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Teachers' Perceptions on Women in STEM: Breaking the Stereotypes

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Abstract

Drawing on an online professional development modular course that addressed critical approaches to the issues of race, immigration, English Language Learners (ELLs)/Emerging Bilinguals (EBs), and gender and sexual orientation, this paper reports teachers' perceptions on gender stereotypes in Science, Technology, Engineering, and Mathematics (STEM) education. In particular, building on the course readings, we discuss teachers' emergent approaches to address gender stereotypes in teaching practice that improve girls' participation in STEM fields. Data is collected from a pre-course survey and teachers' discussions during the course. Centering on the course readings from theoretical and empirical research that address gender issues, discussion prompts were used to elicit teachers' insights on gender stereotypes in education. A thematic analysis method was then employed to discuss strategies for challenging gender stereotypes in teaching practice from teachers' discussion posts. Teachers recognize that gender stereotypes have been embedded in the social norms that influence teachers' practice in an underlying way. Three promising strategies are identified to address gender stereotypes in STEM education, including integrating role models into the curriculum, developing a growth mindset, and promoting justice classroom discourse. We also discussed ways to support teachers in addressing gender stereotypes in their practices.

Keywords: Gender Stereotype, STEM, Classroom Discourse, Role Model

According to the National Center for Educational Statistics (2019), women earned less than 43% of bachelor's degrees in mathematics and statistics in 2016. Women's share of bachelor's degrees in computer sciences, engineering, and physical sciences were 19%, 21%, and 19%, respectively. However, the trend is different in psychology, biological sciences, and social

sciences. In psychology, women received around 75% of degrees at all degree levels—bachelor’s, master’s, and doctorate degrees. In biological sciences, women received more than half of the degrees at each level. In the fields of social sciences, women earned more than half of their bachelor’s degrees. Although women are generally underrepresented in Science, Technology, Engineering, and Mathematics (STEM) fields, they are undoubtedly underrepresented in traditionally male-dominated STEM fields (Ceci et al., 2014). Though overt gender bias is waning in K-12 educational contexts, underlying negative messaging persists concerning the fallacy of females’ inferior mathematics and science skills and continues to influence assumptions about girls in STEM careers (Dou & Cian, 2022; Hill et al., 2010; Master, 2021). Gender stereotypes negatively impact teachers’ expectations and evaluations of their students in the classroom, which determine the external support students receive from teachers (e.g., Alan et al., 2018). Thus, teachers play an important role in shaping students’ beliefs about gender implications and norms. Increasing teachers’ awareness of gender stereotypes through professional development is an urgent need to promote gender equity in STEM fields and improve social justice in K-12 education (Kuchynka et al., 2022).

The authors (hereafter, “we”) designed and taught a Professional Development (PD) course for K-12 in-service teachers and educators across a Midwestern State to explore critical theory on race, immigration, English Language Learners (ELLs), and gender. In this study, we investigate teachers’ perceptions of gender stereotypes in STEM from the perceptions expressed in the PD course. We report our findings by analyzing teachers’ responses from pre-course surveys and structured discussions during the course. The survey data revealed that the majority of teachers clearly described the prevalent negative stereotypes about females in STEM. Some teachers used personal experiences as evidence to illustrate the stereotypes and other teachers shared counter perspectives aimed at reducing and addressing them. Building on the course readings, the discussion questions aimed to further teachers’ awareness of gender stereotypes in education and promote strategies to challenge and disrupt stereotypes in K-12 classrooms. We used a thematic analysis approach (Braun & Clarke, 2012) to interpret teachers’ responses. We reported teachers’ initial perspectives on gender role stereotypes in education and their perceptions of girls and women’s particular ways of learning. In addition, we identified three promising strategies to address gender stereotypes in STEM, including integrating role models into the curriculum, developing a growth mindset, and promoting justice in classroom discourse. Based on the findings from this study, we discuss practical classroom implications and suggestions for addressing gender bias in teachers’ development.

Literature Review

Stereotypes embodied in sociocultural influences play a part in shaping individual beliefs and motivation over time (e.g., Lubienski & Ganley, 2017). Individuals’ negative stereotypes of STEM are a predictor of their math/science self-efficacy, career interests, and goals (Garriott et al., 2017). Women’s free career selection might be influenced by underlying gender roles that expect women to be family oriented. Hill et al. (2010) warned that even individuals who consciously refute gender stereotypes can still hold that belief at an unconscious level. This means that stereotypes are particularly worrisome because they are indirect, and we may be entirely unaware of them. As we continue to overlook them, these unconscious stereotypes ultimately remain within the U.S culture (Corbett & Hill, 2015). In this literature review, we explored gender stereotypes that permeate K-12 education, and strategies addressing gender stereotypes in K-12 education.

Gender Stereotypes

Upon analyzing 400 studies and developing a causal framework to explain the dearth of women in STEM, especially in math-intensive fields, Ceci et al. (2009) concluded that women's preferences, representing both free and constrained choices, constitute the primary factor in making a career choice. The choices which seem to be made from personal intentions are also shaped and limited by sociocultural circumstances. As Eccles (1994) pointed out, an individual sometimes does not actively or consciously consider the full range of objectively available options in making their selections. He continues to explain that "many options are never considered because individuals are unaware of their existence. Other options are not seriously considered because individuals have inaccurate information regarding either the option itself or the possibility of achieving the option" (Eccles, 1994, p. 589).

Traditionally, gender-stereotyped roles posit that women prefer to work with people doing service work, whereas men prefer assuming leadership or individual work. Su et al.'s (2009) meta-analysis on gender differences in career interests revealed that men gravitated toward things-oriented careers and women gravitated toward people-oriented careers. Diekmann et al. (2010) speculated that women's avoidance of STEM careers might be because STEM careers are often perceived as incompatible with their communal preference (e.g., working with or helping other people). Eccles and Wang (2016) investigated the personal aptitudes and motivational beliefs in 12th grade that move an individual toward or away from STEM fields at age 29 ($n=1200$). They found that among STEM disciplines, female students have a preference for people-oriented work, which is a strong predictor of their choice to pursue people-oriented STEM fields (such as health, biological, and medical sciences) rather than other STEM fields (such as mathematics, physical, engineering, and computer sciences) (Eccles & Wang, 2016).

In addition, women's advancement in STEM fields is shunted and hindered due to institutionalized gendered and intersectional barriers. Bird and Rhotan (2021) explore whether STEM faculty members working in universities perceive systemic barriers to equity in STEM, as a legitimate obstacle. They argue that despite meritocratic beliefs, certain groups of employees in higher education are held back due to the enforcement of systemically inequitable policies and practices.

Gender Stereotypes in K-12 Education

Students' gender stereotypes on mathematics and sciences significantly associate with their mathematics and science identity, which in turn was an influence on their STEM course taking and performance (Starr & Simpkins, 2021). In the book *Women's Ways of Knowing*, Belenky et al. (1986) claimed that girls and women prefer collaborative learning that is based on care and communication. Scholars have also envisioned a collaborative learning environment in which students were working in small groups, sharing experiences, and discussing different ideas; where teachers trust their students' thinking and encourage alternative methods (Becker, 1995). In such educational environments, instead of seeking confirmation about right or wrong, students gain confidence from different ways of solving problems (Anderson, 2005). Furthermore, successful collaboration in a classroom provides students with a supportive environment to engage in intellectual risk-taking to solve challenging problems and exchange mathematical ideas.

On the other hand, there are serious negative consequences when such supportive and caring environments are not available to all students. Implicit gender stereotypes and differential expectation for male and female students that teachers hold negatively impact girls' mathematics learning and diminish girls' performance in mathematics (Matheis et al., 2020; Robinson-Cimpian et al., 2014). In terms of students' mathematical abilities, Copur-Gencturk et al. (2020) found that teachers rated White-sounding names higher than Black and Hispanic-sounding names. When the authors examined non-White teachers' perceptions of students' abilities, they found that the teachers favored White students, of both genders, over students of color, whereas White teachers favored boys over girls. Alan et al. (2018) found that teachers' beliefs on gender disparity play a crucial role in mitigating or widening the gender gap in STEM. They reported that teachers who are gender-biased in their beliefs in STEM and specifically Mathematics had a striking detrimental effect on female students' test scores, both written and verbal. Thus, by transmitting their biased-laden traditional role of gender beliefs to the girls in their classrooms, teachers condition young girls to pursue other fields.

Also, the attitudes and behaviors of male peers, such as taking over girls' work or belittling the contributions of girls, worsen the discouragement of girls (Allan & Madden, 2006). In a recent study of 1500 participants from four informal science learning sites, McGuire et al. (2020) examined stereotypes about STEM within informal science learning sites. The participants ranged from early childhood to adolescents. Findings from the study revealed that boys, more than girls, identified that their gender 'should' be better at STEM than girls. In addition, underlying gender stereotypes play a role through curricula. Kerkhoven et. al. (2016) examined how educational resources within visual content of online education databases perpetuate gender bias. The analysis revealed that men were more likely to be depicted as science professionals compared to women and fewer men were depicted as social science professionals.

Addressing Gender Stereotypes in Teacher Education

Teachers play an important role in communicating stereotypes with students which shape how STEM is perceived, learned, and practiced (Liu, 2020). Due to the integration and interdisciplinary nature of STEM, teachers often have limited PD opportunities to develop an awareness of critical issues (Pourdavood & Yan, 2020). Thus, without developing teachers' awareness of gender bias and stereotypes, it is likely that teachers will continue reinforcing stereotypes when they communicate with students daily. In addition, teachers often feel that they lack the necessary knowledge and skills of STEM content to engage students in STEM investigations. More specifically, STEM is a growing field in education therefore, addressing equitability and representation is a critical need in teacher education. Nesmith and Cooper (2019) found opportunities for professional development over multiple years beneficial for "providing opportunities for the teachers to discuss and reflect on each experience within campus and grade level teams" (p. 495).

Stereotypes of females' inferior mathematics ability shape the personal evaluations of teachers of the students in their classrooms (Riegle-Crumb & Humphries, 2012). Teachers often use adjectives like 'hard-working' to refer to girls but use 'bright' to refer to boys who perform at the same level (Walkerdine, 1998). In Wang's (2012) study, the teachers held lower expectations for girls to perform well in mathematics than for boys. Thus, girls may have less external support in developing interests in mathematics (Wang, 2012). In middle or high school classrooms, "teachers

were more likely to stress the association of mathematics with activities, careers and domains that interest boys, such as engineering or physical domain” (Wang, 2012, p. 1653).

Teachers can, thus, break gender stereotypes by creating a supportive learning environment and inclusive classroom culture (Rogers et al., 2021). Using inclusive and non-discriminatory pedagogies could improve equity for women and minorities, promote connected knowing, and value girls’ voices (Anderson, 2005; Dersch et al., 2022). A supportive learning environment demonstrates care about the girls’ needs, recognizes their contributions, and offers opportunities for recognition and development (Rogers et al., 2021). Having conversations with students about women’s contributions in STEM fields and acknowledging girls’ intellectual achievement would counter stereotypical messages and promote girls’ confidence in STEM learning. Through reflecting on their own beliefs and stereotypes, teachers have opportunity to develop their awareness of their behaviour in teaching. Thus, they have the opportunity to restructure their perceptions of female students in STEM (Matheis et al., 2020).

In addition, providing role models could be another intervention for teachers to disrupt stereotypes (Sears et al., 2021). In STEM fields, female role models demonstrate that women can overcome stereotypes. It may be especially critical for women to know someone like themselves has been successful (Lockwood, 2006). Evidence has shown that STEM women hold weaker implicit gender-STEM stereotypes than non-STEM women (Smeding, 2012). Creating welcoming communities can help girls break stereotypes and reinforce their STEM identities. By surrounding girls with female role models, girls are more likely to perceive positive messages about women in STEM, which weakens stereotypes, and, in turn, enhances ingroup identities (Smeding, 2012). Girls are the most eager and participatory in teams that have either gender parity or a female majority and far less engaged in teams with female minorities (Dasgupta & Stout, 2014).

The reviewed literature informs us that teachers’ perceptions of gender stereotypes in STEM fields impact students’ stereotypes in gender and STEM, self-efficacy in STEM learning, and career interests. The culture of the classroom, discourse, and learning environments the teacher creates would be a space for students to either interrupt stereotypes or continue to communicate stereotypes. Therefore, it stands to reason that a foundational step in helping teachers create an inclusive learning environment would be to understand their perceptions of the stereotypes and what strategies they have recognized to address stereotypes. Thus, the following two research questions guide this study:

1. What are teachers’ experiences and understanding of women in STEM?
2. What strategies did the teachers develop based on their experiences and engagement in the course that can be used to break gender stereotypes in K-12 education?

Methods

The participants in the study were in-service teachers and educators who enrolled in an online professional development course designed to raise understanding and knowledge of critical perspectives on race, gender, ELLs and immigration. All teachers consented to participate in the study. In this paper, we use the terms “participants” and “teachers” interchangeably. As stated before, the purpose of the study was to understand teachers’ conceptualizations and development in the knowledge of gender stereotypes in STEM.

Data Sources

The data for the study includes the class materials that were collected in the form of a pre-course survey, as well as online discussions to which the teachers contributed weekly in response to the readings the facilitators assigned. The pre-course survey consisted of a set of questions that addressed participants' range of engagement with diversity, equity and social justice, critical perspectives on gender, and their expectations for taking the course which is further examined through their reflection papers for women and STEM (Osei-Tutu et al., 2021). The pre-course survey questions that teachers responded to were:

- What is your understanding of diversity?
- What do you think about when you hear: Diversity, Equity, Inclusion, and Social Justice?
- How would you define Equity and social justice in education?
- Describe gender stereotypes you have heard in learning math, science, engineering, sexuality, etc.
- Briefly discuss any engagement in conversation about diversity, inclusivity, and social justice.
- Why are you interested in these topics? What do you hope to gain from these workshops?

We have a total of 158 survey entries which were collected at the beginning and end of the course. During the semester, the number of participants were reduced to 67 due to their inability to keep up with the pace and rigor of the course.

The module on gender issues consists of two themes: women in STEM and gender minorities in K-12 education. We selected three readings including two theoretical articles and one practical report that focus on the issue of women in STEM. Clance and Imes's (1987) article focuses on the therapeutic intervention to address the imposter phenomenon that successful and high achieving women experience; Dasgupta's (2011) article discusses that developing ingroup identity can address stereotypes and build girls' confidence in STEM; Hill et al.'s (2010) work unpacks the environmental factors that shape girls' achievement and interests in STEM and proposes recommendations to support women in STEM and counteract stereotypes. These readings' historical perspectives shed light on gender stereotypes in education, in particular, girls and women in STEM fields. We selected these readings to prompt participants' engagement in the issues of women in STEM and engage them in the further discussion. These readings also were used to develop the discussion questions with the intention to collect the participants' views as well as their own experiences of women and STEM. Building on the content of the articles, teachers engaged in online discussion with group members supported by a facilitator. The discussion prompts for this module were:

- Do you think that girls or women have distinct ways of knowing? Please provide evidence to support your answer.
- What strategies can we use in practice to address negative gender stereotypes?
- What factors influence women's participation in STEM? Since the last decade, in terms of women in STEM, what has changed, and what remains?

Data Analysis

The research method employed to analyze the data is thematic analysis, to systematically review the data and actively seek out themes (Braun & Clarke, 2012). Thematic analysis is a

flexible and accessible qualitative research method to analyze data in educational settings. For our project, we sought out repeated meanings across our data sets (Vaismoradi et al., 2013) between all the researchers to capture information that illuminates and addresses the research questions. After independently reviewing the data, the researchers identified and assigned themes by using attributes that were “summative, salient, essence-capturing, and or evocative” to categorize the data (Saldana, 2016, p. 4). Subsequently, all the themes were compiled, and these were further sorted by the researchers collectively after deliberation and clarification. We discussed the usefulness and relevance of each theme, and only after a mutual understanding among the researchers. Member checking was not incorporated as the participants of the study were enrolled in the course. The themes were finally distilled to align with and answer the research questions. A summary of teachers’ notable comments has been highlighted in the findings section below.

Findings

In this section, we report our findings from analyzing teachers’ initial survey results and their responses to the discussion questions. First, we describe teachers’ initial perspective of gender role stereotypes. Then we report teachers’ perceptions of girls’ and women’s particular ways of learning. Finally, we summarize the promising strategies to address gender stereotypes in STEM, including integrating role models into the curriculum, developing a growth mindset, and promoting justice in classroom discourse. We provide direct quotes of the participants to feature our participants’ voices without adulteration in an effort to engage in dialogue with the readers about the interpretation for the quotes. Additionally, the selected quotes highlight the significance of participants’ experiences as they relate to each theme.

Teachers’ Initial Perspective of Gender Role Stereotypes in Education

In the pre-course survey, teachers shared stereotypes they have heard or experienced in education. They recognized that gender stereotypes are a cause and also a reason for women’s underrepresentation in STEM fields. Common stereotypes teachers identified were that women are emotional while men are rational; women are good at social science, language, and art while men are good at math and science; and the perception that women are less capable in logically oriented fields such as STEM.

The existence of gender stereotypes in K-12 education was further evidenced in teacher’s personal and classroom teaching experiences that illustrates the perception of women as caregivers and not equal partners. These norms permeate the culture in society, norms in the classroom, and curricula. A teacher shared,

My own daughter was treated discriminatorily at a university where she worked in psychology. The men there treated her as if she were to take care of them, not be their peers.

Similarly, another teacher described her experience of being fed stereotypes that demoralized her and dissuaded her from pursuing the field altogether,

When I entered high school, not only did my parents discourage me but my teachers as well. Even though I was very good in physics and mathematics, they all encouraged me to consider health-related programs rather than engineering because engineering was for boys and not lucrative to girls. The truth is that their

words made an impact on me and that is how I left the idea of becoming an engineer behind.

The participants also explained that stereotypes were steeped in patriarchal thinking and disciplines were recommended to students based on their gender role as illustrated in the following quote,

From personal experience; "you can't be a veterinarian, that's a man's job." That was in 5th grade coming from my own teacher. I changed my mind along the way to become a teacher, but her words still stick with me, and I would never tell one of my students that. She also believed that women were better served in the home.

Similar to the previous participant's response, the following participant also recognized that teachers play an important role in instilling stereotypes and that stereotypes did not just impact the participants when they were younger but are also reinforced in schools and the curriculum today. A science teacher said,

I heard a high school counselor tell a student that my course is better suited for women as they need to know this skill for life, males should be in a more "manly" curriculum.

As a science teacher, there are always gender stereotypes about men being more in the STEM fields and so on. Even in my curriculum, the scientists we learn about are all men.

When I was growing up and in school, it was a given that the boys went into the math and science fields and girls went into teaching. Robotics clubs and science extras were always made available to the boys.

In addition to the stereotype of females' having less capability in STEM, another stereotype that plays out as a microaggression is that women in STEM fields are exceptional and remarkable, and to succeed in these fields, they have to sacrifice or hide feminine attributes. A teacher shared this experience,

I also know from a college course on gender and women in the sciences that women in science are often viewed as being more masculine, less social, and often meaner and less capable. Women are also often viewed as being less analytically minded.

Women who were doing well in STEM were thought as exceptional, which reinforced the stereotypes that women in general are not capable of learning the subjects that traditionally, men dominated. Teachers recognized that girls and women are not incapable in mathematics and science, but stereotypes confirm their negative beliefs and have an impact on their education. As a teacher said, "Women are less likely to enter careers in math and STEM; it is more due to the shaping of mindset. It is not reflective of ability or skill." The fixed mindset of gender roles in STEM undermines girls' performance as well as their interests in STEM fields.

Teachers' Perception of Girls and Women's Particular Ways of Learning

Teachers' responses to whether girls/women have distinct ways of knowing exposed a nuanced understanding of learning differences and its impact of academic achievements. Even for those that agree with gender differentiated learning styles, their view was oriented towards supporting ALL students to succeed. Based on the responses we received, participants shared anecdotal

evidence about the gender variation in approaches to learning. In the section below, we share examples and personal experiences that help elucidate the perceptions. The first one below is an example of a participant's personal experience suggesting that gender norms did not always dictate the kinds of activities girls and boys have. A teacher shared interesting stories about her family,

My older brother and I [female] are perfect examples of this. My brother is an attorney, very smart, high I.Q. and excellent in math. Unfortunately, if you give him a hammer, he hurts himself. For me, I am the hands-on learner, figuring things out usually by common sense, and not particularly interested in that A+. I can change a flat tire, rewire the house, and fix the toilet. I approach all challenges with some common sense and humor. We both have excelled in our fields and did it by hard work, determination, and grit even though we have completely different approaches to learning.

As we explored the ways in which gender roles inform learning styles, participants offered specific examples based on their experience of working with students as catering to the individual styles also maximizes learning. The following examples offer valuable insight into learning about learning differences so that students, regardless of gender, may succeed academically. A teacher said,

Yes, I think girls and women have a distinct way of learning. Often within my classroom, my female students require more visual explanations of new material. They seem to grasp it quickly when they can see how to do the skill. Whereas my male students typically show more interest and understanding when they are working with the skill being taught and discovering through exploration. Neither way is wrong, but I think it is very important as an educator to make sure and teach using a variety of teaching methods to help all learners to learn.

Yet, others were of the view that the expression of emotions accounts for this distinctiveness. They explain that women find it easy to express emotions. A teacher said, “*many girls take on a bit more emotional labor than boys and that can change the way they think, but that is more of a case-by-case basis and based on culture and family environment.*” Aligning with the above comment, a participant expanded on this view by discussing decision-making processes,

Because they acknowledge their emotional side more than men, they have a different way of knowing based on emotions. In a decision, women might consider many different factors being affected by their decision where men may have a narrower focus of just making a quick decision.

However, there is a second group of teachers who do not believe that girls' or women's distinct ways of knowing are shaped by biological differences, but rather oriented by social norms. As one participant expounded,

I am aware of the plethora of books on the line of “men are from Mars; women are from Venus” in terms of personal/social relationships but I have no evidence to support that any of this is true other than from my own observations. I would prefer to stick with the context of this set of readings and say that women and men are equally equipped to gain new knowledge and apply their knowledge to new situations. What is different is the opportunities presented to them.

Among the participants' there was also evidence to deny the presence of differences in learning styles among males and females. Participants accounted for the individual differences rather than ascribing generalized views as the following participant explained that "*I do not believe that females have a distinct way of learning. I believe that both males and females can have strong math and language arts skills. I think it is more about the individual, than the sex.*" Instead, the plethora of social and cultural norms that are still remarkably present and persisting in this yet changing world, are what these groups of teachers use to explain why such perceptions of distinction exist. Approaching it from the professional field, one participant finds that,

In many ways, girls and women are required to have distinct ways of knowing in order to be successful and reach particular achievements. The cultural expectation for women to fulfill a particular role that both edifies and impresses men (but not too much of either) requires a specific instinct—at once we must be both independent and dependent, smart, but not too smart, attractive, but not overly-to maintain desirability, the highest currency in heteronormative relationships.

How various cultures perceive and treat women also accounts for these major differences that people have come to associate with men or women. Teachers shared various examples of how these cultural and societal norms are reinforced. In this study, we are not focusing on whether girls and women have different ways of learning, rather we aim to encourage teachers to be aware of how social norms and bias influence students' learning and impact on their career selection later.

Promising Strategies for Addressing Gender Stereotypes in STEM

Building on their understanding of the readings in the course, participants identified promising strategies that can be adopted in the fight against gender stereotypes in education. We carefully analyzed the participants' responses to addressing negative gender stereotypes in practice. We identified three themes that teachers proposed to counter stereotypes in education, including integrating role models into curriculum, developing growth mindset, and promoting a justice-oriented classroom discourse.

Integrating Role Models into Curriculum

Participants proposed that integrating female role models in the curriculum will engender a sense of belonging for girls and women when they make career decisions. Thus, the knowledge of women and their contributions in STEM fields, would encourage girls to pursue their future careers in STEM fields. Teachers recognized that introducing female role models could be a strategy to reduce gender stereotypes. A participant said, "*For young students, seeing is believing and if more young girls see women in STEM roles, then the more likely they will become interested in selecting roles in math and science.*"

Another participant illustrated through their own experiences the impact that integrating role models in the curriculum had on inspiring and motivating young girls to pursue STEM fields. The teacher tells the story of representation below:

*Our school has made a focus on doing STEM units for each grade level. We have started to pair the STEM projects with books for the primary grades. The books that have been read include women in STEM roles. For example, my students heard the story *Hidden Figures* during the month of March. The story sparked interest in boys and girls alike to learn more about space and science-type jobs.*

Some female teachers who taught mathematics and/or science in the K-12 setting position themselves as role models for their female students. They are conscious of girls' representation in STEM courses and make efforts to advocate for increasing girls' participation in their courses. A participant stated,

One change that I am aware of as a science teacher is an effort in schools to bring in more STEM courses, and to have representation when talking about STEM subjects. Girls are more likely to see, during their grade school education, examples of women in STEM careers than they were a decade ago. I personally have been making efforts in this to make sure that my students see someone who looks like them working in scientific fields.

Seeing themselves as role models, female teachers play a crucial role in supporting and encouraging girls to pursue careers in the STEM field. A participant shared, "As a child, I never saw myself in any of those roles. When I became a teacher, I found myself changing the names in equations to represent all genders." Similarly, another participant stated,

I teach in a science-based program, but one that is dominated by women on one level and men on another. I am working on a lesson to show that we all bring excellent points of view to the table. My goal is to remove some of his male chauvinistic ways and humble this student a bit. (Any suggestion would be appreciated for this). The young ladies had to take a step back, but they did come out swinging and showed their worth in our lab.

In addition to the explicit or seen aspects of curriculum, there is the implicit or hidden curriculum which is harder to identify. Therefore, teachers suggested being aware of the implicit messaging or hidden curriculum that is being promoted in their institutions. Teachers can consciously select or adapt curriculum including female figures and integrate role models in teaching which is an effective way to inspire girls. A participant pointed out,

Children's picture books have images of women in aprons and dresses cooking or cleaning, and muscular men doing work outside or sitting behind a desk in their own office. These stereotypes are often subtle (in the illustrations) and go unnoticed, but in elementary school we teach students to use the illustrations to help them make meaning. In order to challenge these stereotypes, they need to be openly acknowledged and discussed.

With that said, teachers who were focused on an inclusive STEM curriculum recognized that they were pushing against societal gender norms. Teachers recognized that stereotypes on gender roles are harmful for both boys and girls. Therefore, integrating female role models in curriculum would possibly break down the social expectations on gender roles.

Developing Growth Mindset

Participants argued for a growth mindset teaching approach to be used with girls in order to teach them that with effort, skills can be learned, and that failure is not always negative in this journey. Specifically, teachers discussed advanced coursework necessary for cultivating and maintaining specific skills needed to support female students. A teacher suggested the need to,

Encourage high school girls to take Calculus, Computer Science and Physics, etc., showing them their potential for success in these fields and to help them on that

path. I am helping them to develop their spatial skills through different games and challenges that could be fun for them and entertaining as well.

Exposing students to STEM early in their academic journey and introducing STEM as a part of extracurricular activities can be a way to support building girls' confidence and developing a growth mindset. Teachers also saw a connection between engaging STEM curricula and female student engagement. A teacher expressed,

If girls are not exposed to cool STEM activities, they are not interested in science, technology, engineering, and math. Hill points out that poor or underdeveloped spatial skills can also be a reason why we have so few in STEM. Many women do not have the confidence to participate in STEM activities; therefore, they believe they will not succeed in the STEM field.

Participants also call for school efforts in developing a growth mindset to promote girls' participation in STEM. A teacher said,

Schools should promote and encourage females in math-oriented programs, such as math or science bowls. This will give them the confidence that girls can perform well in STEM academics.

Developing a growth mindset is not an instantaneous process; it does not happen all at once. To actively reject gender stereotypes in STEM education, teachers should counteract the underlying stereotypes by reflecting on their own biases and engaging in new discourse. As previously described, teachers have recognized the stereotypes which are implicitly embedded in the culture and curriculum. Thus, teachers not only need to be constantly mindful of stereotypes, but also, they need resources and support to address these stereotypes. Integrating female role models into the curriculum is a feasible strategy for teachers to use in their daily teaching. In particular, female teachers can position themselves as role models for girls which could greatly encourage girls to develop belonging.

Promoting a Justice-oriented Classroom Discourse

Stereotypes are often embedded in everyday life and infused in daily communications. To curb stereotypes in teaching, teachers need to intentionally create classroom norms to conquer the negative perspectives on gender stereotypes. Classroom discourse, therefore, plays a critical role in sending messages to students about gender roles and careers, including teaching students what they should and should not say. Participants shared strategies they have implemented or plan to use in their day-to-day teaching to reduce gender stereotypes. Through classroom discourse, teachers proposed blurring the perspective and learning practice boundaries regarding gender in the classroom. A participant shared,

Another strategy is to be vocal when hearing a stereotype being used. A simple "why do you think that?" or "we don't use that language in this classroom" or "I don't find that funny." can be a useful tool to stop the stereotype and to get others to think about why they've developed an assumption/bias.

Another participant shared a scenario in teaching and strategy used for communicating with a male student who condemned his female peers in group work,

I teach in a science-based program, but one that is dominated by women on one level and men on another. I am working on a lesson to show that we all bring

excellent points of view to the table. My goal is to remove some of his male chauvinistic ways and humble this student a bit. (Any suggestion would be appreciated for this). The young ladies had to take a step back, but they did come out swinging and showed their worth in our lab. I experienced one in class today. I had a male student quite loudly say, "I am screwed in my lab assignment because I am stuck with two girls." After gathering my thoughts and not exploding on said student, I explained to him that he should be honored to be graced with such talented ladies that know far more than he does in terms of this assignment and that he was placed in that group for a reason.

Creating a justice-oriented environment and promoting classroom discourse requires teachers not only to fight against negative messages but also to recognize and champion girls' talents in work and provide opportunities for them to show their talent. A participant shared,

I try to challenge all of my students, especially my girls, if they show a huge interest in math. It's amazing to see a positive dynamic in my classroom where both boys and girls are encouraging each other rather than trying to "fit the mold" that society has tried to create.

Classroom discourse can be extended in communicating with parents. A participant shared her experience with parents' concerns about their sons playing with girls' toys or their daughters playing with boys' games. The participant expressed the way she discussed gender roles with parents as below:

I would reply that playing with dolls encouraged a nurturing/gentle behavior and would later help their son to be a good parent/that playing with Legos encouraged fine motor development and spatial awareness. I would frequently tell my students that "we don't have girl/boy colors" and addressed similar stereotypes with examples: "My uncle is a nurse. Boys can be nurses, too." The idea was to address them casually but firmly and not in an embarrassing manner.

Classroom discourse sends underlying messages to students about gender roles and career expectations. Promoting justice discourse requires teachers to recognize gender stereotypes and potential biases and to develop a mindset to intentionally fight gender stereotypes. The findings reveal that teachers recognized gender stereotypes in education. The shared experiences from their own learning and teaching remind us that gender stereotypes need more attention in classroom practices.

Discussion

The pre-survey data and findings reveal that teachers recognize an implicit proliferation and exacerbation of gender stereotypes in K-12 education. Not only do teachers recognize the gender stereotypes plaguing the STEM fields, but they also encounter, experience, and perpetuate gender stereotypes during classroom instruction. From such experiences, teachers expressed that gender stereotypes prevalent in schools result in women's underrepresentation in STEM fields (Alan et al., 2018; Dou & Cian, 2022). Teachers' knowledge, experiences, and understanding of women in STEM and gender stereotypes were twofold: personal encounters and reports from other information resources.

Experiences and understandings from personal encounters include experiencing discrimination by peers or teachers, evidencing a higher representation of men than women in STEM courses and the availability of Robotics or Science clubs for boys rather than girls. Second, teachers' understanding of women in STEM and gender stereotypes from report or people or hearsay include (a) STEM fields being considered as male talents and attributes; (b) a falsified assumption that males are better at math, science, computers, and engineering while females are better at reading, writing, social studies, art, and other creative things; (c) school authorities, such as teachers or school counselors, categorize programs for students based on assumptions regarding the students' professional goals; and (d) a misconception that women in science are often viewed as being more masculine, less social, and often meaner and less capable, as the teachers indicated. Teachers' shared experiences and perceptions of gender stereotypes align with literature that girls and women have lower self-efficacy and face more challenges in STEM fields (e.g., Bird & Rhoton, 2021; Ceci et al., 2014; Dersch et al., 2022). From personal experiences and hearsay, these narratives informed teachers' perceptions and conceptualization of women in STEM fields and the gender stereotypes (Allan & Madden, 2006).

Additionally, a sentiment reflected in teachers' personal and shared experiences, is that women have distinct ways of learning and knowing (Belenky et al., 1986). From personal experience, teachers indicated that women gather and assimilate information differently than men. Though it may not be clear if this is a case of nature versus nurture, they believe that women are more intuitive and process multiple information holistically, whereas men compartmentalize information. Teachers proposed that men and women would approach answers very differently when a question is posed. They shared that some female students in their class require more visual explanations of new material because they can grasp concepts faster through simulation. However, the male students show interest and comprehend faster when working with the skill being taught and discovered through exploration. From shared experiences, teachers expressed how the distinctiveness can be attributed to how women express their emotions. As women openly share their emotions, they develop the strength of knowing through emotions. However, some women feel inadequate in the same job or working space as their male counterparts. Teachers, therefore, play a critical role in communicating stereotypes with students. Teachers' knowledge about the disparity in learning and knowing between boys and girls necessitates differentiated instruction and scaffolding in teaching STEM courses (Anderson, 2005; Master, 2021).

Curriculum Integration and Growth Mindset

A prominent perspective we argue is the role curriculum plays in perpetuating gender stereotypes and biases. As Kerkhoven et al. (2016) and Bird and Rhotan (2021) have expounded, the curriculum is fundamental in centering these databases and institutionalized gender biases. However, beyond affirming this view, teachers discuss strategies to mitigate these biases and disrupt these stereotypes through several approaches. First, there is the need to integrate role models in the curriculum that reflect successful women in the STEM field (Dasgupta, 2011). By emphasizing the major contributions women have made, and continue to make, in the field of STEM, an atmosphere of possibilities will be created that propels young women toward the field. Another approach to inverting the STEM curriculum will be to address the gender roles in the curriculum. As teachers explained, women are barely mentioned in the STEM field as examples of successes, but when they are, they are often placed in supporting roles (Robinson-Cimpian et al., 2014). By providing representations of women who are leaders in the STEM field, a clear message is sent to both boys and girls that the field is not the sole prerogative of men. This means

that teachers first have to be reflective on their complicity in maintaining gender stereotypes and consciously adapt their curriculum and approach to teaching to support change (Copur-Gencturk et al., 2020; Riegle-Crumb & Humphries, 2012).

Project-based learning is another aspect of curriculum adaptation that is crucial to dismantling gender stereotypes. Creating opportunities in the curriculum for girls and boys to learn, engage, and intern with women in the STEM field throughout their education, will engender positive mindsets for all involved. For girls, the myth of inability will be broken, while the “boys club” mentality for boys will be shattered (Dasgupta, 2011). With such mindsets, women and girls’ sense of belonging in the STEM field would be strengthened. When people feel a sense of belonging, they are enabled to succeed. To push back against what Herzig (2004) finds, a sense of belonging will mean that females “fit” perfectly in the STEM field.

Breaking stereotypes in the STEM field also requires the development of a growth mindset. Teachers who are educated, aware and conscious of gender biases in the curriculum and teaching are better able to break the barriers. This growth mindset is what will retain women in the STEM fields (Corbett & Hill, 2015) while encouraging women to resist the societal gender norms that condition women to relinquish their desires to succeed in the field in order to support their husbands’ careers (Lubienski & Pinheiro, 2019). Additionally, teachers who are conscious of gender bias in teaching will bring a reflective attitude towards building a classroom and school culture of equity where all genders thrive.

Developing a growth mindset also means paying attention to societal influences of gender stereotypes. Many of our teachers discussed how gender norms in the society or community affect how women engage in STEM, as well as fields they gravitate towards due to their upbringing. Thus, women in the field should work towards mentoring and supporting young women to pursue STEM careers: they should encourage them to take calculus, chemistry, engineering and all the courses that have been rendered as shrines for men. As one participant aptly puts it, “*girls should be taught to use a growth mindset, understanding that skills can be learned, effort is just as important as intelligence, and failure can lead to growth.*”

One major issue that affects equity and change is the fear and refusal to engage in conversations about controversial issues. “Teachers report often avoiding these types of discussions due to concerns about the unpredictability of student reactions, accusations of trying to push a political agenda, and insufficient knowledge or skills to work through complex issues” (Fournier-Sylvester, 2013, p. 1). Therefore, it is important as a major part of the growth mindset, to be ready and open to discussions on gender biases and stereotypes in the field. It is important to create spaces for such conversations to take place in and outside of the classroom, including project-based learning environments. It tells the students, society, and girls and women in particular, that they have the potential and ability to succeed in STEM and it is our responsibility to help them reach it.

Promoting Justice Classroom Discourse and Improving Teacher Education

By supporting teachers through professional development, school districts are ultimately supporting student learning and growth. Within STEM education, professional development often focuses on how teachers conceptualize curricula (Ring et al., 2017) and implement integrated approaches (Shernoff et al., 2017) to STEM learning. Providing teachers with opportunities to collaborate with their colleagues about the successes and challenges of implementing STEM lessons has a positive correlation with teachers’ improved self-efficacy (Nesmith & Cooper, 2019).

Similarly, many in-service teachers lack experience with professional development that focuses on social justice issues. While the diversity of U.S. classrooms continues to increase, the demographics of teachers remain White, female, and monolingual. Therefore, professional development is needed to support teachers whose cultural and linguistic backgrounds differ from their students. Several factors must be considered when providing in-service teachers with transformative pedagogy, therefore becoming a social justice-minded educator requires a shift in mindset. Active implementation of multicultural education required a gradual and in-depth awareness of shifting one's attitudes toward students' learning (Pourdavood & Yan, 2020).

Based on our teachers' responses, STEM educators seek professional development grounded in social justice (Ring et al., 2017). For many, their teacher education programs did not expose them to culturally responsive, sustaining, and relevant pedagogy that aims to develop teachers' critical perspectives in education. Furthermore, while they recognize the importance of role models in promoting STEM education for young female students, overall, our teachers felt that they lacked the necessary knowledge and training to support their students. Therefore, bridging the gap between STEM education and social justice pedagogy has the potential to promote a shift in classroom discourse that is more equitable and inclusive. Not only does STEM for social justice provide teachers with a toolkit to support students of diverse backgrounds, in terms of women in STEM, but it also has the potential to amplify females' contributions by making them visible and explicit within K-12 settings (Dou & Cian, 2022).

Conclusion

Regarding the professional development course, it can be said that teachers presented critical insights into the reasons for the lack of female representation in STEM fields. In this paper, we analyzed the teachers' responses to two research questions that explore teachers' understanding of women's experiences or lack thereof in STEM. The authors of the course designed and implemented a four-modular-course to cultivate teachers' critical knowledge of issues of intersectional identities (race, gender, immigration status, and language ability). Our experience teaching the course highlights the need for prioritizing social justice issues of women and the representation of women in STEM in teaching, learning, and curriculum. The challenge of teacher professional development and teacher education is to identify the spaces to address gender stereotypes. Based on teachers' responses, we have confirmed the existence of the stereotypes in the minds of the teachers, the potential or perceived impacts on the participants and their classrooms and propose three strategies for addressing gender stereotypes in education, namely, integrating role models in curriculum, developing a growth mindset and promoting justice-oriented classroom discourse.

The outcome of the professional development course and teachers' learning has implications for teacher professional development and teacher education. Our course is a good example of a learning community for teachers to acknowledge gender stereotypes and how they perpetuate them. We discuss curricular development that integrates role models and project-based learning helps dismantle gender stereotypes as well as promote a growth mindset.

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