonnert, Fox, & Adkins, 2007). Thus, when hearing that more women are entering the science fields, it does not necessarily mean they are entering the male-dominated science areas. “Whereas the percentage of women engineering majors has been increasing by an estimated annual rate of only 0.3 percent, biology and the physical sciences each had estimated annual rates that were about three times that high” (Sonnert, et al., 2007). And although women hold nearly half of all jobs in the U.S. economy, they hold less than 25 percent of STEM jobs (Beede et al., 2011). With those numbers, half as many women are working in STEM jobs as one might expect. This may be due in part to the fact that while women hold a disproportionately low share of STEM undergraduate degrees, especially in engineering, even if they do obtain an undergraduate degree in a STEM discipline, they are less likely than their male counterpart to work in a STEM occupation (Beede et al., 2010).

“Recent research has consistently shown that gender differences in math achievement have been substantially reduced” (Ma, 2011). However, while women have surpassed men in college attendance and completion rates, women received only 19 percent of bachelor’s degree in engineering, 19 percent in computer science, and 21 percent in physics in 2007 (Ma, 2011). Furthermore, in 2009 only 24 percent of the computer science or math workforce was female (Beede et al., 2010).

Each of these statistics aids in pointing out the obvious gap in gender representations among STEM participants. Although countless studies will show the gap is decreasing ever so slightly, it does not disprove its remaining existence. With this data in mind, discussion about possible reasons the gap is not decreasing more can begin.

THE DETERMENT OF WOMEN IN STEM

Education

Exposing females to the benefits and opportunities of a STEM occupation in middle school and high school is pivotal. “Preparation in science and mathematics during the middle and high school years is often cited as an important influence on women’s decisions to enter or exit STEM majors in college” (Shapiro & Sax, 2011). Without proper preparation early on, they lack both the skills and the knowledge about the fields to even be interested in them. In a paper published in 2012, “Why STEM Fields Still Don’t Draw More Women” the author interviews a group of scholars asking why women are less likely to major in STEM fields than men. The Dean of the College of Engineering at North Carolina A&T State University noted two factors behind a woman’s decision whether or not to pursue a STEM major, one of which being “personal capabilities and preparedness to succeed” (Why STEM Fields, 2012). Before society can attract more women into the STEM disciplines, they need to make sure the women they are recruiting are properly equipped.

Most people have no idea what they want in their future until their late high school years, but in “Women’s Paths in Science: A Critical Feminist Analysis” Jillian Kinzie found that women’s pathways into or out of STEM are already beginning to be formed as early as eighth grade (2007). This means exposure before this point could aid in increasing the number of women interested in STEM fields later on. One study reported an increase in middle school girls’ interest in engineering after the girls were exposed to a 20-minute narrative delivered by a computer-generated female agent describing the lives of female engineers and the benefits of engineering careers (Kinzie, 2007). It only took those girls twenty minutes to get a glimpse into what STEM fields can offer. Imagine what steady exposure throughout middle school would do for them by the time they reach eighth grade.

THE DETERMENT OF WOMEN IN STEM

Exposure early on can affect how well females perform academically, which plays a huge part in whether or not females pursue a STEM career. Low math achievement in eighth grade may play a role in the number of math courses women take in high school, thereby limiting the number of women who have adequate preparation to enter college-level math and science courses (Shapiro & Sax, 2007). By not even attempting those courses in high school, women limit their abilities and are then more unlikely to be successful in a college learning environment. As some studies have shown, “women entering college often have little exposure to engineering and computing” (Why STEM Fields, 2012). Women may still be interested in STEM fields in college without adequate experience from high school, but whether or not they have some background knowledge does help determine whether they stick with their majors in college or not (Shapiro & Sax, 2007). “Interestingly, a higher percentage of women reported concerns with inadequate high school preparation than did men” (Shapiro & Sax, 2007). If women are not given the same preparation as their male peers in high school, it makes it very difficult to stay at the same academic level once in college.

Women’s experiences with the curriculum as well as their academic interactions with instructors and peers are influential in shaping women’s interest in and longer-term commitment to STEM. If students view their faculty as role models, which many students do, such interactions will promote student interest in STEM (Shapiro & Sax, 2007). The presence of a role model may be more important early on, but the importance of women faculty is huge throughout the entire academic career of a woman. This importance is underscored in a study that concludes that the “growth trajectory of the percentage of female undergraduate majors was somewhat steeper in the presence of a larger percentage of women faculty” (Sonnert et al.,

THE DETERMENT OF WOMEN IN STEM

2007). Having somebody to look up to and relate to makes it easier for females to remain in a predominately male discipline.

As important as female faculty are, the environment presented is equally significant. Mara Wasburn and Susan Miller of Purdue University-West Lafayette, Indiana second that statement in their article “Retaining Undergraduate Women in Science, Engineering, and Technology: A Survey of a Student Organization.” They note that “the absence of women faculty and mentors both within the classroom and outside of it, few women students in their classes, and the lack of supportive networks can create a ‘chilly climate’ for women in non-traditional fields” (Wasburn & Miller, 2004). Also, a discriminatory atmosphere may be extremely discouraging to female students. In some cases, “faculty have been described as excluding women from activities in the classroom and subjecting them to different grading practices than their male peers (Sonnert et al., 2007). Another study found that nearly one-third of female respondents felt professors in their technology classes treated female and male students unequally (Wasburn & Miller, 2004). According to Sonnert et al. (2007), women tend to prefer more cooperative forms of learning, so such environments can be especially disheartening and unappealing, deterring female entrants.

Social Environment

A woman’s learning environment helps shape her life, but there are other forces in the environment that need to be accounted for. Other large factors include her family and her peers. When talking about family, one must point out both family influences and expectations. Starting with the influences, obviously parental encouragements or discouragements will inarguably affect a young woman’s career aspirations. Shapiro and Sax (2007) point out that a woman is more likely to pursue a career in STEM if one or both of her parents have a career in a STEM

THE DETERMENT OF WOMEN IN STEM

field. More notably, having a father as an engineer is associated with persistence toward a career in STEM (Shapiro & Sax, 2007). Historically, many parents have accepted the stereotype that men are more apt to succeed in STEM than women, and as a group, parents have lower educational aspirations for daughters than for sons. (Shapiro & Sax, 2007).

Not only do parents' jobs matter, but the emphasis they place on family values influence what a woman wants in her future. Adolescent family attitudes that emphasize parenthood negatively affect women's intentions in STEM attainment (Burge, 2013). These views are consistent with a woman's parents being role models for what she wants out of a family. If her parents emphasize the importance of family and hint at one day wanting grandchildren, obviously that will be sitting on the back of a woman's mind.

Moving to family expectations brings up the issue of women wanting one day to have children. "Contemporary young women, especially those who aspire to professional careers, anticipate high levels of work-family conflict" (Burge, 2013). It appears that early in a woman's college career is when she perceives a STEM career being incompatible with successfully raising a family. Even when men and women report equal levels of academic ability, first-year college women are still more likely to anticipate that conflicts between work and family responsibilities will be a barrier to career success (Shapiro & Sax, 2007). They use this incompatibility as a reason for exiting STEM (Burge, 2013). Research demonstrates that female STEM graduates, both at the bachelor's and master's level, who have children are much less likely to pursue further study in STEM relative to men (Burge, 2013).

Although many think the harsh stereotyping and other professional barriers are the key reasons more women are not pursuing STEM careers, Pooran Wynarczyk and Chloe Renner (2006) found in their paper "The 'Gender Gap' in the Scientific Labour Market" that family

THE DETERMENT OF WOMEN IN STEM

responsibilities are more to blame for dissuading women. These responsibilities include both family-life and spouses. In “Conflicts Between Graduate Studies in Science and Family Life” written by Vanessa Wyss and Robert Tai in 2010, they find that “many women have indicated that the needs of their spouses weigh in greatly when they make career choices.” In a series of interviews explained in Wyss and Tai’s (2010) paper conducted among women scientists, all of the women identified balancing a career in science with a personal life as a struggle. The women also indicated that the needs of their spouses weighed in greatly when they were making career choices. Data from the National Institute of Health found that 31% of married women indicated a willingness to make concessions to accommodate their spouse’s career, while only 21% of married male respondents reported the same (Wyss & Tai, 2010). This evidence provides that family responsibilities may impact career-related decisions more for women than for men.

While these factors exist, they do not have to be the rule. “Providing the necessary resources, exposure, and encouragement would help young women understand that their gender shouldn’t determine the career path they choose, and that pursuing a STEM career does not make them less feminine” (Why STEM Fields, 2012). Some scientists referred to marriage or a family as a support and a contributing factor to completing graduate school or continuance in science (Wyss & Tai, 2010). In today’s society, more and more men are becoming stay-at-home fathers, which would take pressure off of the women pursuing their career. One female graduate student credited her husband for taking over most of the laundry, cooking, and other household chores in order for her to be able to graduate in four years (Wyss & Tai, 2010). With this trend becoming more popular, it may help in making the STEM disciplines more appealing to women.

Almost as prominent as family and spouses are in a women’s life are her classmates and peers. As noted in the education section, the learning environment plays a huge role in the STEM

THE DETERMENT OF WOMEN IN STEM

pipeline. “Friendship groups that have a high combination of female friends and performance in math and science facilitate women’s persistence in advanced courses, such as calculus and physics” (Shapiro & Sax, 2007). This is why multiple studies have been conducted on living-learning environments at both high school and collegiate levels. Note that living-learning communities involve undergraduate students who live together in a discrete portion of a residence hall (or the entire hall) and participate in academic and/or extra-curricular programming designed especially for them (Szelényi & Inkelas, 2011).

The results of one study suggest that this popular intervention may improve gender equity in STEM fields by providing positive experiences and environments for those who participate in them within their first year of college (Szelényi & Inkelas, 2011). These L/L programs benefit college students in terms of a range of academic and social outcomes: social and academic transition to college, first-year retention, GPA’s, critical thinking, enjoyment of challenging intellectual pursuits, etc. (Szelényi & Inkelas, 2011). In a second study, “Independent girls’ schools sent four times more girls on to do A-level physics than maintained co-ed schools” (Kantaria, 2012). Interactions with peers can provide women with an avenue to exchange information, find study partners, and create informal peer role models. With the help of L/L communities in their undergraduate careers, women will be able to feel more comfortable in the STEM environment and will be more likely to continue with their STEM desires.

Society

Stereotypes are a large portion of the societal influences that affect women when discussing STEM fields. Some of these stereotypes include long-held popular misconceptions. When talking about the computer science field, these would be “that computing is too hard for girls, that it’s geeky, that it requires a singleminded 24/7 focus, and maybe – worst of all – that

THE DETERMENT OF WOMEN IN STEM

computer science equals programming and so provides little benefit to society” (Why STEM Fields, 2012). More generally, two stereotypes are prevalent: girls are not as good as boys in math, and scientific work is better suited to boys and men (Hill et al., 2010). These misconceptions are too often confirmed by girls’ peers, by cues in the popular media, by a lack of role models that run counter to stereotypes, and even by advice from their parents and guidance counselors (Why STEM Fields, 2012). Children are aware of these stereotypes as early as elementary school and can express stereotypical beliefs about which science courses are suitable for females and males (Hill et al., 2010). In a report published in *Science Education* by Buck et al. in 2008, it was concluded that girls and young women have been found to be aware of, and negatively affected by, the stereotypical image of a scientist as a man. The negative effects can be seen in a female’s performance and aspirations in math and science. This phenomenon is called “stereotype threat” (Hill et al., 2010).

With the existence of these stereotypes, women perceive themselves to be less successful than their male counterparts:

Girls assess their mathematical ability lower than do boys with equivalent past mathematical achievement. At the same time, girls hold themselves to a higher standard in subjects like math, where boys are considered to excel. Because of this, girls are less likely to believe that they will succeed in a STEM field and, therefore, are less likely to express interest in a STEM career. (Hill et al., 2010)

In extreme cases, rather than repeatedly confronting a negative stereotype, girls and women might avoid the stereotype by avoiding math and science altogether (Hill et al., 2010).

Fortunately, the stereotype threat can be alleviated by teaching students about it, reassuring

THE DETERMENT OF WOMEN IN STEM

students that tests are fair, and exposing students to female role models in math and science (Hill et al., 2010).

Although many people say they do not believe the stereotype that girls and women are not as good as boys and men in math and science, research shows that those individuals may still hold that belief at an unconscious level. As noted earlier, this phenomenon is known as implicit bias. Because people are not aware of them, these unconscious beliefs may be more powerful than explicitly held beliefs and values:

Implicit biases against women in science may prevent girls and women from pursuing science from the beginning, play a role in the evaluations of girls' and women's coursework in STEM subjects, influence parents' decisions to encourage or discourage their daughters from pursuing science and engineering careers, and influence employers' hiring decisions and evaluations of female employees. (Hill et al., 2010)

However, once brought to the forefront, these implicit beliefs can be changed if the holder of the belief so desires (Hill et al., 2010).

Another prominent bias in today's society is known as workplace bias. This circumstance is noted when women in male-type fields are penalized for their success (Hill et al., 2010). They are considered less competent than men and then pay the price of social rejection in the form of being disliked (Hill et al., 2010). When a woman is disliked by her coworkers, it has clear consequences in every aspect of a woman's career.

"Overall, the belief of male mathematical superiority is pervasive in U.S. culture." (Ma, 2011). Because society treats STEM fields as male domains, students grow up to believe such perpetuated notions. Luckily, stereotypes, biases, and other cultural beliefs can change.

THE DETERMENT OF WOMEN IN STEM

Educators and parents can start by encouraging girls' achievement and interest in math and science.

Conclusion

After examining the literature used in this paper and discussing the issues that are still prevalent in our society, it is very clear that something needs to change. With this new millennium upon us, the need for a technologically literate workforce is imperative. "If we want to attract the best and brightest minds into the fields that will advance us as a people, a country and a planet, we can no longer look to only half of the population" (Why STEM Fields, 2012). Women comprise nearly fifty percent of the available STEM talent pool, making it more important to not only attract but also to maintain them. Women's underrepresentation in STEM signifies a loss of potential influence and innovation that may have an impact of the ability of the United States to remain globally competitive. "Attracting and retaining more women in the STEM workforce will maximize innovation, creativity, and competitiveness" (Hill et al., 2010). By looking at educational factors, different social environments, and societal influences, this thesis provides the United States with a first step on defining the reasons as to why a gender gap still exists. The start in overcoming any issue is accepting its existence. With this thesis, women struggling to survive in male dominated fields can finally begin to answer the questions that stump many researchers, and hopefully action will be taken to remedy this matter at hand.

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THE DETERMENT OF WOMEN IN STEM

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