The influence of gender stereotypes on Chinese international high school students' perception of self-competence in STEM subjects: A qualitative study

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Abstract. Although gender stereotypes in the STEM fields have been robustly studied, the research targets have rarely included international high school students in China. This study aims to explore how gender stereotypes influence Chinese international high school students' perception of self-competence in STEM majors. Six students of grade 11 in an international school in Hangzhou, China, were interviewed to collect detailed knowledge of their perception of self-competence in STEM fields and the influence their parents, teachers, textbooks and social media have on their ability perception in these fields and career aspirations. The change of which factors may ameliorate the self-competence of high school students will also be analyzed. This study discovered that girls' parents more frequently hold gender-stereotypical opinions regarding girls' abilities in STEM subjects. This stereotype will significantly undermine a girl's self-competence and prevent her from delving deeper into STEM fields. For girls, same-gender teachers typically hold fewer gender stereotypes regarding their STEM capacities and can serve as great STEM role models that inspire and boost girls' confidence. The international students perceived almost no gender stereotypes in their teachers. The learner profiles emphasized by the IB diploma programme in school have helped students develop prominent critical thinking abilities and allowed them to rationally evaluate gender stereotypes related to female STEM competence in social media and textbooks. Based on the results, several suggestions to help eliminate the influence of gender stereotypes regarding STEM competence on students and create an equal development environment for them are also provided.

Keywords: Gender stereotypes; STEM subjects; self-competence; interview.

1. Introduction

The widespread ways sexism impacts children from birth across all spheres of their lives means that equity and justice are frequently denied to them [1]. Sexism is commonly demonstrated through gender stereotypes, which refer to shared ideas that associate certain groups with particular features or characteristics. They are transcendent of an individual's personal beliefs and are held by a particular society [2]. The stereotypical gender role beliefs of their immediate environments, such as social media and textbooks, and intimate people, including their parents, relatives, neighbors, peers and teachers, will strongly influence the ability beliefs of adolescents [3]. These stereotypes might cause adolescents to think that members of their group do not achieve professional goals or belong to particular academic fields. Consequently, their self-competence in this field will be lower. The self-competence will further manifest influences on students' major choices and career decisions [4].

According to previous studies, girls are the objects of negative stereotypes in STEM subjects (stand for science, technology, engineering and mathematics). The past findings suggest that citizens commonly believe that boys are more interested and competent than girls in these four academic fields [5-7]. These stereotypes have significantly undermined the perception of the self-competence of girls and affected their interests and momentum to pursue higher achievements in the STEM fields. In 2018, only 19.9% of all bachelor's degrees in computer sciences, 22.2% of all engineering degrees, 42.3% of all mathematics and statistics degrees, and 20.8% of all Physics degrees went to women in the United States [8]. The underrepresentation of women in high-level STEM education will further lead to uneven gender distribution in the STEM labor market and ultimately affect the future

development of these fields. In 2019, among all the engineers employed in the United States, only about 15.9% were women; meanwhile 84.1% were men [9].

At the same time, it is noteworthy that women received a majority of degrees in some STEM fields. At every level, women received at least 70% of psychology degrees. Over 60% of bachelor's and master's degrees and over half of doctoral degrees in the biological sciences were earned by women [8]. It is possible that life sciences are linked to assisting others, and the idea of "women as helpers" is congruent with gender stereotypes [1]. These data demonstrated that the proportion of men and women in different majors in STEM fields is different, which deserves more in-depth exploration.

Although gender stereotypes in the STEM fields have been robustly studied, the research targets have rarely included international high school students in China. Compared with those students studying in traditional local schools, students studying in international schools are more likely to enter the global labor market after completing their studies. Their future career choices will significantly impact the development of the worldwide STEM labor markets. Thus, it is crucial to determine how and to which extent the gender stereotypes regarding STEM competence affect their ability beliefs.

This study aims to explore how gender stereotypes influence Chinese international high school students' perception of self-competence in STEM majors. Six students (three girls and three boys) of grade 11 in an international school in Hangzhou, China, are interviewed to get detailed knowledge of their perception of self-competence in the STEM fields and the influence of their parents, teachers, textbooks and exposure to social media have on their perception of self-competence in these fields and their career aspirations. Since this school does not provide any engineering related courses, the influence on engineering field will not be included in this study. The change of which factors may ameliorate the self-competence of high school students will also be analyzed based on the results. This study will also provide suggestions about improving curriculum design and creating an equal developmental environment for high school students.

2. Method

The data was gathered from qualitative interviews. Each interview lasted about 20 minutes and was conducted one-on-one in the quiet study room of the school (Avoid outsiders or noise disturbing the outcomes of interviews). In order to ensure the continuity of the interview, mobile phone recording will be used throughout the interview. The transcript will be written down after the interview. Before conducting the interviews, a total of 15 interview questions were prepared. These interview questions examine the STEM courses the students taken in the school (1 item), their perceptions of self-competence in each STEM field (4 items), their future career aspirations (1 item), and four intimate factors related to gender stereotype formation: parents (2 items), teachers (3 items), STEM textbooks (2 items), and social media (2 items).

Three girls and three boys were randomly picked from grade 11 of an international school in Hangzhou, China, and were interviewed voluntarily and anonymously. All of them have taken mathematics course in the school; 1 girl and 2 boys have taken the same series of technology-related courses; 1 girl and 2 boys have taken the same series of chemistry course; 3 girls and 2 boys have taken the same series of biology courses; 2 boys have taken the same series of physics. All students have been taught by the same group of teachers for one year and are using the same series of textbooks. The textbook used in the Mathematics course is the Mathematics: Analysis and Approaches published by Haese Mathematics. The textbooks used in other STEM subjects are from the Oxford IB Diploma Programme (including Biology, Physics, and Chemistry courses). The textbooks are used in every class (each subject has 4-6 lessons per week).

3. Results

3.1 Perception of Self-competence in STEM Subjects

Table 1. Students' self-evaluation of their competence in Science, Technology, and Mathematics

	students		STEM subjects		
			science	technology	mathematics
Self-competence	girls	1	5.00	5.00	5.00
		2	4.00	3.00	3.00
		3	5.00	1.00	6.00
		Average	4.67	3.00	4.67
	boys	4	4.00	5.00	4.00
		5	6.00	4.00	3.00
		6	5.00	6.00	6.00
		Average	5.00	5.00	4.33

Students were asked to assess their self-competence in science, technology, and mathematics respectively during the interview (on a 7-point scale: 1=this subject is so difficult for me, I can not handle it at all; 3~4=the difficulty level is moderate for me; 7=very easy and relaxing).

The average self-competence of girls in the science field is 4.67 (5,4,5), and the average self-competence of boys in the science field is 5 (4,6,5). The difference between the self-competence of girls and boys in science subjects is not very distinct. In the technology subject, the average self-competence of girls is 3 (5,3,1), meanwhile the average self-competence of boys in this course is 5 (5,4,6). There is an obvious difference between the self-competence perception of boys and girls. The results indicate that boys have higher estimations of their abilities in technology fields than girls. For mathematics, the average self-competence of girls is 4.67 (5,3,6); the average self-competence of boys is 4.33 (4,3,6). The girls' perception of self-competence in math is slightly higher than that of boys, but this distinction is not very evident.

3.2 Parental Influence

In response to questions related to the gender stereotypes held by parents, all three girls reported that their parents have different levels of gender stereotypes regarding their ability in STEM fields. According to data from the interview, girls indicated that their parents often expressed that boys are more interested in STEM subjects than girls from an early age, and boys are often better at computer science and other STEM subjects in their classes. For example, one girl stated, "My parents suggested my brother to take STEM-related courses such as physics and computer when he chose courses in junior high school. But when I was going to choose courses in high school, they suggested I take courses like literature and economics." In the interview, girls reported that their parents have also told them "It is sensible for girls to achieve lower scores in STEM courses.". According to the three girls interviewed, the opinions and words with gender stereotypes of their parents have undermined their confidence and momentum of exploring deeper in STEM fields.

Differently, boys reported that their parents usually hold gender-neutral opinions regarding students' competence in STEM fields. Two boys reported that their parents believed there would be students who were good at science and students who were not good at science, regardless of gender. These gender-neutral attitudes of parents have no apparent impacts on boys' self-competence in STEM subjects.

Additionally, the interviews' results suggest that parents' career choices will influence their views regarding the competence of boys and girls in STEM fields. The mother of one girl interviewed studied an engineering-related major at the university and engaged in an engineering-related job after graduation. In contrast, her father is working in a management-related career. She reported that her

parents hold a relatively low level of gender stereotypes and are confident about her ability in STEM subjects. A boy whose parents have both engaged in jobs in STEM fields also expressed that his parents believe students' abilities in STEM subjects should be evaluated based on their personal circumstances rather than gender.

3.3 School Influence

3.3.1 Teachers' influence

Girls reported that they are more willing to learn and discuss with STEM teachers of the same gender since female teachers are more meticulous and considerate in the class. At the same time, girls also found it easier to establish intimate relationships with teachers of the same gender. From their perspective, asking female teachers about academic questions after the lessons will be more relaxing and cheerful, which may help them resolve problems more timely and achieve better academic outcomes. Two girls also reported that female teachers could inspire them and make them more confident when studying STEM subjects.

Both boys and girls reported that teachers nominate boys to answer questions more frequently in STEM classes. Especially, girls notice that male teachers nominate boys more frequently in their classes. According to the boys, the words and treatment of teachers have no distinct influence on their interests and self-competence in STEM subjects.

Despite the difference on nomination frequency, all students claim that boys and girls are generally treated equally in STEM classrooms. Teachers do not evaluate students' aptitudes using gender stereotypes. They place greater emphasis on and make comments about each student's actual academic performance.

3.3.2 Textbook influence

Most students interviewed did not identify gender-stereotypical sentences and illustrations in their textbooks. However, some students reported that they did notice that most of the scientists or other vital people portrayed in the textbooks are males. When asked whether this kind of gender representation in textbooks will influence their perception of ability in the STEM fields, girls reported that this gender difference would not affect their self-competence since they attributed this difference to the low status of women in history. Since they will not need to face the plight of the women in the past and can now receive similar education resources and opportunities in the school, they are more confident about themselves and can judge this kind of unequal portrayal rationally.

3.4 Social Media Influence

Girls followed more feminist celebrities and bloggers on social media. Many women on the internet have shared their high achievements in STEM fields and steadfast aspiration in the STEM fields. Girls expressed that these feminist celebrities in STEM fields have encouraged them to practice harder and boost their perceptions of self-competence in STEM subjects.

Both boys and girls did report that they have seen many gender-stereotypical opinions, including "inferior girls in STEM fields" and "STEM is the male domain", that criticized the capacity of girls in STEM subjects on social media and the internet. Students, however, stated that these gender-stereotypical comments on social media would not affect their perceptions of self-competence in STEM courses.

4. Discussion

4.1 Perception of Self-competence in STEM Fields

In science- and mathematics-related subjects, the difference between the average self-competence of girls and boys is very subtle. Girls' self-perceptions of capacity in mathematics even slightly exceed that of boys. This circumstance may be because mathematics is taught by a female teacher. A female STEM teacher may have less gender stereotypical opinions and will give more attention and

comments on the same gender students. The effect of same-gender teachers will be discussed deeper in 4.3.1. Teachers' influence.

Compared to science and mathematics subjects, the difference between the average self-competence of boys and girls in the technology subject is very prominent and noteworthy. The response of one girl may help explain this difference: Since boys are commonly perceived to be more interested in computer games and other activities that are related to technology, they have received most of the teachers' attention in technology-related classes since childhood. Teachers' neglect might severely undermine girls' interests in the technology field, leading to their weaker initiative and inferior performance in technology classes. Other studies also demonstrated that early gender-stereotypical preconceptions that girls are less interested in computer science than boys will lead to differences in girls' and boys' motivation for computer science and innovative activities. Gender-interest stereotypes predict and contribute to females' decreased feeling of belonging in computer science classrooms [10,11].

4.2 Parental Influence

The interview results demonstrated that parents' gender-stereotypical opinions would negatively impact girls' interests and momentum in the STEM domains. They may generate the view that the group they belong to is not equipped with strong talents and competence in STEM fields congenitally. This thought will further prevent them from practicing harder in STEM classes or choosing STEM subjects as their majors or careers in the future. According to a previous study, even after adjusting for demographic characteristics like race and socioeconomic status (SES), parents' gender stereotypes may influence the formation of children's gender stereotypes. Adolescents' stereotypes would predict their identity in math and science fields, which would foretell their performance in those subjects and their STEM career objectives [12]. If the parents hold the gender stereotypes that girls are not as competitive as boys in STEM fields, girls' preconceptions of their abilities in these fields will be undermined. Chances are they will stop striving to improve their academic outcomes in these fields and avoid choosing these subjects as their future majors.

The results also suggested that if both parents or the mother are working in STEM fields, they are less likely to hold gender-stereotypical views of their children's competence in STEM subjects and are more likely to encourage their children to try harder in these domains. When the mother herself majored in the STEM subject and decided to pursue a career in these fields after graduation, she has experienced the gender stereotypes regarding girls' capacity in STEM fields in person and more clearly understood that girls also had prominent potential in these fields. Growing up in this kind of family, a girl will not be influenced by parental gender stereotypes and can perceive their mother as a role model in STEM fields.

4.3 School Influence

4.3.1 Teachers' influence

According to the interview results, girls reported that having a female STEM teacher would make them more willing to ask and discuss questions with the teacher. They explained that female teachers could have more common topics with them, and discussing academic questions with female teachers would be more relaxing and pleasant. Some findings of a past study can further explain these feelings: same-gender students may receive extra attention or comments from teachers [13]. Additionally, male and female teachers may have different communication or teaching styles better suited to adolescents of the same gender [13]. From the students' perspective, it is probable that a teacher's gender will also affect how students view him or her. The role-model effect contends that regardless of the teacher's other traits and behaviors, adolescents will be more comfortable, motivated, and focused when a teacher of the same gender is present in the classroom [13]. Similarly, with a female teacher, girls will feel less frightened by stereotypes [13]. Teaching by a same-gender STEM teacher, girls can be inspired that women are also capable of pursuing high-level education in STEM fields and are more likely to establish enthusiasm in STEM subjects.

Regarding the difference between the nomination frequency of girls and boys in STEM classes, both boys and girls interviewed provided consistent explanations: boys are probably more noisy and inattentive in classes. Teachers nominate boys in order to grab their attention back to the lesson. In addition, students surmise that it may be more comfortable for male teachers to nominate same-gender students.

All students have reported that they have not experienced gender-stereotypical treatment from school teachers. The uniqueness of the international school may have contributed to this phenomenon. Being capable of teaching in an international school, most teachers have traveled to and studied in other places around the world with different cultural and educational backgrounds. These experiences, different from what most teachers have gained in traditional Chinese schools, have equipped them with broader horizons and minds. The research results of Alfaro and Quezada revealed that with their experiences gained abroad, educators broadened their horizons and engaged with more profound personal and professional development [14]. They have also developed a clearer understanding of the teaching ideology that guides their work with divergent student groups and become more sensitive and open-minded about multiculturalism-related issues [14]. As a result, they are relatively less affected by traditional stereotypes when teaching students. The absence of teachers' gender stereotypes at school may significantly moderate the difference between boys' and girls' perceptions of their abilities in STEM classes. These features can help explain the relatively subtle difference between the average self-competence of girls and boys in science subjects and mathematics subjects.

4.3.2 Textbook influence

As demonstrated in the results, though the students noticed that most of the famous scientists and scholars portrayed are males and women are underrepresented in the textbooks, they stated that they would not be influenced by this kind of gender representation in STEM textbooks. These exceptional critical thinking abilities may also result from the unique education objectives of the school's international curriculum. This international school adopts the IB diploma programme. In addition to training students to achieve excellent academic outcomes, the school also attaches great importance to students' character of being principled, open-minded, and reflective. Students have been taught and practiced these abilities through various assignments and activities. Consequently, they will be less vulnerable to stereotype threats in objects they frequently use, including textbooks.

4.4 Social Media Influence

In response to questions regarding the influence of STEM gender stereotypes on the social media they frequently used on their self-competence perceptions, both boys and girls reported that their self-perception of STEM abilities would not be negatively impacted by the stereotypes they were exposed to on social media. Girls articulated that they would dismiss these gender-stereotypical views when they saw them and would not be influenced by them. Boys also reported that they usually estimate the competence of girls in STEM subjects based on the performance of girls around them instead of the unsubstantiated opinions on social media. These rational judgments may also result from the influence of the distinctive school curriculum.

4.5 Suggestions

4.5.1 Adopting effective teacher training programs

From the interview results, it is obvious that eliminating teachers' gender stereotypes can significantly reduce the stereotype threats to students and help create an equal developmental environment for students. To reduce or eliminate the gender stereotypes that many teachers are still holding unconsciously, developing teacher training programs that focus on equipping teachers with teaching strategies that can help boost the motivations and confidence of students of all genders and guiding teachers to reflect on the gender stereotypes that they may hold when treating students. One example of this kind of program is the REFLECT curriculum [15]. By educating them to plan lessons

in a way that allows boys and girls to develop their interests and competencies jointly without being constrained by gender stereotypes, the training program REFLECT seeks to promote secondary school teachers' abilities for reflective coeducation [15]. Teachers learn about scientific discoveries on the existence and maintenance of gender discrepancies in academic motivation, accomplishment, and aspirations and about ways to eliminate these gender inequalities through effective teaching approaches [15]. The pilot research revealed that teachers who had voluntarily trained in REFLECT had already adopted better teaching strategies and were less sexist than the typical teachers [15]. These trained teachers can manage to create more equal STEM learning environments for students so that both boys and girls can pursue their interests in STEM fields without the restriction of gender stereotypes.

4.5.2 Reducing the stereotypical opinions of parents

As reported by girls, even some moderate remarks such as "It is sensible for girls to achieve lower scores in STEM courses" will affect how girls perceive their capacities in STEM subjects. Thus, it is paramount for parents to reflect on the unconscious stereotypes they hold in their accustomed daily expressions when educating their adolescents. Some referential recommendations are listed here:

- ✓ Avoid classifying adolescents into their gender groups when remarking on their potential in STEM fields (girls often.../boys generally good at...). These expressions will make students involuntarily put themselves into a particular gender group and try to follow the gender norms that are socially assumed for that gender.
- ✓ Evaluating adolescents' STEM performances based on their actual personal circumstances. When students encounter problems or make mistakes in STEM learning, parents should help them analyze the personal factors that lead to these mistakes rather than attributing these mistakes to their gender.
- ✓ Constantly encouraging adolescents to explore the STEM domains that they are interested in.
- ✓ Valuing the development of critical thinking ability of their children and helping them rationally treat gender stereotypes from other environmental factors.

4.5.3 Organizing more STEM activities on campus

Influenced by gender stereotypes that they have been exposed to in every phase of life, girls often avoid choosing technology-related courses after getting into high school. Chances are that it will be very hard for them to generate interest and determine to pursue careers in the fields they have not explored. Providing girls with more opportunities to engage in STEM-related activities can help them explore more aspects and directions of STEM fields and increase their possibility of developing enthusiasm for STEM subjects. The results of Screpanti and her teammates' investigation on the effect of attending a robotic camp that lasted for two weeks in an Italian school on girls demonstrated that girls who participated showed exceptional academic performance and expressed interest in gaining more technology-related experiences [16]. By holding STEM summer camps and other weekly activities more frequently on campus, the school can provide students with more chances to explore STEM subjects and improve the interests for both boys and girls in these subjects. The negative influences of gender stereotypes can also be greatly compensated.

5. Limitations

As this study only concerns about one international school in Hangzhou, China, the results may not represent situations in all the international schools in China. Moreover, only six students were interviewed in this study. The sample size is relatively small. Also, this study has only studied the gender stereotypes of parents, teachers, textbooks and exposure to social media. Gender stereotypes may also exist in other aspects of human life or other fields. To illustrate, boys are frequently viewed as more notorious and problematic than girls [1,17]. Boys are also facing stereotypes of being inferior at reading and other language-related tasks [18,19]. In the future, this study will be conducted in more international schools in other provinces of China and incorporate gender stereotypes in different fields

and aspects of daily life to obtain a more representative picture of gender stereotype influence on self-competence and the overall development of adolescents.

6. Conclusion

The current study discovered that in science- and mathematics-related subjects, no distinct differences were found between the average self-competence of girls and boys. However, the average self-competence of boys is evidently higher than that of girls in the technology field. Girls' parents more frequently hold gender-stereotypical opinions regarding girls' abilities in STEM subjects, while boys reported that their parents usually hold gender-neutral views about students' competence in STEM fields. This gender stereotype from the parent will significantly undermine a girl's self-competence and prevent a girl from delving deeper into STEM fields. Parents are less likely to hold gender-stereotypical views of their children's competence in STEM subjects if both of them or the mother are working in STEM fields.

Concerning the teachers' influence, girls demonstrated a preference toward female STEM teachers, probably because same-gender teachers hold fewer gender stereotypes regarding their STEM capacities and can serve as great STEM role models that can inspire and boost girls' confidence. It is also discovered that male teachers have nominated boys more frequently in their classes. But students mainly interpreted this higher nomination frequency as a method to grab the attention of boys who are generally noisier and more inattentive. Overall, the international students perceived almost no gender stereotypes in their teachers. This absence of gender stereotypes can be coherently explained by teachers' experiences of having studied in different countries with divergent cultures that equipped them with broader minds.

According to the students, no gender-stereotypical sentences and illustrations were found in the textbooks used in this international school. Although students do have noticed that women are underrepresented in textbooks and the majority of notable scientists and experts portrayed are men, they expressed that their self-competences have not been affected by this kind of gender portrayal. Students have developed prominent critical thinking abilities due to the learner profiles emphasized by the IB diploma programme in school. They can rationally comprehend the "underrepresented women" in history without being influenced by this kind of gender role portrayal.

Gender-stereotypical opinions regarding girls' capacities in STEM fields are very prevalent on social media, but the distinctive school curriculum has allowed students to evaluate critically when seeing those stereotypes. Also, following more feminist STEM celebrities on social media has encouraged girls to keep striving in STEM subjects and promoted their self-competence in STEM fields.

This study mainly reveals the effect of the gender stereotypes of parents, teachers, textbooks and social media on Chinese international high school students, which is a group that has rarely been focused on in past studies but whose career choices will significantly impact the global labor market. Based on the results of the current study and previous research, adopting effective teacher training programs, reducing the stereotypical opinions of parents, and organizing more STEM activities in school are all practical and effective strategies to eliminate the influence of gender stereotypes regarding STEM competence on students and create an equal development environment for them.

This study only concerned about one international school in Hangzhou, China, and the sample size of the current study is relatively small. In future studies, researchers can focus on expanding the sample size to obtain a more representative result. Also, since gender stereotypes may also exist in other aspects of human life or other fields, it is crucial for future researchers to explore how gender stereotypes of other factors or in other fields impact the self-competence of international school students.

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