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Chinese Female Students and the STEM Gender Gap: How Stereotype Threat and Expectancy Value Shape Performance and Engagement

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ABSTRACT

Globally, women have been underrepresented in science, technology, engineering, and mathematics (STEM) fields, and this is true in China. The current study seeks to identify factors that shape adolescent girls' decision-making when deciding whether to pursue STEM studies and the barriers they face. The study likewise seeks to develop recommendations to encourage and empower girls to choose STEM. Data was collected from one-on-one interviews with six Chinese female international students: three in the STEM fields, and three in non-STEM fields at a comprehensive university in southwestern Ontario. The interviews explored the familial, educator, and peer influences that promoted or challenged gender stereotypes related to STEM. The data suggests that girls are less likely to enjoy or enroll in STEM classes if their parents and teachers promote negative stereotypes about STEM, offer disparaging criticisms of the girls' STEM performance, and have different expectation based on gender. Inversely, girls are more likely to enroll in STEM if they have parents and teachers who prepare them for and encourage them to pursue STEM. This is likewise true in instances where parents objectively discuss and deconstruct sexist views of girls and STEM, and girls who have role models who work in STEM fields, whether those role models are male or female.

Keywords: female, STEM, China, mathematics anxiety, stereotype threat, expectancy value theory

DEDICATION

To my parents Kunxian Qiao and Hong Zhou,

to my advisor Dr. Clayton Smith,

to all people who supported me.

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2020 to 2021 has been an unusual year for the world, and will be remembered in human history. During this time, I finished this master's thesis in Canada, over 10000 kilometers from my hometown. I would like to show my appreciation to my advisor, Dr. Clayton Smith, who was like a lighthouse to guide me to find my way when I was lost in the research ocean. Dr. Smith helped me find the result coast, even inspiring me for the future of the deeper research field. I would like to thank my parents. I could not have finished my master's study without their physical and mental support. Also, I would like to thank my boyfriend; during Covid-19, we supported each other to finish our studies and work. Likewise, there are lots of people who backed up this research and I could not have finished these studies without their support.

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LIST OF APPENDICES

LIST OF ABBREVIATIONS/SYMBOLS

APA	American Psychological Association
CMAQ	Child Math Anxiety Questionnaire
EQAO	Education Quality and Accountability Office
GDI	Gender-related Development Index
GDP	Gross Domestic Product
GEM	the Gender Empowerment Measure
GEM	Gender Empowerment Measure
GGGS	the Global Gender Gap score
GII	the Gender Inequality Index
GRE	Graduate Record Exam
HDI	Chinese Human Development Index
NAEP	National Assessment of Educational Progress
NAS	National Academy of Science
NHS	National Household Survey
NRC	National Research Council
OECD	Organisation for Economic Co-operation and Development
PISA	Programme for International Student Assessment
PPP	Purchasing Power Parity
PRC	People’s Republic of China
STEM	Science, Technology, Engineering, and Math
UN	United Nation
UNDP	United Nation Development Programme

USSR	Union of Soviet Socialist Republics

CHAPTER 1: INTRODUCTION

Throughout grade school, I was constantly trying to balance my academic responsibilities with my thirst for reading the most recent news in celebrity and society magazines. I excelled in math early, but after struggling to compete in the International Math Olympiad competition, I focused on reading. My parents would give me breakfast money, but I would spend most of it on magazines, and my father would always spoil me by purchasing whichever magazine I had my eye on when we were in the grocery store. In high school, when I began to struggle in chemistry and physics, my parents were told that I did not have the potential to excel in these subjects, assuring them that there was no need to see this as a failing on my part because girls were simply “not good at science” because they generally lacked the cognitive abilities to process science. As a consolation, my parents encouraged my reading and adult mentors urged me to pursue a career in the arts and humanities. Thus, when I had to choose which academic stream I would follow, I made that same choice many girls in China make. I passed on science and opted for the humanities.

Reflecting on my experiences, my choice was influenced by the ways in which I was socialized, and this is consistent with many young female students in China. Though China does not publish statistics, it is widely regarded that when all students must choose which stream of study they will pursue, a disproportionate number of female students choose arts and the humanities. In contrast, male students disproportionately choose subjects relating to science, technology, engineering, and math (STEM). As a result, 80% of post-secondary student studying STEM disciplines in China are male, while female students are overwhelmingly drawn to the social sciences (He et al., 2020). This is reflective of an infamous quote from Dai Zhang, a renowned ancient Chinese historian and writer of the Qing dynasty (1636-1912). He famously wrote "女子无才便是德," which roughly translates to "Innocence is the virtue of women." This encapsulates the sentiments of the Confucian patriarchal value system, which has been maintained even as China has seen social progress in other forms.

To address the gender gap in STEM enrollment in China, it is critical to determine the factors that shape this phenomenon. However, though this subject is studied extensively in Western countries, there is limited research on this phenomenon in China. Therefore, it is critical to outline the background of this subject, conduct an extensive literature review to ascertain what is known, and determine what research approaches could provide insights into the STEM gender gap.

Background of the Problem

To situate current trends in China with respect to the gender demographics of STEM enrolment, it is important to first establish the importance of STEM in China, both historically through the Maoist era and in contemporary China. It is likewise important to consider how gender is socialized in China's Confucian, patriarchal society and the impact this has had on the relationship between gender and education. In recent decades, there have been factors that should have equalized gender gaps in STEM, such as China's one-child policy. Thus, it is important to consider these within the context of more current statistics relating to sex/gender and STEM enrolment.

Importance of STEM in China

China's relationship with STEM is long standing. Following the Maoist revolution, the Chinese government put an emphasis on STEM in order to promote technological development in China. Since then, with the expansion of the globalized, market economy, China has continued to emphasize STEM to remain competitive in global markets. Both phenomena have shaped the ways in which China engages with STEM.

STEM in Maoist China

When the People's Republic of China was established in 1949, China was influenced significantly by the Union of Soviet Socialist Republics (USSR), whose Cold War put significant importance on technology, and in turn, STEM subjects. Thus, as Deng (1993) notes, Chairman Mao Zedong believed that science was vital to national development under his leadership. At this time, 38,000 Chinese students were sent to the USSR to study science, and the Chinese Academy of Science was founded during the 1950s (Deng, 1993). The importance placed on STEM is encapsulated by a famous saying by Chinese physicist Qian Weichang: "学好数理化，走遍天下都不怕 (Xuehao shuli hua, zou bian tianxia dou bupa)."(n.d). This roughly translates to "Knowledge of Mathematics, Physics, and Chemistry affords you to face the world with confidence." Thus, STEM was important throughout Mao's tenure as China's leader, and this was clear in the curriculum in its schools (Jenkins, 2008).

STEM in contemporary China

Though China has moved away from its communist economy to a more market-based model, this change has only strengthened China's focus on STEM, and the global economy is increasingly reliant on technological advancement. In contemporary China, STEM education development differs from traditional efforts in four central ways: (1) a broadened scope of students' academic learning, (2) the important and ever-increasing use of educational technology, (3) ever-increasing calls from academic fields and various employment sectors to increase STEM literacy of all students, especially women and minorities, and (4) an increasing call for integrated STEM education and the related need to examine and document how students learn in integrated modes (Honey et al. 2014; National Science Foundation 2010; National Research Council [NRC], 2011a, 2011b, 2013).

Gender Issue in China

Although the Maoist revolution was supposed to promote equality, and the focus on the globalized market economy has brought significant progress, China has still maintained traditional views of gender handed down by the Confucian tradition. As a result, women in China have not always been able to realize the advantages of social progress. For example, social expectations tied to women and family have had impacts on how women engage with the domestic sphere, education, and their careers.

Domestic Sphere

According to Yin-Wang (2019), women are near the equality achieved with men in education and employment despite the decades-long egalitarian socialization under state socialism that molded women more into nationalized 'state persons' than feminized 'wives' and 'mothers' (Chen, 2003; Wang, 1998; Zuo, 2014). However, masculine and feminine are usually defined as STEM students and art students respectively in a stereotype in China.

Regarding education, the ways in which girls are socialized shapes both their decisions with regard whether to pursue higher education and which fields they should enter. Girls are usually taught by their parents that they should do something girly. However, boys are also taught to avoid tender and delicate hobbies, and they should have manly performance.

Chinese Women: STEM vs. the Humanities

Despite showing promising STEM-field skills in early levels of education, female students in China overwhelmingly opt out of STEM subjects in favour of enrolling in the humanities. According to Lindberg at al. (2010), with respect to mathematics performance, male and female students are similar. Moreover, in grade eight and nine, the average physics grade of female students is higher than male students (Yang, 2019). Despite this promising performance in younger grades, female students do not continue to show an interest in or motivation for STEM subjects. As a result, when they choose which stream to enter—STEM or the humanities—most female students choose the humanities (Cai et al, 2016). Consequently, by the time female students write the Gaokao exam (National College Entrance Examination), they are underperforming in STEM subjects despite doing better overall than their male counterparts (Li & Wang ,2019).

STEM, Gender, and Contemporary China

Though there has been significant progress in China regarding the access women have had to higher education and STEM, there is still a significant gap. For example, the Gender Empowerment Measure (GEM) (World Economic Forum , 2018), a globally recognized index that measures gender equality, ranked China at 103 out of 149 counties regarding gender equality, with low rankings for both economic and educational opportunity.

Economic Participation

Regarding economic participation and opportunity, China hosts a wide gender gap, ranking 86 out of 149 (Global Gender Gap score [GGGS], 2018). This is particularly disheartening given that China has become the second largest economy when considering nominal Gross Domestic Product (GDP), and the largest economy in the world using purchasing power parity (PPP) (The World Bank, 2019). Although China has seen significant economic growth and prosperity, women have not seen the benefits of this economic growth in the same way that their male counterparts have.

Education Participation

Part of the reason women are getting equitable access to the economic opportunity in China is due to their limited participation in education, especially STEM. According to GGGS (2018), China's education gender equity ranked a meager 111 out of 149, placing it significantly below the global average. This might be due in part to the fact that China remains the world's lowest-ranked country regarding sex ratio at birth: significantly more boys are born than girls. This means that more male students are competing for positions in higher education. Thus, the lower birth rate and educational attainment of female adolescents reflect the inequality that still exists in Chinese society.

This limited access to education is particularity prevalent in STEM subjects. For example, Ma et al. (2016) report that STEM subjects were the most popular disciplines among male students, and although female students comprised more than half of those enrolled (51.75%) in post-secondary institutions, they comprised less than 20% of students enrolled in STEM subjects. Given that people with degrees in STEM subjects earn as much as 26% more than peers with the same level of education in a different field, (Graf, Fry, & Funk, 2018), it is not surprising that women in China do not have secure equitable access to economic participation.

Over the past 40 years, China has been going through a transition to a market-oriented economy to remain competitive in a globalized market, and this has led to significant economic, political, and social progress. However, Chinese society has continued to maintain many of the social and family traditions inherited from China's Confucian traditions. Since 1976, the end of the Maoist era, China's economic development has depended on demographic dividends. While the one-child policy was in place from 1978-2015, China's birth rate was declining (Xinhua News Agency, 1991). Even after implementation of the two-child policy, China's birth population declined from 17 million in 2017 to 15 million in 2018, equal to a birth rate of 1.05% (Chinese National Bureau of Statistics, 2019). In the past, when Chinese parents had both a son and a daughter, resource dilution often meant that the son would receive more household resources than the daughter, which meant that boys often had more educational opportunities than girls. However, one of the unintended consequences of the one-child policies was that parents no longer had to choose between their children, and the daughters of this generation received more academic opportunities as a result. This was facilitated by two other factors: the Chinese government's emphasis on demographic dividends, which prioritized education, and its emphasis on closing the gender gap in academic outcomes (OECD, 2015). However, the OECD (2015) report reveals that while boys and girls are equally proficient in mathematics and science, they have different attitudes with respect to their academic pursuits and choices.

Even though international public opinion advocates equality, a bias still exists in many aspects of people’s lives, especially gender bias. As a result, imbalanced sex ratios are becoming a major issue in China. In the 1980s, the sex ratio at birth was 108:100 boys to girls, but in the 21st century, the ratio went up to 120:100. The ratio soared to 130:100 in middle-western China, especially in rural areas (Tania, 2011).

Feminism

Parish and Wills (1993) argue that the distribution of education by gender is a key determinant for gender inequality. Therefore, stereotypes that have led to a gender gap in STEM fields have become a critical issue to gender equality. Impacted by the Age of Enlightenment, feminist views started to be expressed by some Western philosophers and writers (Tomalin, 2021). From the 19th to 21st century, three waves of feminism reshaped the ways in which the Western world defined and saw gender, which in turn helped women secure political equality in many respects. As a result, the United Nations (UN) declared that the years between 1975 and 1985 as the decade for women (O'Brien, 2009). This led the UN to create the United Nation’s Girls’ Education Initiative (n.d.) to “promote girls’ education and gender equality through policy advocacy” (para. 1). The UN (2020) has likewise included gender equitable education as one of the primary goals outlined in their Sustainable Development Goals. These goals have in turn shaped China’s domestic policy as it has released a platform that expressly aims to achieve and conform to the goals outlined in the UN’s Sustainable Development Goals (Paul, 2016).

Feminist movements have fought and continue to campaign for women’s rights, which include the right to vote, to hold public office, to work, to earn fair wages and equal pay, to eliminate the gender pay gap, to own property, to receive education, to enter contracts, to have equal rights within marriage, and to have maternity leave (Echols, 1989). However, the Global Gender Gap score stands at 68%, which means that there is still a 32% gender gap to close on average (GGGS, 2018). There still is a distinct gender gap in some Western countries; for example, the ranking of the Global Index score of the United States was 51 out of 149 in 2018 (GGGS, 2018).

Statement of the Problem Situation

In China's top university, females are still underrepresented. The gender ratio was 48:52 at Peking University in 2018, while the proportionality was 34:66 at Tsinghua University and 21:79 at Zhejiang University, which are famous for STEM field studies (China Power, 2018). In comparison, female students are more likely to study overseas than male students. Chinese female students accounted for 51% in the US and 63% of those in the UK (China Power, 2018).

According to Hango (2013), in recently decades in Canada, the women ratio has increased with respect to university enrolment in general, but these trends do not hold true for science, technology, engineering and mathematical (STEM) fields, which remain male-dominated. For example, among post-secondary school graduates between the ages of 25 and 34, women represented only 39% of students who graduated with a STEM degree but comprised 66% of students who graduated with non-STEM degrees. The ratio declines in the STEM fields, with only 23% women graduate from engineering, and 30 percent women graduate from mathematics and computer science (National Household Survey [NHS], 2011).

This gap seems to be explained by OECD's Programme for International Student Assessment [PISA] scores, which uniformly suggest that male students outperform female students in math and science, most notably with respect to their ability to apply science knowledge, describe and interpret scientific phenomena, and predict patterns and changes (OECD, 2015). However, the OECD suggests PISA scores are shaped by students' self-efficacy and self-confidence, not their cognitive capacity, and that this barrier inhibits female students more than male students. PISA measures three main categories of academic ability: reading, mathematics, and science. Of the three, reading is the most critical as the skills develop through reading comprehension are required in the other two categories. Even though girls outperform boys in reading, they lag behind boys in the other two categories (OECD). Overall, female students generally perform at a higher level than male students, who make up 60% of those who fail to achieve PISA's baseline level of performance in STEM subjects (OECD, 2015).

According to OECD (2015), the key barrier is confidence or self-efficacy. They found that female students who earned above-average scores in math experienced higher levels of anxiety on average than boys. This is supported by the fact that, upon comparing the math scores of male and female students who shared comparably levels of confidence or anxiety regarding mathematics, the math scores were equal (OECD, 2015). This suggests that girls may fear making mistakes and cannot psychologically differentiate between making a mistake and being mistaken. This is supported by a plethora of studies. For example, Namkung et al. (2019) and Ramirez et al. (2013) found that there is a math anxiety that has a significant, negative impact on mathematics performance, and this is likewise supported by Anis et al. (2016), who specifically found that mathematics anxiety was more likely to inhibit the performance of female students with respect to standardized tests. Anis et al. suggest that one critical phenomenon is environmental factors, which are more likely to shape math anxiety among female students. For example, if a female student has a female teacher who displays math anxiety, they are more likely to develop math anxiety themselves (Anis et al.).

Purpose of the Study

The OECD 2012 PISA survey data demonstrates that there is a gender gap in STEM fields that is more significant in developing countries. In the globalized marketplace, nations whose workforces possess higher levels of education, particularity in STEM fields, often have distinct advantages over those that have a less educated workforce. This is supported by the National Academy of Science ([NAS], 2007, 2010), who notes that nations can improve their economic strength by developing human capital through STEM education. While the gender gap in aspiration for and participation in STEM careers remains significant around the world (OECD 2015), it is of concern in China. Although the general level of education in China has been improving since 1949 with the foundation of the People's Republic of China (PRC), in 2008, the Chinese Human Development Index (HDI), Gender-related Development Index (GDI), and the Gender Inequality Index (GII) are all rated at No.86 (UNDP, 2018), which means gender inequality remains severe in China. This study will try to explore this phenomenon. The purpose of this study is to explore the social, cultural, and individual factors that have shaped China's gender GAP in STEM.

Research Questions

The study will be guided by two key research questions:

1. How does experience in education (e.g., school, extracurricular classes, private educational institution) shape female Chinese students' perceptions of their STEM abilities?
2. What social and cultural factors, influences and expectations are given consideration by female Chinese students when deciding whether to enrol in STEM programs and how do they shape this decision?

Theoretical Framework

Past research has often relied on feminist theory to analyze and interpret data to gain insights into the gender gap in STEM performance and enrolment. Though insightful, it is important to use alternate theories that consider different perspectives and complement the existing literature. To this end, there are two theories that have the potential to provide critical insights into the STEM gender gap: negative stereotype theory and expectancy-value theory.

Negative Stereotype Theory

Examining how negative stereotypes become internalized by individuals has the potential to provide detailed and specific insights into the STEM gender gap, particularly regarding the gap in performance. Stereotype threat theory suggests that negative stereotypes associated with people's social identities shape their behavior, and in turn, create a feedback loop that reinforces such stereotypes, and causes them to eventually conform to it (American Psychological Association [APA], 2006; Steele & Aronson, 1995).

According to the APA (2006), the proliferation in standardized testing provides a plethora of data that education administrators believe objectively assesses students. For example, in the United States, the Scholastic Aptitude Test (SAT) is a standardized test that is required to get into many colleges, while the Graduate Record Exam (GRE) is required to get into many graduate programs. These were reinforced by international tests such as PISA and America's No Child Left Behind Act, which implements standardized testing in grade school and high school. Likewise, Ontario introduced Education Quality and Accountability Office (EQAO) tests to assess student performance. Because many of these tests saw disparities in academic performance among certain groups of students, including students of colour and female students, these tests reinforced the mistaken notion that differences in genetics and/or culture led to different academic outcomes (APA, 2006). This is applicable in a Chinese context, which has traditionally relied on high stakes testing and currently utilizes a national standardized test, called the Gaokao, as the entrance exam for universities.

However, Steele and Aronson (1995) suggest that these differences are not the result of differences in genetics or culture but rather anxiety created by negative social stereotypes. When students identify as members of a social group, there may be negative stereotypes that place pressure on them to perform well on tests and disprove stereotypes. This can cause such students to doubt themselves and create anxiety. In turn, it impedes their academic performance, particularly in high stakes testing contexts. Thus, Steele and Aronson (1995) suggest that a stereotype threat can undermine intellectual performance.

They therefore developed the theory to understand how anxiety shaped the different test results between African American and European-American students. Thus, the stereotype threat is purportedly a contributing factor to long-standing racial and gender gaps in academic performance and may occur whenever an individual's performance confirms a negative stereotype. Thus, test scores that seemingly confirm a given stereotype may be the result of anxiety associated with a stereotype threat rather than being the result of an individual's personality traits or characteristics (APA, 2006).

Stereotype threat can arise from visible differences of other people that indicate social identity, such as race or gender (Inzlicht & Ben-Zeev, 2000, 2003). Self-efficacy is a standard used to measure individuals' own belief in the ability to complete tasks and achieve a goal. Stereotype theory will be applied to evaluate the experience of Chinese females who are in STEM field.

Expectancy-Value Theory

Though understanding how stereotypes shape engagement in STEM is important, it is also vital to understand the pragmatic value of addressing social issues, which can simultaneously provide insights into the reasons behind such gaps. In this context, expectancy-value theory can highlight the reasons why there has been a lack of investment in female students with respect to STEM at the macro, messo, and micro levels, while also explaining the value of prioritizing a more equitable STEM field.

Jacquelynne Eccles's application of expectancy-value theory in education has expanded its use within the field (Anderman et al., 2001; Eccles, 1983; Eccles & Wigfield, 2002). Expectancy-value theory proposes that students' achievement and the related choices are motivated by expectancies for success and subjective task values. For example, students are likely to pursue art if they expect to do well in the subject and they value art.

Expectancies refer to how confident an individual is in his or her ability to succeed in a task, whereas task values refer to how important, useful, or enjoyable the individual perceives the task (Eccles, 1983). Theoretical (Eccles, 1983) and empirical (Nagengast et al., 2011; Trautwein et al., 2012) studies propose that expectancies and values interact to predict important outcomes, such as engagement, continuing interest, and academic achievement.

According to Eccles (1983), subjective task values include four components: attainment value, intrinsic value, utility value, and cost. Attainment value refers to how important a task is with respect to one's identity. For example, if one defines themselves as a writer, then they will likely make time to practice and develop this craft. Intrinsic value is the enjoyment or interest a person associates with a task. For instance, a child may enjoy playing videos games and so is intrinsically motivated to play them. However, they may not take the same enjoyment in solving math problems and will thus be unwilling to engage in them without the promise of an external reward. Utility value refers to the usefulness or relevance of a task. For example, a person may be disinterested in learning how to use Excel or PowerPoint, but both may be valuable skills in a professional context. Therefore, they may take the time to use such programs effectively. In contrast, a person who has no interest in pursuing a career in math may be disinclined to learn trigonometry because they feel there is no practical value for it in their lives.

Individual characteristics and experiences associated with STEM-related activities shape the development of self-efficacy, interests, task values, and long-term life goals, which in turn, influence educational and career choices in STEM and non-STEM fields (Eccles et al., 1993, Jacobs et al., 2005). Therefore, it is likely that male and female differences in STEM field selection are associated with gendered differences in these motivational beliefs, such as self-efficacy, interests, and task value (Wang & Degol, 2013).

Analysis and Interpretation

When used in conjunction with each other, negative stereotype theory and expectancy-value theory have the potential to provide unique perspectives and insights into the gender gap in STEM that can complement the existing knowledge derived from feminist-based analysis. By analyzing how stereotypes shape student's self-efficacy and mathematics anxiety, it becomes possible to understand some of the factors that contribute the gender gap in STEM performance. Alternately, interpreting data with expectancy-value theory can help to understand how negative stereotype threat shapes the way people evaluate their relationship with mathematics and their engagement with it. This can provide insights into the gap in STEM enrolment. Thus, when used jointly, negative stereotype theory and expectancy-value theory have the potential to build on the existing knowledge of the STEM gender gap and expand the current understanding of this phenomenon.

Importance of the Study

In the past three decades, China's GDP has increased 37.7 times, from just over $360 billion USD in 1990 to over $13.6 trillion USD in 2018. As a result, China is the second largest economy when considering nominal GDP and is the largest economy in the world using PPP (The World Bank, 2019). However, though the nation has become prosperous, female professionals have not received proportionate benefits as traditional majors on campus because they believe these subjects are masculine.

Thus, when adolescent girls seek to establish their own gender identity, they can be unduly influenced by familial disciplinary practices and the guidance offered by teachers in school. In these contexts, stereotypes often inhibit their options, leading to a gender gap regarding performance in STEM fields. According to Spencer et al. (1999), females' risk being judged based on the negative stereotypes that they underperform in math ability. This stereotype threat could cause anxiety and consequently impair girls' self-efficacy, causing them to underperform during STEM assessments (Beasley& Fischer, 2012; Steele et al., 2002). This can in turn negatively impact the development of economies in the country. According to UN Women (2018), reduced stereotype for females in the workplace is good for business and economies grow.

This issue will be investigated by analyzing individual experience, and family factors, including gender stereotypes. This phenomenon has not only existed in the past decades, but also continues today, and it should be considered by the public. Moreover, girls should become more aware of the variety of opportunities for advanced educational development. Thus, the purpose of the proposed study is to identify the reasons for the STEM gap in China.

Scope and Limitation of the Study

The current study seeks to understand why there is a gender STEM gap among Chinese female students in Canadian universities by exploring their experiences. This population is chosen in part due to convenience but also because this population is relatively affluent. Thus, financial barriers will typically be excluded, allowing me to focus on the social and cultural issues that shape this phenomenon. As a result, the study will be limited in that it will not explain how economic factors shape this phenomenon, and neither will it explore the potential biological factors that influence this trend. Likewise, it will, by design, exclude the perspectives of male students, which could offer insights into this trend. Neither will the study include other ethnic, racial, and national populations. Though information on each of these would offer valuable insights, the data collection would be overwhelming and require an extensive research team. Thus, research into those topics will be recommended for future research. Likewise, because the study is exploratory in nature, its primary objective is to inform future research, not policy. Thus, it will be limited in that respect as well. However, it does have the potential to provide critical insights into the ways that social and cultural contexts shape the choices made by this population and could, in turn, provide valuable insights that could guide future research.

CHAPTER 2: LITERATURE REVIEW

Although the educational attainment of gender equality has been improving in recent decades, women are underrepresented in the fields of science, technology, engineering, and math (STEM) around the world (Campbell, Denes & Morrison, 2000; OECD, 2015). The Programme for International Student Assessment (PISA) shows that girls still lag behind boys for getting a high score in science performance (OECD, 2015). Researchers have tried to explain and analyze the segregation of gender STEM education.

Mathematics Anxiety

One of the critical issues is that the gender disparity in STEM test scores is mathematics anxiety, which has been shown to negatively impact test performance and math performance in general, and on high-stakes test most especially. Moreover, it has been shown that mathematics anxiety disproportionality inhibits the performance of female students.

Mathematics Anxiety and Performance

Research has shown that mathematics anxiety can inhibit students' ability to successfully complete mathematics tasks. For example, Namkung et al. (2019) sought to determine whether there was a relation between mathematics anxiety and the mathematics performance of students by conducting a meta-analysis. Related databases, such as PsycINFO and ERIC, use several relevant search terms, including 'arithmetic,' 'math,' 'numerical,' and 'anxiety.' Articles selected for the literature review were limited to early childhood education and/or secondary students written in English. When analysing the data from 131 different empirical studies, they used ROBUMETA to address the variance in sample size, which Selten et al. (2019) note can effectively moderate and explain variations in sample sizes. Namkung et al. likewise used Fisher z-transformation to identify correlations in the data, which is an approach supported by Borenstein et al. (2005). Based on this approach, they conclude that there is a significant negative correlation between mathematics anxiety and performance and that students' grades are impacted by this relationship. This was especially true of complex, multi-step mathematics questions. This was in turn reflected in their grade. The study is limited as it only outlines the outcome and does not investigate the causes for mathematics anxiety. Likewise, it explores mathematics in English speaking countries and does not focus on gender. However, it does effectively establish that mathematics anxiety inhibits students' ability to perform math tasks.

Mathematics Anxiety and Standardized Tests

Given that China relies on standardized testing as a central component to assessment, it is important to consider how mathematics anxiety impacts performance on high-stakes tests. Using a standardized test, Ramirez et al. (2013) conducted a quantitative study to determine how mathematics anxiety impact students' performance. They had 154 students (85 girls and 69 boys) from five different schools in the first or second grades complete a math measure and followed this up by assessing them with a scale that measures mathematics anxiety. To assess the students' math skills, Ramirez et al. had the students complete the Woodcock-Johnson III Applied Problems subtest, which gives students increasingly difficult math problems. To assess students' mathematics anxiety, Ramizer et al. administered the Child Math Anxiety Questionnaire (CMAQ). With this data collection, they then used Cronbach's alpha, a measure of scale, to determine the reliability of the data. Based on their data, they concluded that students' capacity to perform mathematics tasks is inhibited by math anxiety. They go on to suggest that early identification of mathematics anxiety, followed by treatment, can help students overcome (?)this issue but this second conclusion seems to be outside the scope of their data. Although their explanation of the data is compelling, they make no reference with what software or formulas they used to analyze their data. In this context, a t-test would have been ideal as this formula is often used to compare the means in two different groups (Kenton, 2019). In this case, the two groups would have been students with lower levels of mathematics anxiety and those with higher levels. Moreover, the study appears to be in an English-speaking context, although no mention is made as to where the participants were from, so it would be ideal to get related data that applies to a Chinese learning context.

Mathematics Anxiety and Gender

Although math anxiety affects students of both genders, female students in China are disproportionally impacted by this phenomenon. This is supported by Xie et al. (2019), who surveyed a total of 751 Chinese high school students, 450 young women and 301 young men, between the ages of 12-18. Their results of their questionnaire—which relied on self-reported data to measure self-esteem, test anxiety, general anxiety, math anxiety, and control beliefs—suggests that despite the fact that there was no difference between the genders with regard to math performance, the young women reported higher levels of mathematics anxiety than their male counterparts. The results of their t-test analysis suggest that self-esteem, when mediated through test and general anxiety, led to mathematics anxiety; however, male students also saw their mathematics anxiety mediated by their perceived ability to control their anxiety. Thus, they conclude that improving self-esteem and increasing student's sense of control can help mediate mathematics anxiety (Xie et al., 2019). Thus, future practice and initiatives should consider the ways in which teachers and schools can promote self-esteem and among all students, especially female students, and equip students with the tools required to control anxiety.

Sondergeld et al. (2020) observe that though there are gaps in STEM enrolment and performance with respect to many social markers, such as race and ethnicity, the reasons for the gender gap are multifaceted, which is likewise supported by Sass (2015). For example, Sondergeld et al. (2020) note that results from tests carried out by the National Assessment of Educational Progress ([NAEP], 2015) found that there were significant gender gaps in science achievement, with girls scores lower at all levels (grades four, eight, and twelve); however, they likewise found that the gap in mathematics was negligible. Sass (2015) suggests that part of the issue is inadequate academic preparation in early grades, which in turn reduces the number of female students who eventually enrol in STEM programs.

Zirk-Sadowski et al. (2014) explored the potential biological factors that may cause differences in math anxiety by testing 182 participants between the ages of 8 and 11. To test their hypotheses, they used latent factor modeling and found that though there is a difference between the genders with regard to math anxiety, this difference was related to their experiences: the uncontrollability of math study, where male students had control, female students did not, and that these differences likely shaped the prevalence of math anxiety. Uncontrollability experience causes human-learned helplessness, which makes people unbelieve that they can control or change their state (Zirk-Sadowaski et al, 2014).

STEM situation in Middle School

Regardless of what the STEM enrolment numbers are in post-secondary schools, the academic performance of students in middle schools seems to suggest that female students possess the same potential to succeed in STEM as their male counterparts. For example, the math performance of girls and boys in grade four through eight are equally good (Berwick, 2019). Moreover, according to U.S Department of Education (2012), female students in grades seven and eight have a higher pass rate in algebra than their male peers. At age 15, female students demonstrate almost the same literacy assessment scores as male students in science (National Science Board, 2000), and as they enter high school, the number of female and male students enrolled in advanced science and math courses are nearly equal (National Girls Collaborative Project, 2020).

As the grade level increase, gender differences begin to emerge (National Girls Collaborative Project, 2020).

Motivation, the Role Model Effect, and STEM

Students' academic achievement is affected by their families, teachers, and other social factors. According to Hofstede (1991), individuals could be oriented by and loyal to their in-groups, such as families and peers, which can impact individual motivation as people often seek to achieve and conform to in-group's expectation. Students who are in more collectivistic or interdependent background have been found to have higher standardized test scores and report higher levels of personal motivational (Phalet & Lens, 1995; Verkuyten, et al., 2001). Moreover, León et al. (2015) found that if students find it interesting or meaningful to explore in a certain subject with supports from teachers, their self-discipline can greatly contribute to a thorough understanding of mathematics.

Role Model Effect

Several studies have explored the impact of the role model effect. Some suggest having positive female role models, such as female STEM teachers and or females in the STEM profession, has the potential to encourage more female enrolment in STEM. However, findings sometimes conflict with each other.

Microsoft (2018) administered 11,570 questionnaires to girls and women between the ages of 11 and 30 across 12 European countries, and found that role models clearly have a positive impact on girls' perception of STEM subjects. Approximately 41% of girls with role models report an interest in STEM subjects, compared to 26% of girls without a role model. The results of the survey also show that over half (51%) of girls with role models can imagine a future career in STEM. However, only 38% of young women with STEM role models work in STEM fields. This was supported by Young et al. (2013), who used the Implicit Association Test to measure college STEM students' attitude toward science. They found that the female STEM professors provide positive role models for women and help to reduce the implicit stereotype that science is masculine in the culture-at-large.

Based on an experimental study, Bamberger (2014) challenges the notion that role models have a positive impact on female students' perception of STEM; however, the study has a small sample size and the experiment has some flaws. Bamberger invited 60 grade-nine female students: 30 students were in an experimental group, and 30 students were in control group. The experimental group visited a high-tech company to meet with female role models and scientists while the control group did not. Prior to the experiment, 80% of the female students expressed “they would like to choose” STEM for their major (p. 557). At the end of the project, 40% of female students “chose a non-scientific major” (p. 557).

The numbers, as presented by Bamberger (2014), seems to suggest that exposure to a female role model decreased student interest in STEM; however, there are two key points to consider. The first is the language. There is a significant difference in the language used for the two numbers. Several students may “like to choose” STEM but still eventually “chose a non-scientific major.” This difference does not necessarily suggest a change in perspective but merely a change in the framing of the questions put before them. Ideally, Bamberger should not have compared the percentage of those enrolled in STEM with those who expressed an interest in the subject; she should have compared it to the national average, which would serve as an actual baseline. Alternately, she could have asked students what subject they planned on enrolling in during the pre-test rather than asking them which subjects they would like to choose. This is also problematic as she did not collect this same data from the control group afterwards. The other issue is that her experiment is flawed as she included two variables: the field trip itself, and the female presenters. One group went to a STEM location and saw female STEM workers, the other group did not attend the field trip. Those who attended the field and did not enroll in STEM may have been overwhelmed with the environment they saw and not negatively influenced by their female role models. This variable was not addressed in the experimental design. Ideally, all students should have attended a field trip to the same location to control for all variables, and all should have received the same presentations, the difference being that the presenters in one group would be female while the presenters in the other would be male. However, the control group attended no field trips. In addition, Bamberger's sample size is small and culturally homogenous, which makes it significantly less reliable than the global survey conducted by Microsoft (2018), which had a significantly larger sample size and broader diversity of participants.

Familial Resource

With respect to familial resources, there is a preference of parents. In a study by Buchman and DiPrete (2006), older brothers have a negative influence on their sisters' chances of graduation. There is high possibility for females who were born before 1960, live in a small family, and both parents were college-educated to enter college education. Parents with less education often favour sons over daughters (Buchmann & DiPrete, 2006; Low, 2015). Low (2015) found that mothers invest more in each successful son than in each daughter. According to a survey from asset-management company, T. Rowe Price (2017), 50% of parents who have only boys saved money for their children's college, while only 39% of parents who have only girls would do it. Parents of all boys were more likely to claim that they will cover the whole cost of college: 17% of parents who only have boys in family, compared with 8% of parents with only daughters (LaMagna, 2017). Most (72%) of girls' parents said they would like to send their children to less expensive colleges to avoid student loans, which is 12% higher than boys' parents (LaMagna, 2017).

One of the key issues that inhibits young girls' engagement in STEM is an inequitable division of familial resources. Because Confucian traditions in China have a patriarchal bias, families often prioritize male offspring. As a result, both direct and indirect resources are disproportionately awarding to male offspring in favour of female offspring. In addition, the resources parents allocated to their children are often based on the perceived return they expect on their investments.

Expected Returns

From the perspective of population economics, the cost of raising a child include direct costs (e.g., child's daily expenses, tuition fee, recreational expenses, etc.) and indirect costs (e.g., opportunity and time cost of parents, lost education or work achievement). If parents have to spend more than the payoff of their children, the desire to have a baby would decrease, but if parents invest less than the payoff of a child, they would be more willing to have a baby (Li, 1994). Based on this logic, and combined with Chinese tradition, people have boy preference because they believe that boys are more beneficial for their family than girls.

Boys become higher wage earners worldwide. With respect to the expect returns, research suggest that parents tend to believe boys will provide families with higher earnings through their labour (Geary, 2010), higher pensions (Gerhard, 1991), facilitate generational reproduction (Zhou & Xu, 1998), improve the family's reputation (Zhou, Zhang& Tao, 2000), and can help fulfill parents' personal goals (Zhou & Xu, 1998; Zhou, Zhang& Tao, 2000).

Wage Earners and Pension

The median wages for women were $40,675, compared with $50,741 for men in 2016 (Laughlin, 2018). Kolesnikova and Liu (2011) found that the improvement of education level of females helped to narrow the wage gap; however, women still underperform in high paid occupations. Males are more likely to study STEM subjects, and to be doctors and lawyers, while females are more likely to study humanities or arts, and they are more likely to be teachers or office clerks. The gender occupational segregation could be a crucial factor of the wage gap. A report by Zurich Insurance Co. Ltd. (2018), over the course of her career, the average British woman would earn 37% lower retirement income than the average British man, which was 47,000 pounds. In Canada, women need to save 26% more than men for retirement (Tatelman, 2017).

Social expectation and Family Reputation

Social expectation and family reputation play a significant role in students' motivation and attainment. Some researchers are focused on social value as an agent to impact student's achievement and their study motivation (Fan, Lindt, Arroyo-Giner, & Wolters, 2009; Patrick, Ryan, & Kaplan, 2007). A survey of U.S adults conducted from Parker and Stepler (2017), with advanced education, concluded that females have less pressure to support their family financially, while males have more pressure in this situation.

Parents' Personal Expectation

A few studies have strong supporting evidence that parental expectation has an important impact on student expectations and academic achievement (Rutchick et al., 2009; Yamamoto & Holloway, 2010). Referring to an analysis of America national survey data, Moakler and Kim (2014) found that students are more likely to choose STEM majors if they have confidence in these fields and their parents have STEM occupations, while less females would like to choose STEM.

Gap in the Current Research

Several studies have outlined the effects that mathematics anxiety has on female performance on STEM, and the resulting gap in STEM enrolment and employment. However, few studies have analyzed and identified the source of the mathematics anxiety and how it makes female students feel or shapes their choices regarding STEM. Specifically, there is limited research with respect to how familial, educator, and peer influences promote or challenge gender stereotypes related to STEM. Regarding familial influences specifically, there is a scarcity of research addressing the value of the son preference, as well as parents' perceptions of investing resources into their daughter's education as it relates to STEM subjects. Likewise, although some researchers have explored the impact role models and mentors with relation to encouraging female students to study STEM in Western contexts, few studies have explored this phenomenon as it relates to the experience of Chinese female students. Thus, future research should explore these gaps to develop a more nuanced understanding of the social, cultural, and individual factors that have shaped the gender gap in STEM.

CHAPTER 3: METHODOLOGY

Introduction

To understand the reason for the STEM gender gap among Chinese female students in Canadian universities, it is critical to understand their experiences. Thus, the current study will employ a qualitative research method. To understand the merits of this approach, it is necessary to first understand why qualitative research is ideal. It is likewise critical to outline who the participants are and how and why they will be recruited. Once this is established, it is also important to establish the merits and demerits of focus-group and one-on-one interviews with respect to the purposes of the current study to understand which is more ideal, and then consider how thematic coding can be used to analyze this data. In order to conform to research ethics standard, it is likewise vital to consider any potential ethical concerns.

The Chinese government does not outline clear statistics regarding the STEM gender gap in China, meaning there is limited information on this issue. Therefore, exploratory research is an essential first step to understanding this problem, which is the goal of the current study. To this end, a qualitative case study is likely the most appropriate research design; however, when outlining the methodological approach to the current study, it is important to determine why this research design is most appropriate. It is likewise important to explain why conducting this research into this population—female students from China—and why it is important to conduct this research in Canada. The study will also be using one-on-one interviews with open-ended research questions, so it is important to offer some rationale as to why this approach is more advantageous than other options. In addition to outlining proposed data analyses and methodological assumptions, it is important to consider any potential ethical concerns. A critical review of these considerations demonstrates that qualitative cases studies have the potential to provide critical insights into the current study's research questions and that one-on-one interviews with open-ended questions are the ideal method of data collection.

Research Design: Qualitative Case Studies

Creswell (2014) states that qualitative research is an approach that is ideally used to explore and understand the meaning individuals or groups ascribe to a social or human problem. Given that the gender gap in enrolment among Chinese international students in Canadian universities is a social problem, qualitative research is an ideal approach to developing a thorough understanding of this issue. Creswell also states that when evaluating a phenomenon, case study inquiries can help provide detailed information through "an in-depth analysis of a case" (p. 14). With respect to case studies, Yin (2009) also notes that they are effective when investigating a contemporary, real-world phenomenon that researchers cannot possibly control. Yin also suggests that the case study should gather data that is appropriate for analysis through the study's chosen theoretical approaches. The current study will employ both stereotype threat and expectancy value theories, and case studies would provide ideal data that can be analyzed with these theories. Both Turner (2010) and Yin (2009) note that case studies typically rely on "how" and "why" questions; thus, it will be critical to utilize open-ended questions during data collection. Yin also notes that such case studies are exploratory in nature and are typically used to establish data that can inform future research. Given that the current study is exploratory in nature, qualitative case studies seem to be the ideal research design.

Site

When seeking to understand China's STEM gender gap, it would be fair to assume that China would be the most sensible location for such research. However, there would be restrictions to such approaches. For example, Zurndorfer (2018) notes that the Chinese government has traditionally restricted access to artifacts concerning women's contributions to society, and progress in the area of gender studies in China is more likely to occur in instances where Chinese academics are in contact with Western scholars. Citing security reasons, the Chinese government also restricts access to Google, Facebook, and other websites (Yuan, 2018), which can make it difficult to access some information. Thus, conducting research in a Western nation, such as Canada, that is host to many Chinese international students would allow ease of access to data and ensure that approval of such research would not be impeded by political conflicts.

A comprehensive university in southwestern Ontario was chosen as the location from which participants would be recruited for several reasons. First, the school offers a comprehensive variety of programs—nearly 200 undergraduate programs and over 60 graduate programs ("Fast facts," n.d.). These programs include a prestigious engineering program and humanities programs that recruit heavily from an international pool of students. The school is also host to in excess of 3,700 international students ("Fast facts," n.d.). This will allow the researcher to pull from a large pool of potential student participants from both STEM and non-STEM programs, facilitating ease of recruitment while providing access to the targeted population.

Participants

Morse (2000) argues that researchers should consider several factors when deciding on how many participants they will include in their study. These factors include the scope of the study, the nature of the topic, the amount of useful information obtained from each participant, the use of shadowed data, and study design. For example, a quantitative research study that is relational survey design should have between more than 30 of participants. This would allow the research to develop data. In contrast, a qualitative study focusing on in-depth understanding should have between 5 to 50 number of participants. This can help develop to understand in-depth data analysis. Because the current study is focusing on in-depth interviews. Thus, the recruitment process aimed to select around 6 of participants. In order to ground theory and have in-depth interviews, six participants will be recruited in this study. Regarding participants, there are two key factors to consider: recruitment and the inclusion criteria.

Recruitment

Because the current study only requires a small number of participants from a relatively small community on campus that the researcher is a part of, two approaches will be used for recruitment: convenience sampling and snowball sampling.

Convenience Sampling

Typically, convenience sampling involves selecting participants from a population that is easily at hand, which can help to expedite data collection (Saunders et al., 2019). In this case, the researcher will invite peers from the Chinese international student community whom she already knows. This can be limited, especially in quantitative research, as it may create biases by pulling from small, homogenous pool, which can create misleading data (Bornstein et al., 2017). However, in the context of the current qualitative study, the population being pulled from is already a homogenous community. Moreover, the pre-existing rapport that the researcher has with some of the participants may allow participants to feel more comfortable about sharing personal information, which could enrich the data being collected.

Snowball Sampling

Snowball sampling involves asking participants to recruit people from the population being studied and is especially helpful to enlist participants from hidden populations (Baltar & Brunet, 2012). Like convenience sampling, there is a potential for bias (Baltar & Brunet, 2012); however, given that the population being studied is a homogenous group and that the study is qualitative, this should not be an issue. This approach will allow the researcher to gather additional participants who are unknown to the research to minimize any potential concerns that might be associated with enlisting participants who are known to the researcher.

As the one-on-one interviews will require students to invest in excess of an hour of their personal time, the researcher will provide an incentive in the form of a $20 gift certificate. The University of Alberta (n.d.) suggests that, when offering an incentive, "it must not be so attractive as to be seen as an inducement to participate" and that both the researcher and the Research Ethics Review (REB) should give consideration to "the economic circumstances of those in the pool of prospective participants" (para. 3). Given that many of my potential participants come from relatively affluent families and are able to afford an international education, it is reasonable to assume that a $20 gift card would not be a significant enough form of compensation that it would 'induce' participation. Thus, the use of an incentive within this context seems like a reasonable form of compensation for the participants' time.

Inclusion Criteria

This study will explore Chinese female students' experiences in STEM, both regarding female students who enrolled in STEM fields and those who did not. Ideally, the study aims to recruit three participants from each of the two categories. And they will come from different fields in STEM and non-STEM. Because the current study wants to understand the contemporary climate in Chinese high schools, the study seeks to recruit participants who graduated from high school within the last eight years.

Those participants enrolled in STEM must meet three inclusion criteria:

1. Each participant must be female.
2. Each participant must be currently studying in a STEM field at the post-secondary institution.
3. Each participant must be an international student who is originally from China, and they are required to have attended high school in China.

Those participants who are not enrolled in STEM must meet three inclusion criteria:

1. Each participant must be female.
2. Each participant must be currently studying a discipline outside of the STEM field at the post-secondary institution.

3. Each participant must be an international student who is originally from China, and they are required to have attended high school in China.

Data Collection

The proposed study used semi-structured, open-ended interviews to collect data. Interviews were structured or semi-structured. According to Sanker and Jones (2007), semi-structured questions are advantageous because they are more structured than in-depth or ethnographic interviews which research topics by exploring. Semi-structured interviews included closed-ended and open-ended questions, which targeted the participants' opinion, and explored individual experiences thoroughly. Thus, the current study used this model to explore female students experience with STEM and non-STEM studies. There were several kinds of interviews that were used for qualitative studies, and one-on-one interviews were effective when looking to collected detailed and potentially personal information. It is important to note the benefits of one-on-on interviews and outline the steps involved in data collection.

One-On-One Interviews

One-on-one interviews involved one person interviewing another person, typically in a private location. Moreover, efforts to triangulate specific data was required leading questions, which might taint the data. However, they did offer some advantages that other methods did not. For example, when working in private with a researcher who was perceived as a professional and who maintained one's confidence, participants might be more comfortable discussing answers to questions that might include personal information or details. Likewise, so long as the researcher did not employ leading questions, participants' answers were less likely to be unduly influenced by pressure to conform.

Because the current study was examining issues relating to the issue of Chinese female students, there were some personal experiences that inform participants' views on STEM. In this case, one-on-one interviews were likely more suitable in this study. Likewise, because Chinese students came from a collectivist society, they might feel more inclined to conform to their peers. Thus, the current study employed one-on-one interviews to research the issue of Chinese female students and the STEM gender imbalance in Canadian universities.

Steps to Data Collection

Data collection methods in qualitative study include one-on-one interviews (Gill, et al. 2008). According to Creswell (2014), there are three steps for the data collection: (1) set the boundaries for the study, (2) collect information, and (3) establish the protocol for recording information. The data collection process in this context involved any combination of several options: semi-structured observations, one-on-one interviews, documents, and audio material. Within this context it was important to consider what language the interviews were conducted in, how they were recorded, what methods of member checking were utilized.

Language

During the one-on-one interviews, participants were asked to answer some open-ended questions. Although the data collected for an English publication, the participants will be native Mandarin speakers. Consequently, some of the participants felt more comfortable speaking in their native language and would be more effectively able to express their thoughts through their native language. Therefore, each participant was given the option of conducting the interview in English or Mandarin. Each interview recorded using an audio recording device (iPhone, with iCloud disconnected): those that were conducted in English will be later transcribed based on the recording; those that were conducted in Mandarin will be translated.

Recording

Though King et al. (2018) note that participants are not necessarily more self-conscious being video recorded, potential participants whom the researcher has spoken with expressed reluctance about being filmed during the interview process. Thus, to avoid having participants potentially dropped out of the research due to concerns about having their image recorded, and because it is unlikely that a video recording will provide any important additional information that cannot be obtained through traditional audio recordings and note taking, the current study will use audio recordings to chronical the data. The researcher will use her password-protected laptop and store the audio files in an encrypted folder under a pseudonymous name to protect the anonymity of the participants. These files will be used during the transcription/translation process. After this study is completed, all recording will be destroyed.

Data Analysis

Because the proposed study collected data through open-ended, semi-structured questions, the data analysis will begin with coding. By identifying key words or phrases, often highlighted due to their repeated use in a passage, the researcher labeled these sections with these words or phrases, which Creswell (2014) referred to as *in vivo* labelling. In this process, Creswell recommended that the research read each transcription thoroughly, made a list of the important themes, and then made a mind map or cluster of the central ideas, paying attention to which ideas were common or unique. Creswell likewise suggested that recoding was necessary after this process completed. Thus, to ensure thoroughness, the research went through the data a second time to determine if any key themes were missed. Once all findings had been identified and coded, they would then be interpreted using negative stereotype threat theory and expectancy value theory.

Credibility

In order to ensure the reliability and validity of the study, several steps were necessary. For example, because the interview was conducted in Mandarin and then translated into English, there might be something lost in the translation process. To address this, the proposed study relied on member checking. Although the researcher only had one data stream—one-on-on interviews—the data from each interview was triangulated with others to determine which themes were most common. Moreover, because the study was written in English and the researcher conducted the interviews in Mandarin. As the researcher is a native Mandarin speaker, she used a peer debriefing to ensure the content considers the cultural perspective in which the study took place. Perhaps most importantly, it was critical that the researcher situated herself, addressed any potential biases, and articulated why she was qualified to conduct this study.

Member Checking

According to Lincoln& Guba (1985), member checking is "the most crucial technique for establishing credibility" in qualitative research (p. 314). This is important to the research process for (?) researchers to get participants feedback and respondent accurately, credibly, and validly in a study. Therefore, to verify the accuracy of translations/transcriptions, the file was shared with the participants for member checking. Once the transcriptions or translations had been validated through the member checking process, the researcher began the coding process. And the coding procedure labeled and organized the collective data to explore difference and relationships between them (Creswell, 2004).

Situating the Researcher

Though a researcher's experience provides critical insights that are required to conduct effective research, West (2009) also notes that a researcher's cultural and personal background could potentially create biases. For example, he notes that one's religious beliefs, class, and racial identity could instill data interpretation with a bias. Thus, it is important to recognize my potential biases and to make a conscious effort to ensure they did not corrupt my data collection or analysis. For example, because my subjects were Chinese women, I might be inclined to empathize with them more than an objective researcher would as I share social markers with them. Thus, I was important for me to be cognizant of how I felt when I conducted the interviews and analyzed data. To ensure these potential biases did not affect the data collection, I relied on questions I developed through a rigorous editing process with my peer debriefer. Likewise, when editing the work, I had it reviewed by my peer debriefer to help identify any potential bias in my interpretation. Based on people's life experiences, cognitive bias could be nonnegligible. Cognitive bias could be defined as a misunderstanding in remembering, assessing, and thinking, which is based on personal cognition (Chegg Study, 2020).

Moreover, to mitigate researcher's bias, all participants reviewed the study results as a form of member checking.

That said, my experience and identity were important assets during my study. When the social identities of a research interviewer and participant differ, there is potential that these differences could inhibit data collection. Though Tarrant (2016) notes that difference in social markers, such as gender, do not automatically mean the data collection will be inhibited, there are several studies that show that they can. For example, Hassan et al. (2017) found that female participants might be reluctant to offer male interviewers' access to certain details of their lives. Furthermore, Khunou et al. (2019) note that perceived race can play a similar role. Because I had the same racial identity and gender of my participants, some of the barriers that could otherwise impede data collection could be eliminated. Moreover, because I am bilingual, the participants were able to speak in their native Mandarin, which allowed them to express themselves more clearly. In addition, my own familiarity with Chinese culture and education allowed me to easily frame their perspectives in a manner that would be difficult or time consuming for somebody outside of Chinese culture. This could prove especially advantageous during the coding process and data analysis. My educational background and experience as a graduate student likewise provided me with important insights that facilitated the success of the study.

Methodological Assumptions

The methodological approach that I had chosen was based on some key methodological assumptions that were shaped by a relativist view of the world. According to the *Stanford Encyclopedia of Philosophy*, relativism is simply the belief that one’s truth is dependent on or relative to their person context, and these contexts can be shaped by culture and experience (Baghramian, & Carter, 2020). For example, I believed that behaviour could be explained based on an analysis of one’s cultural identity. I also believed that ethnic or cultural groups tend to share beliefs and that these beliefs shaped people’s lifestyles, behaviours, and choices. My questions were based on this belief, which assumes that the answers they provide can explain how their cultural context has shaped their behaviour and choices. To this end, I had not proposed conducting any biological assessments on the participants.

Ethical Consideration

This study and its associated interviews were conducted in accordance with the *Tri-Council Ethical Policy Statement* and the ethical research review procedure. Though discussing the issues may be distressing, the data could provide insights for future students who may face the same challenges and help them address these barriers and limitations. Likewise, the interviews may provide individual participants an opportunity to understand their life experience in a more critical manner and reflect on their views. However, risks do exist. For example, when speaking about personal issues, participants may experience a heightened emotion response or anxiety. To lower the risk, participants will be reminded before the interview that they can decline to answer any question or end the interview at any time. If their body language suggests that they may be uncomfortable with a question, the researcher will remind them that they do not have to answer.

As anonymity may be a concern, the current study will use pseudonyms to protect the participants’ respective identities. The study will not mention which province they are from or the schools they attended, and all efforts will be made to hide any information that can give their identities away. To maintain their privacy, all data will be stored on a password protected computer in an encrypted file. The data will also be deleted after research is completed.

Summary

This exploratory study seeks to develop an understanding of the factors that shape the STEM gender gap, and because this requires nuanced details, a qualitative study is ideal. Open-ended and semi-structured are likely the most ideal mode of data collection as they will allow participants the freedom required to provide their own thoughts on their experiences and include whatever content they feel is important. And One-on-one interviews will protect the anonymity personal privacy. Member checking and the support of a peer debriefer would provide the checks and balances required to ensure the validity of the findings. Thee coding and theoretical analysis should be able to allow me to develop new insights from this data if possible.

CHAPTER FOUR: FINDINGS

Introduction

Throughout the data collection process, six participants shared their stories and experiences regarding their education in China. Based on their experiences, there were family, academic environment influences, professional expectations, and motivation factors that influenced their decisions regarding enrollment/not enrolment in STEM, which shaped both their academic and professional expectations. Moreover, they also outlined the perceived opportunities that they would have access to and their motivations regarding their decisions to enrol/not enrol in STEM.

There were a total of six participants, each of whom have been pseudonymously named: April is a PhD student and in Mechanical Materials Engineering, the same major in undergraduate; May majored biological sciences in undergraduate, and she is in the Master of Medical Biology Technology; June studied Civil Engineering in college, and she is now an undergraduate student in Civil Engineering; Amber received an arts bachelor degree in English Education; Rose holds an arts bachelor degree in English; and

Participant / Field	April	May	June	Amber	Rose	Coral
STEM	YES	YES	YES			
Liberal Arts				YES	YES	YES

(Table1)

Coral was undergraduate Education major. Now, they are all masters students from the faculty of education (see Table 1).

Family Influence

Data was collected from six females who came from different academic backgrounds. The participants offered varied insights into the impact of parental input and involvement, parental expectations, parent's education background, and siblings' background. These insights help to explain how parents can influence female students' decision with respect to which discipline they choose to study.

Parental Input and Involvement: STEM Participants

Based on the data, parental involvement seemed have a clear correlation with respect to how the students in STEM chose their majors. For example, May received considerable academic pressure from her parents because they had a high standard for her. Alternately, June's mother was busy with work, which compelled June to become self-disciplined in her studies since her childhood.

According to May, her parents were stricter with her than with her brother regarding academic performance. They held her to this standard under the pretense that, if a woman had poor academic performance, it would affect her social status and her ability to have equal standing with her husband within the context of a marriage. May likewise stated that her parents observed that boys are held to a lower standard with respect to academic performance and that they therefore did not need to hold their son to as high a standard as May. May also reported that her parents believe that women are a disadvantaged group in society and that, in order to compete with men, women must work harder and score 30% higher than the average grade of male students. Thus, she noted that her parents put extra pressure on her to get extracurricular tutoring in subjects such as chemistry and that she was expected to secure a 90% average while her brother only needed to secure 60%. Thus, it is clear that, though May's parents believe society to be sexist and that it would be more difficult for May to find success than it would be for many men; however, they asserted that May could achieve her goals if she put the work in to do so. Likewise, according to May's assertions, they were also willing to provide May with the support she needed to succeed by paying for and encouraging her to take tutoring lessons.

Like May, April's parents cultivated her interest in academic studies and offered her support and direction. April's parents were supportive of her choice to study STEM, though their primary concern is that April be happy. For example, her mother, who was a physician, offered April a lot of parental advice when she struggled with math in elementary school. However, her father seemed to have a more significant influence on her. He was constantly alerted to the risks that April might encounter. For example, April reported that her father told her that girls who study the humanities often have an easier time finding a job. He also reportedly told April that there were no females in his college classes, and his colleagues were almost all male. However, April's father did not adopt the role of dictator but rather acted as more of a philosopher: he was not exerting influence so much as ensuring April would be fully aware of the challenges she might encounter. As a mechanical engineer, he was familiar with what the expectations and reality of STEM is, both in academia and within the professional realm. This steady stream of professional advice benefited April and allowed her to choose the area where she would devote herself. April said that she was not very interested in STEM at first but that her father's professional influence and the continuous deepening of her own learning gradually led her to follow the route that her father took. Though April's father did not encourage her to study STEM, neither did he dissuade her. He did highlight the kinds of challenges she might face, but also offered support should she choose to take on these challenges and never suggested she would be unable to succeed in STEM.

June's mother worked hard as a building engineer to make money to raise June alone. This allowed June to understand the significant economic returns that learning STEM-related subjects can bring when she was young. After getting divorced from June's mother, her father was reportedly almost indifferent to June. Her mother did not interfere with June's professional choice because she was busy with work and never asked June to take any extracurricular classes. June, though, established her own rules and expectations for her academic studies. Though June's mother did not press her to study STEM, she offered an example of a woman who could find independence through STEM and likewise did not perpetuate gendered stereotypes about who should be in STEM.

Parental Input and Involvement: Liberal Arts Participants

Based on the data collected from the non-STEM participants, there were some alarming differences between how their parents reportedly addressed their daughters' academic studies and engagement with STEM. For example, Amber's parents seemed to be neglectful of her academic development, and Coral's parents reportedly adopted some sexist perspectives relating to girls and STEM.

Sexist Neglect

Based on the data collected from Amber, one of the key factors that may have impacted her choice of study was her parents' neglectful approach to her academics. For example, Amber noted that most of her classmates were expected to complete extracurricular academic work and had tutors to help them improve their academic performance; however, Amber's parents did not pay for any tutoring services for her. In addition, they did not seem to pay much attention to Amber's academic studies, as demonstrated by the fact that they were unable to name any of her teachers. Though this may seem like general neglect, there are seemingly sexist overtones to it. For example, though Amber's parents could not name her teachers, they could name all her brother's teachers and took a high level of interest in his studies. They also had high expectations for her brother and gave him guidance but had no expectations for Amber, nor did they offer her guidance. In addition, to ensure that her brother could receive a high-quality college education, they considered changing her brother's household registration status to show that he lived in Beijing. This cost a great deal of money. However, they did not do the same for Amber, so she was still registered in her actual home and did not have the same access to admission opportunities as her brothers. Thus, her parents' neglectful approach likely inhibited her academic potential and reinforced sexist stereotypes about academic performance and gender as they clearly sought to nurture her brother's academic success and did little for hers.

Sexist Mentoring

Coral's father worked in the STEM field and offered her mentorship; however, his guidance was often shaped by overtly sexist overtones. According to Coral's recollection, the concept of sexism enveloped the entire family. Her father was an engineer. Many years of experience in dealing with cement and drawings convinced him that there is no room for women in this industry. He had repeatedly hinted at Coral that women studying STEM are asking for hardships. He and Coral's mother also stated that becoming a teacher or a lawyer is the ultimate destination for girls. Coral's STEM scores were above average, and she knew how much work and sacrifice went into her efforts to achieve her grades. Therefore, while her parents praised their friend’s son’s genius achievements in the STEM field, Coral’s inferiority complex made her mistakenly internalize her father’s sexism. She gave up on physics and chemistry, which she once loved, and entered the educational world as her parents wished. Coral's father's inherent stereotypes of women seem to have had a significant impact on her academic and career choices, and in the end, she did not choose STEM as her study direction.

One of the primary reasons that young female students opt to not pursue STEM studies is because they follow their parents’ advice to choose a ‘feminine’ subject. In the name of taking care of their daughters, some parents will instill their own views in their daughters and expect them to follow these views. In some cases, these views may include sexist stereotypes. For example, Coral was told not to enroll in STEM because her farther believed that liberal arts would be easier for girls to study compared to STEM. Coral likewise adopted this view and ultimately enrolled in liberal arts.

Support

Rose's parents gave all the support that she needed, without accusations or reprimands but patient guidance and assistance. Rose's math scores have always been poor. Her mother created a "wrong question set" to help Rose better understand some classic definitions and concepts. However, this method did not facilitate her interested in any STEM subjects. Rose's mother spent a lot of time and energy helping her daughter review some basic knowledge, but Rose's intense anxiety in the face of the math test made these efforts ineffective. Her parents did not scold her for her struggles; they only made pertinent suggestions and offered some ideas. Rose showed her talents in geography and Chinese literature during her high school studies, which her parents encouraged and praised, and this motivated her to choose the liberal arts field, which she was more adept at. The support of her parents made Rose's academic career seem smooth. Parental support and understanding were Rose's greatest motivation to move forward. She chose to study liberal arts because of the result of her parents' guidance and not from any pressure they put on her.

Parental Expectations: STEM Participants

Parental expectation is an important factor that impacts how parents will guide their daughters. When young females tell their parents that they want to study STEM, their parents may draw on their experience to warn their daughters about how difficult STEM studies and career development will be. Both of April and May's parents expressed concern, but they also respected their daughters' choice and offered encouragement. Both April and May reported that their parents prioritized their daughters' happiness above all else.

Happiness, and High Standard Academic Achievement

According to May, when she was in high school, her parents held her to a higher standard than her younger brother regarding academic achievement. Her parents had a strict standard for May's academic performance because they believed China's traditional feudal system still shaped how society views women and that May would encounter sexism if she chose to study and work in a STEM field.

Within social contexts, May's parents believed women are often at a disadvantage, especially in STEM fields, because of pervading sexist attitudes. To succeed professionally, women must outperform their male counterparts in the workplace. Thus, to prepare May to succeed, her parents held her to a higher standard academically than her brother. For example, May reported that her parents expected her to secure 90% or more on all of her exams, though her brother was only required to secure passing grades. In order to fulfill her parents' academic expectations, May had to invest extra hours in her studies outside of school with the help of tutors.

Though both of April's parents were supportive, they had opposing views regarding the value of one's grade. For example, April's mother held the view that the marks she lost on one exam should be compensated for on the next exam. Thus, she expected April to prioritize and focus on her studies. However, her father took a different approach. He taught her that happiness is the only motivation for learning; thus, instead of striving for the perfect 100%, some space should be left for play and leisure. Thus, April received some mixed messages about her studies.

April's father also asked her to read classic literature to enrich her spiritual world and overall critical thinking, rather than focusing exclusively on what was taught in school. In this context, he asked her to make notes and spent time every week examining the quality of her reading notes so that he could communicate with her about her readings. As a result, April believed that her independent learning ability had a significantly improvement. After entering the university, April received a lot of advice and help from her father in engineering drawing.

When she encountered some academic problems, she always needed assistance from her father. For instance, during high school, April was struggling to the pressures associated with her academic studies, but her father help to guide her through this. As a mechanical engineer, he brought the rigorous spirit from workplace into the whole process of learning and growing up with his daughter. When April experiences academic anxiety, her father used his understanding of psychological and motivational stories to help relieve her anxiety, and through dialogue and exchanges of opinions, he helped to ease April's academic anxiety.

Later, when April encountered academic challenges in university, she always received assistance from her father. He often commented and guided April's sketches until midnight, and he was careful about the problems that April encountered in gasket material and bearing stiffness. The expectation and guidance from the parents gave April a lot of energy to help her understand the mystery and magic of the STEM world. According to April, her parents were tolerant of whether she chose STEM as a professional, and they just hoped that she would be happy. However, April's parents also told her that liberal arts would likely be easier than STEM with regard to both her studies and finding employment.

June lived with her mother after her parents' divorce. As stated by June, her father held the patriarchy thinking and absented from her growing up. June's mother would like to give her daughter an abundant living environment and receive high quality education. However, she spent a great deal amount of time on her work, and did not have time to involve in June’s study. June believed that her mother always wanted her to be as capable as men in her study and future career. In addition, June and her mother wanted to prove to her father that he was wrong with his patriarchy. Therefore, June’s mother used her own actions to tell June--women can be also successful in the STEM fields, despite the unfriendly environments for women in China. As a result of which, June regarded her mother as a role model. June’s mother used her success to prove that women can also achieve the same establishments as men, which also increased June’s confidence to go abroad to study engineering science.

Parental Expectations: Liberal Arts Participants

Some parents want their daughters to study liberal arts because the relevant jobs would be both easier to secure and excel at and would be more feminine than a career in STEM. With regard to future salary expectations, parents of female liberal arts students do not have high expectations for their daughters, and this perception seems consistent with non-STEM participants’ parents.

According to Coral, her parents had strong prejudices about women's STEM work or research and never expected her to achieve anything in STEM. Her father believed that the engineering industry was a male’s field. Because of this, Coral’s father did not have any expectations for her STEM studies or achievements and hoped that his daughter could focus all of her energy on liberal arts studies—the so-called industry suitable for women’s development—so that she could become a teacher or a lawyer. This was despite the fact that Coral always maintained excellent math scores. Her parents believed that this would be a huge advantage for Coral when choosing to study liberal arts. They hoped that Coral could make good use of her advantage on math, especially in China, where many liberal arts students do not have very good mathematics scores. When Coral had to choose her future study path between STEM or liberal arts, she was persuaded to enter liberal arts.

Rose's parents hoped that Rose would find her true interest, through which she could secure happiness and satisfaction. When Rose realized that her limited and mediocre mathematical talent was not enough to support her entry into the STEM field, she retreated to the domain of liberal arts. Rose's parents still maintained their consistent support and encouragement for their children, without any reprimand or complaint.

Parents’ Education Background

In the family environment, daughters are undoubtedly significantly influenced by their parents, and parents’ guiding ideology for their daughters is to a certain extent restricted by their own education level. If we want to explore the influence of the family environment on girls who choose STEM, we must understand the educational background of the parents.

April and May’s parents both have the bachelor's degree. April’s father is a mechanical engineer, and her mother's occupation is a physician. June's mother also has bachelor’s degree of engineering. Based on the data collection, STEM girls’ parents all have bachelor’s degrees, and have the STEM field job. Compared with STEM girls, the education backgrounds of the parents of liberal arts students are more diverse and span a wide range. Amber's father graduated from junior high school and her mother graduated from high school, and they have their own business. Coral's father has a master's degree, which is the only case we had studied, and her mother graduated from college. Rose's father got a college education, and her mother graduated from a technical school.

Regarding the participants' information, it appears that there is a relationship between the parents' educational background and their daughters' choice in STEM.

Siblings

Due to China's one-child policy, most of the participants did not have siblings; however, there were two exceptions to this, Amber and May, both of whom had brothers. There are a few exceptions during the one-child policy era, including: the couple has only one child, who is handicapped or unable to work because of disability; both parents are only children themselves, and they only have one child so far; the couple paid a fine to have more children. The presence of brother within the family dynamic did have an impact on how they each perceived STEM, but nature of the impact and outcomes each experienced were drastically different despite some parallels.

Siblings and STEM: Amber's Experiences

Amber came from rural area where one child policy was not strict enforced in her hometown thus Amber can be born. Her parents had a daughter and a son, but they did provide the same level of engagement with their children's respective academic engagement, which likely had an impact on Amber's academic outcomes. Amber's brother was eight years older than herself, and her parents let it be known that they believed the hopes of the family and the direction of future development were on her brother's shoulders. Thus, Amber's parents paid particular attention to her brother's academic performance and invested enough time in his schooling to be familiar with the names of all of his teachers. They even made an effort to register an address in Beijing to ensure that he would have access to the best high schools in order to improve his chances of being accepted to a more prestigious postsecondary institution. However, Amber's parents did not extend the same level of effort to her. In sharp contrast to the standard her parents had established with her brother, neither her mother or father could name a single one of Amber's teachers, and neither did they make the effort to register an address in Beijing for Amber so that she could likewise have an opportunity to access more prestigious high schools. In addition, Amber's parents express the sentiment that STEM fields were exclusively for boys and ignored Amber's early struggles with STEM, failing to provide her additional tutoring support or parental supports to help her overcome the struggles she encountered with STEM subjects. Amber eventually chose to focus on the arts, and though she did not expressly state that her parents lack of engagement with her academic studies what is the rationale for this choice, there may be a correlation between her parents' disinterest in her academic pursuits and Amber's failure to overcome her early struggles with STEM. There may likewise be a correlation between the fact that Amber's parents promoted stereotypes about gender and STEM and Amber's ultimate decision to focus on liberal arts.

Siblings and STEM: May's Experiences

May's parents had a son and daughter and likewise treated them differently; however, they explained the rationale for this different treatment to May while providing her with extensive support to facilitate her academic success. May has a brother who is three years younger than herself. In order to have the second child, May's parents paid a fine for her birth. As an older sister, she has to play an exemplary role in life and study to set a good example for her younger brother. The strict standards set by her parents are in part derived from this expectation. In addition, her parents are aware of the biases and prejudices that people hold regarding women who study and work in the STEM fields.

Thus, they also taught her that she needs to put in more effort in her studies because others will hold her to a higher standard. Hence, they held her to a higher standard than her brother. Though May's parents held her to a higher standard than her brother, they explained their rationalization to May and also deconstructed and challenged the gender stereotypes that society often holds about gender and STEM. Though anecdotal, this suggests that when parents take an interest in their daughters' academics and explain stereotypes, the daughters may be more likely to pursue STEM studies.

Academic Influences

Based on the data collected from the participants, there were three key factors that influenced the participants' perspectives of STEM studies: academic expectations, expected workload, and familial expectations.

Academic Expectations

The participants collectively outlined how their teachers' input and criticisms shaped/correlated with their decision regarding their chosen field of study. Among the participants who chose to study the humanities, it was clear that their expected academic outcomes in STEM and the humanities shaped their decision. Only one non-STEM participant (Rose) indicated that she had a significant advantage on liberal art subjects in high school. Other two liberal art participants represented that they had an average performance in all subjects in high school; indeed, they have some advantage on one or two subjects in STEM (Amber said she loved and had great performance on chemistry; Coral enjoyed and also got top grades in math). However, Coral was told by her teacher that being good at math would be an advantage for girls in Gaokao (College entrance exam) if they study liberal arts. Her father likewise told her that he expected her to be successful in liberal arts instead of STEM. Impacted by both the teacher and father, Coral quit STEM study.

While, STEM girls get higher grades in STEM subjects when they face to separate courses of liberal arts and STEM. May believes that the STEM field is man's field, but as a girl, maybe have their unique advantage, like writing. All participants in STEM mention that teachers always tell young women that they have to study harder than young men to complete with them in Gaokao.

Expected Workload

The expected future workload would impact girls' academic choice. The expected workload not only shaped which discipline the students chose to study but also which areas to focus on.

Workload: Liberal Arts

The participants who chose to go into the humanities—Amber, Rose, and Coral—expressed that the expected workload associated with STEM would be too exhaustive and even insurmountable, which influenced their decision to pursue studies in the humanities. For example, Coral's parents and teachers said that she could not succeed on STEM, and she chose to enroll in the liberal arts stream in high school based on her parents' expectation. Two of the participants, Rose and Coral, mentioned that they would have to put in significantly more study time to compensate for their shortcomings in STEM. Amber also chose to enroll in liberal arts because she wanted to avoid studying math, and the STEM subjects.

Workload: STEM

Though the participants who enrolled in STEM were not discouraged by the work they would have put in to secure a STEM position, they were discouraged from entering certain fields within STEM because of the associated workloads. For instance, all participants who enrolled in STEM—April, and May—mentioned that their high school instructors told them not to go into construction after completing the bachelor education level because the work would be too difficult for female. Instead, their instructors recommended that they earn a master's degree and focus on research positions. While June knew the work of engineers would be tough because her mother is a building engineer, but she still wanted to enter this field for the high pay. Based on future work with money and considered part of their own interests，extrinsic motivation seemed to dictate their choices to enroll STEM. Based on April and June, they believed that STEM females have less expected workload because of the rough work environment.

Professional Expectations

The teachers and adults within the participants' lives created professional expectations regarding careers in STEM with relation to research and construction, though these experiences were not consistent among all participants.

Though only one participant, June, mentioned having been discouraged to pursue field work in construction, none of the other participants mentioned that they had been encouraged in this respect. Given that they did likewise highlight being encouraged to pursue research, it seems clear that there is a bias with regard to the mentorship teachers provide. April was influenced by her father's career and chose a path of study and development in the engineering discipline. Meanwhile, in order to avoid the harsh working environment of entree level engineering jobs, April continually improves the education background until her PhD study.

Motivation in STEM Enrolment

Based on the participants' responses, those who choose to pursue studies in STEM did so either because they were extrinsically motivated by their future salary or because they were intrinsically motivated by their innate interest and enjoyment in STEM as well as extrinsic motivating factors, particularly salary.

Extrinsic

Based on her interview, June's motivation to pursue studies in STEM was based on extrinsic motivation. She realized that a career in architectural engineering could provide a stable income as she had seen that her mother made a sizable income by working in architectural engineering. This was compounded by the fact that, having grown up as a child of divorce, she saw how important money is to ensure one's autonomy. Thus, when she made the decision about her future career, money became the first factor. Meanwhile, she was not content with earning an undergraduate degree and had considered enrolling in a graduate program in the future. Money as an extrinsic factor, not only helped June to choose her academic path, but also helped her to find her short-term and long-term career pathway and encouraged her to pursue higher education.

Intrinsic and Extrinsic

While June was motivated exclusively by extrinsic factors, April and May were motivated by both intrinsic and extrinsic factors. They both mentioned that they had an innate interest in STEM.

April's Inspiration

Watching her father draw from a young age taught April a lot about engineering, and she soon realized that she had a passion for STEM. During her undergraduate study, April found that Mechanical Materials Engineering is an ancient discipline but she also had a lot of fun exploring and researching in this area. Her intrinsic interest encouraged her to enter the engineering area and pushed her to explore deeply in this field. When nearing completion of her undergraduate studies, she had been told by several teachers that entering the field without a graduate certificate could prove difficult for women in STEM. These same teachers suggested that continuing onto graduate studies would ensure she had more career opportunities, especially with respect to research and development. As an extrinsic factor, career opportunities encourage April to pursue higher education continually. Because she enjoyed engaging in research and theory, and because further studies could improve her prospects, she decided to continue through to her Doctoral studies.

May's Inspiration

May's inspiration was also shaped by intrinsic and extrinsic factors. She likewise reported enjoying STEM very much, and even felt extremely excited during math exams. In addition, she was confident in her prospects with her major in Biomedical Technology as she saw it as a viable profession in the future. May met a role model who was her medical science professor and his rigorous scientific attitude encouraged May. Impacted by her professor, May decided to pursue graduate studies upon completing her undergraduate degree.

When considering how intrinsic and extrinsic motivation intersect, it is important to note that the participants who were motivated by both went on to graduate studies, while June, who was motivated by extrinsic factors, was content with completing an undergraduate program. It is likewise important to note that none of the participants were motivated exclusively by intrinsic factors.

Conclusion

The findings suggest that there is a likelihood that young female students' choice to pursue studies in STEM could be shaped by both their parents and their teachers. With respect to parents, there were several key patterns that arose in the data. For example, when the parents affirmed stereotypes about gender and STEM, the daughters were less likely to pursue STEM; however, if parents deconstructed these stereotypes, their daughters were more likely to enroll in STEM. In addition, parents who invested more time in their daughters' education were more likely to have daughters who enrolled in STEM, while those were neglectful of or disengaged in their daughters' education were more likely to have daughter who enrolled in the liberal arts. In addition, parents with a STEM background and higher levels of education were also more likely to have daughters who enrolled in STEM. It is important to note, as well, that the participants who enrolled in STEM each reported that they saw how well their own parents were able to provide working in STEM and that this influenced their decision to enroll in STEM. Teachers' engagement with students likewise seemed to have an influence on the students' academic choices. Some of the participants reported that teachers discouraged them from engaging in STEM or openly ridiculed their performance in STEM and did not encourage their improvement. In other cases, teachers simply offered less attention to female students and/or asserted that boys were inherently better at STEM subjects. These participants were more likely to enroll in liberal arts. Though the participants who enrolled in STEM did report that some teachers promoted stereotypes about gender and STEM, they also received some encouragement from teachers and had a more positive rapport with their teachers and detailed an intrinsic appreciation for STEM work. They also reported that teachers acted as mentors in some instance and gave them career advice, in which cases the participants were not only more likely to study STEM subjects but were also more likely to pursue graduate studies. Overall, it is clear that when parents and teachers reinforced negative stereotypes about gender and STEM, young female students are more likely to abandon STEM; however, when parents and teachers critically address these stereotypes, show support, and teach young female students about the potential benefits of studying and working in STEM field, these students become more likely to pursue STEM studies.

CHAPTER FIVE: DISCUSSION AND IMPLICATIONS

The current research was designed to answer two key research questions: a) How do experiences in education shape female Chinese students' perceptions of their STEM abilities, and b) what social and cultural factors, influences, and expectations do these students consider when deciding whether to enroll in STEM programs? The findings outlined in this study outline several patterns of behaviour; however, to understand them, it is important to analyze and discuss them through the lens of negative stereotype theory and expectant value theory. This analysis can help identify the implications these findings have for all stakeholders and the broader educational community. This could potentially form the basis of proposed policy changes and best practices for teachers and parents with relation to promoting STEM among young girls. Within this context, it is also important to consider the study's limitations and propose future areas of research.

Discussion

Negative Stereotype Theory

According to McGuire et al. (2020), the gender gap in STEM participation is linked to stereotypes that perpetuate the belief that boys/men are inherently superior at STEM. These stereotypes appear in childhood and are strengthened during adolescence (Cvencek, Meltzoff & GreenWald, 2011). All of the participants were exposed to negative stereotypes about women; however, April, May, and June chose to pursue STEM, while Coral, Amber, and Rose chose to study the humanities. The difference in their choices seemed to relate to how these stereotypes were presented to them. These differences can be understood by analyzing their choices through the lens of negative stereotype theory, which explores how negative stereotypes shape the way people perceive themselves and their abilities.

Family Impact on Liberal Arts Female

Negative stereotype theory offers a potential explanation as to why Amber struggled with STEM subjects and eventually chose to study the liberal arts. In middle school, Amber's grades in all subjects were good and very balanced, her parents—who only had a high school education themselves—invested little effort into her academic growth. Moreover, the adopted traditional and patriarchal views on education, as highlighted by the fact that they did invest significant resources into her brother's academic success. In contrast, her parents reportedly did not give their daughter sufficient support and guidance in her studies. Although her parents did not expressly articulate that the academic performance of boys was more important than girls or that girls could not succeed, Amber felt that their actions clearly conveyed this sentiment. This likely left Amber vulnerable to adopt the negative stereotypes regarding girls and STEM that she might be exposed to by teacher and peers. Eventually, Amber opted to end her STEM studies and focus on the liberal arts.

In contrast, Coral's parents gave significant attention to all aspects of their daughter's academic studies; however, this attention often reinforced negative stereotypes about women and STEM. For example, Coral's parents repeatedly told her about the struggles that women in STEM encounter and noted that this was because girls and women are not as adept at STEM fields as boys. Thus, they highlighted and accepted this negative stereotype to discourage her. In addition, Coral's parents were also full of praise for the achievements of their friend's son in STEM studies but showed a disapproving attitude towards Coral's efforts and choices in chemistry and biology. They tried to reform Coral and eventually convinced her to concede that the profession of teachers and lawyers were more optimal choices for her. Though she performed well in STEM courses, she trusted her parents and thus lacked personal confidence in STEM, which is a typical outcome of the negative stereotype threat. This led Coral to ultimately believe that the humanities were an easier and more optimal study pathway, thereby adopting her parent's negative stereotypes about women and STEM.

Rose's parents differed from both Amber and Coral in that they encouraged her to apply herself; however, other barriers proved to by the catalyst that led to her pursuing studies in the humanities. This suggests that parents do not have to be the source of the negative stereotype threat in order for it to impact a students' performance in STEM or their academic choices.

School Impact on Liberal Arts Female

In addition to parental influences, negative stereotype threat can be caused by influences within the school system. Based on the testimonies of the participants, this influence took three forms: stereotypes, insults, and neglect.

Stereotypes. The participants each highlighted how stereotypes shaped their academic experience. For example, Rose's high school physics teacher publicly stated that he believed men's logical thinking is naturally better than women's, which made Rose feel despised. Rose tried various ways to succeed in mathematics during elementary school, but the constant failure made her feel frustrated. Later, her physics teacher dropped dark clouds and lightning on her STEM sky. The continuous frustration caused her enthusiasm for STEM to ebb, and finally made her disappear into the field. In addition, Rose reported that her teachers were quick to offer praise to male students who showed promise in STEM, but did not afford the same complementary tone to girls.

Insults. Some Chinese teachers turn prejudiced theories into vicious personal attacks. For example, Coral's physics teacher denigrated her talents, stating that she was 'stupid' and had no qualifications to study STEM. When offering criticism related to Rose's failure to complete simple calculations, Rose's math teacher often relied on humiliating language and discouraged her engagement in math. as a result of this humiliation, Rose developed anxiety relating to math, reported losing self confidence in her ability to succeed in math, and ultimately discouraged her from engaging with math.

The perennial negative evaluations have caused these girls to have negative expectations of their own abilities and self-dwarfing in their hearts. Such negative self-expectations will cause great anxiety and uneasiness before the science exams, and such anxiety will make them perform poorly in the exams, forming a closed vicious circle. According to Woodman and Hardy (2003), confidence is an important catalyst for good performance. However, the participants who did not choose STEM received relentless ridicule and discourage from teachers, especially before they were required to choose to pursue a STEM or liberal arts stream in high school.

Neglect. Though the stereotypes did present themselves in overt ways, there were more covert ways that these stereotypes were reinforced, most notable in the form of neglect. Amber reported that her science teacher did not pay attention to her science scores. The teacher's indifference to students' performance made girls who should have been trained with a good STEM mindset lose their prime time to be guided to the path of STEM. In addition, because student performance shapes teachers' reputations and bonuses in China, teachers' focus may be on ensuring that they get the highest class average possible, which could cause them to discourage some students from studying STEM. They didn't guide the girls' interest positively, but only hope that their good grades will increase their future educational qualifications.

Family Impact of STEM Female

While the participants who elected to choose a liberal arts stream had negative stereotypes about girls and STEM reinforced to them by both their parents, the participants who chose the STEM stream were taught about the stereotypes by their parents and informed that they could succeed in STEM despite what these stereotypes suggested. They were also taught that they would have to overcome social barriers and prejudices to excel in the field.

Familial influences are one of the central factors that shape the STEM gender gap. Parents influence children's interests through their own ambitions, values, and beliefs. Parents' occupations, jobs, and social networks all play an exemplary role in children's academy path decisions (Eccles & Wigfield, 2002; Wiese & Freund, 2011). Though May's parents did not ascribe two negative stereotypes about women and STEM, they were very much aware of these stereotypes; thus, to prepare their daughter for a world in which these stereotypes are broadly accepted, they held her to a higher standard than her brother. For example, if May's grades are lower than her younger brother's grades, she will be severely punished. On the contrary, the younger brother's grades are acceptable even if they are much lower than the May's. In addition, they also taught her about the importance of performing at a high level so as to empower her to overcome the stereotypes she would encounter. For instance, her parents taught her that, in social settings, women are often placed in subordinate positions to men based on patriarchal biases and stereotypes about women. Likewise, May's mother told her that within romantic relationships, women who do not demonstrate that they are academic equals to their partner may be victims of neglect and emotional abuse within the relationship. Specifically, she noted that a husband might assert himself within a stronger hierarchical position and lose affection for a wife who is academically inferior.

Though May's parents recognized that their daughter would encounter stereotypes in her professional and personal relationships, they never told her that these stereotypes were true or that she could not succeed. Therefore, whenever May might happen to encounter these stereotypes in social settings, instead of allowing them to impact her performance in STEM, she is prepared to critically process these biases. June was likewise able to overcome stereotype threat; however, the means through which she achieved it were different. First, the absence of her father, who held traditional views of gender and STEM, limited her exposure to negative stereotypes. Second, her mother, who worked in STEM, provided positive same-sex role modelling.

Limiting Exposure to Negative Stereotypes. June reported that her parents were divorced when she was young, and that her father and paternal grandparents were not involved in her life growing up, largely due to the fact that she was not a boy. In traditional Chinese families, a male child is often given preference over female children. Based on this, there is little doubt that June’s father and paternal grandparents would have likely promoted negative stereotypes about girls and STEM. However, because their harmful sexist views on female children kept them out of her life, they did not have the opportunity to reinforce negative stereotypes that she would have otherwise heard. There are many variables at play. For example, June may have been motivated to prove to herself that she did not conform to the passive and dependent archetypal woman that father and paternal grandparent assumed she would be but rather that she was an independent and tenacious woman. However, what is clear is that June did not hear the negative stereotypes about girls and STEM at home, unlike Rose, Amber, and Coral, and thus did not have such ideas programmed into her outside of school. As a result, the absence of negative stereotypes at home may be critical to address the gender gap in STEM. Negative stereotype was transformed by June and her mother into a huge forward momentum, which is also a phenomenon that has to be taken seriously in the research.

Same-Sex Role Modelling. June also had the benefits of having a mother who worked in STEM and who thus provided her with same-sex role modelling. According to research by Bowring (2014) and Eriksson-Zetterquist (2008), same-sex role models play a particularly important role in socializing children's gender-related behaviors. In addition, the modeling of parents' interest in STEM enables girls to imagine themselves as anti-stereotyped STEM roles (Wiese & Freund, 2011; Xie et al., 2015). These concepts offer potential insights in how June was influenced by her mother. As she did not hear the negative stereotypes about girls and STEM, the only example of a STEM professional that she had in her life was her mother. This allowed her to see that women can accomplish in STEM and likewise offered her evidence that would challenge any assertions of girls being unable to excel in STEM that she might be exposed to outside of her home. Though there are other variables that could have influenced June's engagement with STEM, this anecdotal evidence certainly suggests that same-sex role modelling has the potential to address the gender gap in STEM.

April also heard ‘Don’t’ study STEM, study girls ’major’ from her father. April’s father tried to pass on his life-lessons to her. He was very familiar with the reality of China's STEM field and that the production space of female STEM practitioners is small and dark. He wanted to tell his daughter what he knew about STEM-field and tried to convince her to choose what he thought was an easy path. This resistance, aimed at caring for his daughter's future development, did not dishearten April, because the purpose was not to discourage her from studying STEM. In student learning, motivation and engagement are key factors (Guthrie et al., 2004; Wu et al., 2013). April’s strong interest in STEM drove her into this field study and served as motivation for her to pursue further education in the field later in life.

Parents are a child’s first and perhaps most important teachers. In China's traditional Confucian culture, the influence of parents on children's education cannot be overstated (Yang, 2011). These examples demonstrate several patterns. For example, if parents’ study and work in STEM fields, then their daughters may be more likely to study STEM themselves. This highlights the importance of role models. However, these examples also demonstrate that the role models could be male (as is the case with April), female (as is the case with June), or both (as is the case with May). Moreover, the role model may be more overt, as April’s father took on an active role in mentoring his daughter, or subtle, as is the case with June’s mother, who led by example but showed no overt encouragement. In addition, when parents address sexist stereotypes and address the challenges that they can present, their daughters may be able to recognize that the stereotypes are not true. As is the case with both May and April, their parents highlighted the challenges their daughters might encounter, but let them know that they can still succeed despite the fact that they may be held to a higher standard.

School Impact of STEM Female

The stereotype of female students in the liberal arts comes before they face the choice of whether to enter STEM field studies. The pressure and challenges of school for STEM females comes after they enter STEM field studies. People have stereotype perceptions and emotions of some groups, so they are treated unfairly in their behavior--girls in the STEM field are all affected by the above-mentioned prejudice. All participants mentioned that they were treated different than men in STEM classes.

The perception that men are more gifted than women in STEM seems to be ingrained in the minds of some teachers, and they would even express it explicitly and publicly. In May's experience, the chemistry teacher had a deep-rooted prejudice that STEM is a special zone for men. In the classroom, when she puts questions forward, chemistry teachers seldom trust the answers of female students, and give priority to male students to answer the questions. The chemistry teacher publicly accused May as having lack of talent and poor performance in chemistry knowledge in front of all the students, but gave preferential treatment and even encouragement to similar male students with poor grades. The physics teacher is also more inclined to trust the answers of boys in the questioning process of some difficult practice questions in May's high school class. Typical talents in the STEM field are considered to be non-feminine, because the whole subject is fundamentally lacking femininity, and very masculine. In particular, mathematics is almost mythically turned into a discipline. Only the combination of ability and talent can lead to success in understanding, and effort and sweat are not enough

(Kessels, 2015). A sharp contrast can be found in the formation of stereotypes about STEM and the typical 'female' learning style of girls. Regarding the psychological consequences of the mismatch between the stereotypes of stakeholders and the stereotypes of girls, interest can be used as an identity adjustment model to illustrate. (Kessels & Hannover, 2007; Kessels, Heyder, Latsch & Hannover, 2014; Kessels, 2015). Consciously or unconsciously stubbornness to traditional values and behavior patterns; identification and exaggeration of authority--under such an environment, there is almost no room for opposition, and many Chinese high school students also silently agreeing and following with the teacher's concept. According to April, she believes that some of her classmates unknowingly believe in and follow her teachers' concepts.

June did not choose a normal way to received high school education. Instead, she entered vocational and technical school after graduating from middle school. The higher vocational education and technical college model's study is more similar to university, with more freedom of management, but also more direct career challenges. As she studied architecture here, she often heard teachers say that "men have a better future than women in the construction industry." June turned all that stereotype into motivation and, unwilling to fall behind men in her future career, she chose to study abroad for her undergraduate degree.

Expectancy Value Theory

Before investing oneself into any endeavour, people typically consider what benefits the endeavour will yield, and this pragmatic rational can be explained with expectancy value theory. There are two categories of subjective task value: intrinsic and utility (Fan, 2011). Intrinsic value has been identified as the motivating force behind people’s spontaneous behaviours. As such, it is shaped by the intrinsic benefits of an action, which may include the happiness or sense of euphoria derived from participation in a given activity. In contrast, utility value is associated with external factors, and as such is shaped by extrinsic goals, such as achieving a desired outcome from an activity (Fan, 2011). Expected value theory asserts that individuals’ motivations to complete various tasks is determined by their expectations for the success of this task and the value assigned to this task. The greater the possibility that the individual thinks to achieve the goal, the greater the incentive value obtained from this goal, and the stronger the individual's motivation to complete this task.

Utility value refers to the relationship between a task and future goals (Wigfield, 1994). For example, an engineering student studying may not inherently enjoy taking exams or reading textbooks; however, the promise of a secure, high-salary career keeps them motivated to complete their studies. Thus, some goal and activities can play a key role in attaining later outcomes. In this context, the activity must have at least one of two characteristics: it must be essential to achieving immediate goals, or it must be essential to achieve long-term personal goals. Analyzing the participants’ choices through the lens of expectancy value theory offers insights into why some participants chose to study STEM and others chose to study the humanities.

Non-STEM Female Rational

According to Eccles and Wigfield (2002), the expectations of mission value and success are quite different. However, at the same time, the expectation of success tends to predict the value of the children's future tasks, and children tend to attach importance to the areas they think they can do (Eccles & Wigfield, 2002). Without the combined effect of intrinsic value and utility value, it is difficult for girls to enrol in STEM.

Rose chose to study liberal arts as opposed to STEM. She was intrinsically engaged with liberal arts and did not believe that STEM would have more utility value than liberal arts. Based on her past performance in STEM and the feedback she received from both teachers and parents, she assumed that any significant level of success in STEM was nearly impossible and that pursuing this discipline would leave her with few, if any, job opportunities. Alternately, because Rose did perform well in the liberal arts, and because she was informed by both teachers and parents that there would be more career opportunity for her in that field, she chose to study the liberal arts and the humanities. Thus, in accordance with expectancy value theory, Rose made her decision based on which option would yield her the best results based on an effort-to-outcome ratio.

However, it is important to note that the assumptions applied in this formula were likely shaped by the negative stereotypes for which Coral had been exposed. Because both her parents and teachers told her that girls do not perform well in STEM and criticized her performance in this field without encouraging her, she likely believed that her potential success in STEM it was nearly impossible. In contrast, both Coral's parents and teachers highlighted the benefits of her potential success in the liberal arts. In this way, the negative stereotypes she was exposed to informed her of the decision-making process.

Amber said she never thought about studying STEM, though she studied very well in chemistry and math. In her unconscious mind, she did not believe that girls should study and that they could not develop in the STEM field. Moreover, she was not intrinsically motivated to engage in STEM, nor did she foresee any advantageous future outcome by pursuing STEM. Thus, she did not have any expectation for herself in the STEM field. Because her parents were not engaged in her education, she entrusted to the care of her academic interests to her teachers. However, teachers only paid attention to the top students or the students who decided to enrol in STEM. As both school and family failed to encourage her engagement in STEM, she lowered her expectations for her studies.

STEM Female Motivation

Regarding children's talent, parents provide boys and girls with different information and experiences, best education and career choices. For example, they provide girls with more opportunities for reading and social interaction with peers, and boys with more opportunities for exercise and calculation (Eccles, 1993). Parents also have very different attributions to the success or failure of their sons and daughters (Yee & Eccles, 1988). According to the expectancy-value theory (Eccles, 1983), the expectations of family have a comprehensive impact for understanding adolescents' social and academic experiences, values and beliefs, task-specific expectancy, and achievement behaviour.

Intrinsic and Extrinsic Motivation. To maintain one's motivation with a given task, it is ideal to be both intrinsically and extrinsically motivated. This was certainly the case for both April and May with regards to their decision to enrol in STEM.

April's Motivation. April not only expressed a genuine passion for STEM but also recognized the potential benefits she could derive from a career in STEM. For example, April reported that she took pleasure and found fulfillment in doing mathematical calculations. She saw math problems as puzzles or riddles and enjoyed solving them. In this way, STEM offered her a reprieve from her liberal arts classes, which she had an aversion to because they required that she memorize and recite content she did not find interesting. For extrinsic motivation, April was deeply influenced by her father's work. She saw that he had to put excessive hours into his job, but she also saw that he was able to provide for his family and give them a higher standard of living than she saw among many of her peers. As a result, she knew that a career in engineering would offer a high ceiling with respect to potential income and opportunities. Thus, though she knew she would have to invest significant time and effort, she likewise knew her investment would yield great rewards.

May's Motivation. May described a parallel experience with her engagement in biology. She found that she was interested in biology in junior high school, and she gradually believed that biology would be the focus of her future studies and career. May believed that people in biology will always be needed and will provide job security. For extrinsic motivation, she likewise mentioned that people in biology have an opportunity to make important social contributions to society that can save lives. As her parents also work in the STEM field, their encouragement made May determine to study biology.

Extrinsic Motivation. While both April and May were motivated both intrinsically and extrinsically to pursue their study in STEM, June was motivated exclusively by extrinsic factors. Growing up in a single-parent family provided June with harsh but practical life lessons. For example, she saw that a woman could not necessarily depend on a partner for her long-term security as her mother was left to her own devices

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following her divorce. Thus, June recognized the importance of being able to provide by herself. Moreover, she saw her mother work in the construction industry and achieve a lucrative financial return. Through that financial independence, her mother was able to get custody of her daughter and raise her on her own terms. During the interview, June did not express having an intrinsic interest in STEM, nor did she express that she took joy in studying or practicing STEM. However, she did expressly note that pursuing a STEM degree would put her in a position to obtain secure and profitable employment. The key takeaway from June's evidence is that female students who are not necessarily intrinsically motivated to pursue STEM studies can still be encouraged to do so based on external factors and rewards.

Implications

The findings of this study have some significant implication for future practice. Based on the current findings and literature review, the researcher has identified several key stakeholders: parents, female students, teachers, schools, and, more broadly speaking, society. To ensure the female Chinese students have an equitable opportunity to engage with STEM, each stakeholder should consider how they can create opportunities to promote gender equity in STEM.

Parents

The findings of this research indicate that there is a relationship between how parents respond to gender stereotypes associated with STEM and whether their daughters will eventually enroll in STEM studies. If parents want their daughters to fulfill their potential and choose an academic discipline that is most suitable for them, it is critical that they understand how their framing of STEM can impact how their daughters perceive STEM. For example, if parents tell their daughters that girls are inherently bad at STEM and that boys are inherently superior with regard to STEM, their daughters are likely to trust that position and in turn accept any struggles in STEM as a validation of their parents' biases. They will accept that they are innately enabled to succeed in STEM. Conversely, if parents highlight the fallacious nature of gender stereotypes, then their daughters will be more likely to apply themselves in the STEM fields and succeed.

To address this there are several strategies and approaches that parents can use to ensure that their daughters' academic choices are not based on inaccurate and harmful gender stereotypes. These approaches and initiatives could include introducing their daughters to STEM through play during childhood, teaching their daughters about the fallacious nature of the biases that some people hold, teaching their daughters that the struggles they may encounter in STEM are universal and not unique to females, and offer support when they are struggling in STEM.

STEM Play

Early exposure to STEM can ensure that children have the confidence to engage in STEM, and one of the most effective ways to achieve this is through play. For example, Campbell, Speldewinde et al. (2018) report that, if children have enough experience to help them develop understanding of STEM in early childhood, they will often have more self-belief in their ability to learn STEM, especially science and mathematics. This is consistent with April, who mentioned that her father asked her to read science books when she was young. They also report that STEM play games and themes can help increase children's intrinsic interest in STEM and in turn could promote children's future engagement in STEM studies. Unfortunately, none of the liberal art participants mentioned that they had any opportunity to take part in STEM play in their childhood. Thus, parents should support and encourage girls by providing more opportunity to engage in STEM play. This could include activities such as building battery-powered motors, crafts that feature building materials such as pipe cleaners, and LEGOS, each of which Rushton and King (2020) found could help create STEM spaces that are gender inclusive and promote free-choice.

Deconstructing Biases

Clearly deconstructing gender biases in STEM can help young girls navigate and overcome these biases when they encounter them (Moss-Racusin et al, 2015). Carnes et al. (2012) and Prochaska et al. (2006) found that awareness of bias was essential for bias-reduction in STEM. This is consistent with May, whose parents held her to a high academic standard because they realized the impact of gender biases in the society and wanted to prepare May to thrive in academic and professional environments that may not treat her equitably. Unfortunately, some parents adopt and reinforce gender biases and tell their daughters that STEM is for boys exclusively. Therefore, parents should be aware of the biases and teach their daughters to be properly aware of the existence of gender bias in STEM. Parents should likewise teach their daughters to distinguish when they hear other people discourage their passion in STEM. Moreover, when their daughters encounter criticisms and struggles associated with their STEM studies, parents should teach their daughters that everybody struggles with STEM and that their struggles are not inherently because of their sex/gender.

Parental Participation on Student's Study

Parental involvement has a positive influence on students' academic achievement (An et al, 2019; Fan & Chen, 2001; Lam, & Ducreux, 2013), especially in individual STEM subjects (Tan & Goldberg, 2009). An et al. (2019) report that emotional participation has the greatest impact on children' STEM academic achievement and can compensate for the negative effect brought about by some adverse family factors. This was consistent with April, whose parents provided support and mentorship to her regarding her STEM studies. Eventually, April would go onto pursue a doctorate degree in a STEM field. Inversely, Amber's parents neglected her studies, both by failing to help her directly with her studies and by failing to get her a tutor. Amber eventually chose no to pursue studies in a STEM field. This pattern is consistent with current literature, which suggest that when parents get involved in their daughters' academics, it can promote higher level of achievement in STEM. Thus, parents should make the effort to take time out and help their daughters with the STEM homework. In this context, it is important to note that some parents may be more adept at this than others. For instance, An et al. (2019) note that parents' education level is correlated with higher level of academic achievement in STEM (An et al., 2019). Thus, if parents do not have an adequate understanding of STEM to help their daughters personally, they might consider hiring tutors instead. Thus, parents should pay attention and involve positively on their children study. They should also offer tutorial support when the daughter is strong with STEM. This is vital because emotional participation and support of young girls' academic studies can encourage and promote their free choice in their academic studies.

Self-efficacy by Parents' Impact

Self-efficacy has been identified as a major influence on students' goals, attainment, performance, and persistence when difficulties arise (Pajares, 2005). Among students in STEM programs, Rittmayer and Beier (2008) found that students with high STEM self-efficacy perform better and persevered longer in STEM fields on average than students who has lower self-efficacy with respect to STEM. This is consistent with April, May, and June, who expressed confidence in their abilities to succeed in STEM and who eventually enrolled in post-secondary STEM programs. May and April, in fact, eventually enrolled in graduate programs, and April even entered a doctoral program. Thus, each persevered in STEM programs past high school. Their self-efficacy seemed to be facilitated by their parents. For example, June's parents held her to a high academic standard and reassured her that she could achieve the standards they set. Inversely, Coral's father persuaded her to give up the STEM studies because he believed that only boys have the talent to study STEM, even though Coral was doing very well in STEM at the time. Despite her strong early performance in STEM, Coral eventually lost confidence and demonstrated low self-efficacy and discontinued her STEM studies in grade 10. Her father's criticism seemed to inhibit her self-efficacy with respect to STEM.

Thus, parents must be hyperaware that they play a central role in promoting STEM self-efficacy among young female students. If parents tell their daughters that they are inherently bad at STEM, it can have a negative impact on self-efficacy. Thus, parents should articulate to girls that their struggles experience are just part of the learning process. Parents should also reaffirm to girls that they can achieve it as long as they put the work in. This can promote STEM self-efficacy among young female students as they will see their struggles as a natural part of the learning process rather than the result of their innate inability to succeed in STEM.

Teachers

Teachers have the power to both encourage and discourage young female students from engaging in STEM. Thus, it is critical that they practice behaviours that create an open and gender-inclusive STEM learning environment and avoid engaging in behaviours that promote gender stereotypes.

Promoting Gender Inclusive STEM Learning

Educators can design instruction and activities to help educate pre-service and in-service teachers about sociocultural influences (Campbell, Pulse et al., 2018). Starting from primary school, teachers should combine STEM learning and play. Boys displayed higher overall levels of science interests than girls (Leibham et al., 2013). Thus, teachers should pay attention on observation and discovery for girls' interest, and then, give boys and girls different play in STEM guidance based on their different interests. For example, girls might be interested in fashion, beauty, and baking, which are stereotypically associated with femininity and which girls are often socialized to take an interest in. Therefore, teachers can make math lessons about measurements and about dimensions that are associated with fashion, such as designing a dress, or teachers can also make chemistry lessons about how cosmetics be made or how to bake certain foods. When applying these strategies, it is important for teachers to recognize that they must not reinforce gender stereotypes, and also encourage girls to take an interest in the ways that STEM applies to topics that are culturally described as masculine. The goal is not to reinforce gender stereotypes but simply to ensure that all students—whether then personal interests are associated with culinary arts, fashion, mechanics, or some other hobby—are able to see the value of STEM as it applies to their lived experiences.

Avoiding Harmful Gender Stereotypes

Teachers need to be aware that giving preferences to boys can shape the way girls perceive their engagement with STEM. Campbell, Pulse, et al. (2018) found that, when teachers promote stereotypical characterizations, they inhibit women and girls' engagement with STEM. This is consistent with Coral, her high school physical teacher was criticized that she was a stupid student in physical study, although she tried her best on physical study and got a medium grade in her class.

Based on the teacher's authoritative role play that takes place when children are in school, teachers should be aware of the impact of their potential biases. For example, Ertl et al. (2017) report that attributing girls' achievements to talent instead of assiduousness can corrupt girls' study confidence and positivity. If the teacher tells a male student that he is good at math, it implies that one needs to be innately good at math in order to succeed, which will reinforce the stereotype that certain people are good at math and others are not and that if somebody is struggling, they simply cannot succeed. Thus, teachers should focus on the means through which students achieved an end. For example, teachers should praise a student's effort and dedication to study and correlating that with their results rather than simply saying they're good, which will reinforce to all students that it is the effort one applies to the subject that leads to the success and not innate ability.

For example, if a teacher tells a male student that he is good at math, female students may perceive math proficiency as an innate talent and may believe that such talent is needed to succeed in math. While suggesting that somebody is 'good at math' may increase the likelihood of that individual taking the subject, it could inversely discourage others from pursuing the same line of study. In contrast, when feedback relates to the way that a person went about the task and focuses on their controllable efforts, if can have more positive outcomes.

If it is thought that innate talent is needed to succeed in a subject, then perhaps this form of feedback may discourage young people from taking it. This was consistent with all STEM participants' experiences. Their high school teacher would say that girls should play harder on STEM then boys repeatedly. Thus, teachers need to be aware of the ways in which they offer criticism to boys and girls and be conscious of whether they are treating them differently. And they should change this mindset to avoid giving girls a negative impact on their STEM study. Teachers need to be aware that parents and peers can reinforce negative stereotypes about gender and STEM fields. They should provide students with classes that highlight these biases and explain why these biases are untrue so that girls will still feel empowered even when they come across the biases

Educational Institutions: Role Modeling in STEM

Educational institution should be aware of how role models can influence students' learning behaviours. Learning from role models occurs through observation and reflection and is a mix of conscious and unconscious activities (Epstein et al., 1998). Educational institutions could help all students, regardless of gender, to have active role models whose behaviours they can observe and learn from. The role model could be the person in their daily life, STEM teachers, or family members who are in the STEM field. It is vital to be aware of the influence potential role models may have because observed behaviours are often unconsciously incorporated into the belief patterns and behaviours of students (Cruess et al., 2008). In addition, extra time for reflection and discussion should be added in courses. Students of all genders should make use of this time to debrief and discuss what they observed about these STEM role models. Moreover, it is important to make a conscious effort to articulate what the education institutions are modelling.

Students

With the exception of Amber, none of the participants reported that their decision to study either the liberal arts or STEM was influenced by their peers; however, this is an important factor to take into consideration. According to Eaton et al. (1991), peer acceptance is a central concern in adolescence, and this is supported by Nilanjana and Jane (2014), who found that same-sex friends' interest influences adolescent girls' pursuit of STEM. This is consistent with Amber, who said that she never thought about to studying STEM because all her friends chose to study liberal arts. In this context, it is clear that Amber wanted to conform to her peers, and this highlights the potential influence that peers' behaviors can have on others. Thus, it is important that students recognize the importance of developing a circle of friends who have a broad range of interests that include not only arts but also math and science. This means that students should embrace peers who study STEM, even if they prefer the liberal arts and vice versa. It is also important that young female students be aware that they do not have to make decisions that conform to those made by their peers and that they should follow a path that they find to be intrinsically fulfilling. However, youth are not always conscious of how peers and the desire to conform shapes their decision-making process. It is therefore critical that parents and teachers take on an active role in teaching young female students about this, and parents especially should encourage their daughters to have a diverse group of friends and instil them with the confidence needed to make decisions based on what they need and want rather than what they might think would help them conform with their peers.

CHAPTER SIX: CONCLUSION

To address China's gender gap in STEM, it is critical to explore and understand the social, cultural, and individual factors that have shaped this phenomenon and develop initiatives to promote equity in STEM. To this end, the current study seeks to understand the social and cultural factors that have shaped this gap and develop interventions that can empower young female students to enjoy and pursue an education and career in STEM. To achieve this, the study posed two core research questions:

1. How do experiences in education (e.g., school, extracurricular classes, private educational institution) shape female Chinese students' perceptions of their STEM abilities?
2. What social and cultural factors, influences, and expectations are given consideration by female Chinese students when deciding whether to enroll in STEM programs, and how do they shape this decision?

Background and Trends

Based on a review of current literature, there are several critical trends to consider with respect to China's gender gap in STEM. For instance, a number of studies outline the factors that can inhibit female students' engagement with STEM, while other studies outlined the factors that can facilitate female students' engagement in STEM.

Inhibiting Engagement in STEM

Current research has highlighted three key factors that can inhibit young female students' engagement with STEM: exposure to negative stereotypes about gender and STEM, limited access to familial resources, and math anxiety. In China, although most mothers express egalitarian views about boy' and girls' rights and abilities abstractly, some of them still believe that it is useless to send girls to school because they will get married and leave home; thus, many believe that boys have great talent for math (Emily at al., 2009). This may expose young girls to negative stereotypes about gender and STEM. Moreover, based on some people's belief that men will see a higher financial return in their future, parents often invest more in their sons, rather than their daughters. This is problematic because, as Low (2015) notes, family resources are the vital to girls' academy development, and parents with less education often favour sons over daughters with respect to allocated familial resources, whether that includes financial support for tutoring services or the time that parents spend with children helping them with their studies. In addition, when girls are exposed to negative stereotypes about gender and STEM, it can foster math anxiety. Many studies have found that female students are more likely than male students to have mathematics anxiety and to suffer from this problem longer (e.g. Sass, 2015; Xie et al., 2019; Sondergeld et al., 2020).

Promote Engagement in STEM

In addition, multiple studies found that STEM role models have a positive impact on female enrolment in and the reduction of stereotypes associated with STEM (e.g., Microsoft, 2018; Young et al., 2013). Bamberger (2014) found that the female role model could increase enrolment in STEM generally speaking; however, she also found that, in some cases, female scientist role models could discourage female students' interest in STEM if the students attributed their mentors' success to innate ability. Because some students perceive the female STEM professional's performance as linked to an inherent talent and not as the result of their diligence, the mentees were less likely to be motivated to pursue STEM studies. This is consistent with the belief that math skills or STEM skills are innate and not developed.

Thus, in this context, which is also consistent with the participants, it is not enough to simply provide a role model but for the female student to be told and taught that that role model success is the result of her diligence and not the result of some innate ability that allowed her to succeed without trying.

Conclusion of This Study

There are few studies that have identified female students experiences with anxiety in STEM and how it shapes their choices regarding STEM, especially with respect to how family, teachers, and peers' influences promote or challenge gender stereotypes in STEM. To address these gaps the current study conducted qualitative research in the form of case studies and collected data via one-on-one interviews. The findings derived from these interviews outline several important trends with regard to how harsh criticism, education background of parents, and parents' level of education shape female students STEM engagement.

Demeaning feedback and girls' STEM

All participants in this study explained how demeaning feedback from teachers discouraged them from pursuing STEM studies. Whoever STEM or non- STEM girls believed their STEM study were affected more or less by the negative attitude from their teachers, parents, or other adults. Girls prefer to choose their study path way based on their subjects' performance, which means they want to get a higher score on college pass test to enter a better. However, the demeaning feedback which connect gender and STEM or cripple girls STEM confidence would cause girls' self-doubt and affect their attitude on STEM. For example, Coral was once told by her physics teacher that she was ungifted and stupid. Coral also received criticism from her parents, who told her that she did not have the talent needed for success in STEM studies. The negative attitude of adults on STEM would make girls more likely to drop out of STEM studies. April and June received teachers' negative feedback which connect gender and STEM, but not personal hard- working with STEM performance. Although they choose to study STEM, but they often give into self-doubt when they meet difficult in STEM study.

Parental Education Background and girls' STEM

With respect to the main research question regarding how social and cultural factors influence young female students' decisions to pursue STEM studies, the data demonstrated that the participants' decisions to enroll in STEM or liberal arts correlated with their respective families' positions on their abilities, whether that correlation be conscious, unconscious, or coincidental. Girls with at least one parent working in STEM are more likely to choose to study STEM. For example, those who enrolled in STEM had parents who supported their STEM studies and offered STEM role models: June was encouraged by her mother's work, April was shaped by her father's work, and May was influenced by her parents, who both worked in STEM fields. Inversely, lower career expectation from parents and gender stereotypes from the culture negatively impacted participants' achievement motivation. This is supported by the data, which demonstrate a correlation between parents' reinforcing gender stereotypes relating to STEM and whether or not the girls enrolled in STEM. This is supported by past research, such as Lee (2020), who found that parents' negative views of girls and STEM inhibited the likelihood that their daughters would enroll in STEM. The findings also agree with Heaverlo et al. (2013), who outline two patterns: (1) girls' learning experience between middle school and high school can have a significant impact on whether they choose to enter STEM field to study later in life, and (2) the outcome can be positive or negative for girls' motivation or neglect in STEM as it related to professional development opportunities for educators, awareness of STEM resources, careers of parents, and other additional STEM activities.

Moreover, parents' level of education can also impact girls' study pathway. In this study, all STEM girls' parents have college and bachelor's degree. In contrast, one liberal arts girl's parents only had primary education, one had parents who had a college degree, and one a father with a master's degree. This shows that the parents' who have average higher education's daughter are more likely to choose study STEM.

Limitation of the Study

To get in depth and thorough data within a qualitative context, it is critical to be able to develop a positive and meaningful rapport with the participants. However, due to COVID-related restrictions, the interviews for the present study were conducted online using applications, such as WeChat. This created barriers to developing a meaningful rapport. Moreover, when collecting data in a qualitative context, fieldnotes are an important source of data. For example, it is important to be able to observe and record participants' body language. However, while conducting interviews online, it is difficult to observe a person's body language. While conducting the interviews online, there were sometimes Internet connectivity issues. As a result, participants might not have understood my questions clearly and thus their answers may not have been as thorough as hoped. Likewise, the same Internet connectivity issues sometimes made it difficult to understand what participants were saying. However, the study did rely on member checking to verify that all transcriptions were consistent with the participants' intended meaning.

In addition, cultural barriers could impact data collection. Though China is a collectivist society, people do value the privacy and protect their family because filial piety is also a prized value in China. Thus, some participants may have been unwilling to share information about their family that could be construed as negative.

Moreover, many of the social structures that perpetuate sexism are learned implicitly; therefore, people may not be conscious of instances where social constructs of sexism have shaped or influenced their decision-making process. As a result, even if participants were influenced by sexist stereotypes, they may not be conscious of this influence and therefore are unable to explain how it shaped their decision-making process. Thus, the study can only observe whether there is a correlation between sexist stereotypes and whether one decided to enroll in STEM and not whether there was a causal relationship unless this was explicitly stated by the participants.

In order to allow participants to express themselves as clearly and articulately as possible, they were provided with a space in which they could draw on their native language to express themselves. These interviews were then translated into English, which created room for the content to be subverted by the translation process. Thus, special care was taken to ensure that the translations were consistent with the source material; most especially as it relates to two concerns: tense and colloquial phrases. As there is no tense in Mandarin, close attention was given to the temporal phrasing used to ensure that the text accurately reflected the source material. Likewise, colloquial phrases, which are often culturally unique, were either translated into literal expressions or parallel English expressions in instances where such expressions exist. In addition, to ensure that the translations were accurate, a copy of each translation was forwarded to the respective participants for member-checking purposes.

Additionally, since all participants are Chinese students studying in Canada, most of them come from relatively affluent families. This means that their families have economic resources to support their daughters' education. However, this is not the case for less affluent families in China, particularly those in areas that are socioeconomically disadvantaged, such as rural areas. As a result, female students in these areas may encounter additional barriers related to economics that significantly contribute to the gender gap in STEM and that were not identified in the current study's data. Likewise, most of the participants were from urban areas; thus, there is an underrepresentation of students from rural areas. In addition to potential economic factors, rural areas may also encounter geographic barriers as well as different cultural contexts that could likewise make contributions to the gender gap in STEM. As a result, the barriers identified in the current study are not a comprehensive representation of the issues contributing to China's gender gap in STEM.

Furthermore, there is some concern as to the diversity of the programs and disciplines represented among the liberal arts students in the study. Each of the participants who chose the liberal arts stream in high school were enrolled in education. Students from other liberal arts disciplines—such as philosophy, visual arts, English literature, and music—may have been able to offer additional perspectives on this topic. As a result, the current study was not able to offer data as to how students from such disciplines engaged with STEM and how their social experiences shaped their decisions to enroll in liberal arts. The reason for this bias was in part due to the fact that there are a limited number of female Chinese international students in these programs, and none of them volunteered to participate in the study. Thus, future research should seek to address this gap.

Future Research

The current study has identified some issues that may be contributing to the gender gap in the STEM field; however, there are some limitations to the current study that restrict the potential applicability of the findings in a broader context. To address potential gaps, future research should consider several different approaches.

Future Qualitative Research

The current study had no participants who were from rural areas or from less affluent families; thus, future research should adopt a similar model but one that focuses on participants from those populations. In addition, this case study that featured a one-time, one-on-one interview, which it only provides a hindsight snapshot of the students' experiences. Thus, future research should consider adopting a narrative and/or longitudinal model to get richer data. These studies might also interview participants' parents and their teacher to triangulate data.

In addition, future qualitative research could also examine the STEM gender gap among students from rural areas and could include teachers and or parents as participants in order to gather their perspectives. Moreover, longitudinal research could be done that assesses student's basic math and science skills in primary education and in early high school and then revisit whether they enrol in STEM programs or liberal arts programs. This research could ascertain whether girls who demonstrated early proclivity for STEM were able to maintain their high performance, if they ended up enrolling in a STEM program, and what factors were associated with the answer of these questions.

Future Quantitative Research

In addition to collecting qualitative data, it is also important to develop quantitative data; thus, future research could include a survey study that is designed to determine if there are correlations between certain phenomenon and female students' decision to pursue STEM. The questionnaire could include questions related to several of the phenomenon outlined in the current study, such as whether or not the student had one/both of parents who worked in STEM, whether the student had teachers who encouraged/discouraged them to improve their STEM performance, and whether they had parents who discussed the fallacious nature of or promoted sexist gender stereotypes and STEM. The data collected from such studies could help determine whether there are correlations between each of their answers and their decisions.

Future research can be conducted in China which would allow for broadening the sample size to make it more representative. Girls' educational pathways are inextricably linked to family factors. Remarkably, there still is a big gap between rural and urban areas; and developed and underdeveloped areas in China. If this study can be conducted in China in the future, different results may be found.

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APPENDICES

Appendix A: Invitation Letter

Email of Invitation Letter

Chinese Students Volunteers Needed for Research Study

The study is looking for volunteers who are Chinese international undergraduate female students to join. All participates will be required to complete a 30-45 minutes one-on-one, audio-recorded interview. All interviews will comply with the Research Ethics Board of University of Windsor-approved standards. Research participants will receive a $20 Hudson bay's gift card in appreciation for their time.

Contact: Yixin Qiao (Yishin)

Email: qiao115@uwindsor.ca

Appendix B: Consent to Participate in Research

University of Windsor

CONSENT TO PARTICIPATE IN RESEARCH

Title of Study: Chinese Female Students and the STEM Gender Gap: How Stereotype Threat and Expectancy Value Shape Performance and Engagement

You are asked to participate in a research study conducted by Yixin Qiao from the Department of Education at the University of Windsor.

If you have any questions or concerns about the research, please feel to contact the investigator through **qiao115@uwindsor.ca**.

PURPOSE OF THE STUDY

1. Explore social institutions shaped female Chinese students' perceptions of their STEM abilities.

2. Explore what factors do female Chinese students consider when deciding whether to enrol in STEM programs.

PROCEDURES

If you volunteer to participate in this study, you will be asked to:

1. Conduct a one-on-one interview with the researcher.

2. Understand that the interview will be audio recorded.

3. The interview will be around 45 minutes.

POTENTIAL RISKS AND DISCOMFORTS

If you volunteer to participate in this study, you may:

1. Feel uncomfortable when you are not able to understand the researcher's question

2. Feel embarrassed when you will be asked questions about privacy experience, the recall may about your unpleasant memory.

POTENTIAL BENEFITS TO PARTICIPANTS AND/OR TO SOCIETY

The benefits to the participants are (1) help them to understand themselves in their study field. For these university students, they will basically know how to do a study by interview in qualitative method. (2) This research may raise participants awareness about gap of STEM.

COMPENSATION FOR PARTICIPATION

The participant will receive a gift ($20) card from researcher. Only if they complete all the interview and data analysis, they will get the gift card.

CONFIDENTIALITY

All identifying data will be collected and the participants will not be anonymous to researchers. Only researchers will be involved in the interviews and analyse participants' data. All participants will be anonymous in thesis result. All record of interviews will be kept in researchers' personal laptop and will not be shared, and participants have right to review or edit the record. When completion this study, the thesis will be published on Scholarship at UWindsor. Participants' data will be published anonymously.

PARTICIPATION AND WITHDRAWAL

Participants have right to withdraw. However, after completion of the interview, participants will no longer be able to request to withdraw their data. After completion of the interview, participants will no longer be able to request to withdraw their data. Participants will receive a $20 gift card after they complete the interview.

FEEDBACK OF THE RESULTS OF THIS STUDY TO THE PARTICIPANTS

Participants will find the study result on the website of scholarship of Windsor.
Website address: https://scholar.uwindsor.ca/research-result-summaries/
Date when results are available: ___January 31, 2021________________________________

SUBSEQUENT USE OF DATA

These data may be used in subsequent studies, in publications and in presentations.

RIGHTS OF RESEARCH PARTICIPANTS

If you have questions regarding your rights as a research participant, contact: The Office of Research Ethics, University of Windsor, Windsor, Ontario, N9B 3P4; Telephone: 519-253-3000, ext. 3948; e-mail: ethics@uwindsor.ca

SIGNATURE OF RESEARCH PARTICIPANT/LEGAL REPRESENTATIVE

I understand the information provided for the study **[*insert title*]** as described herein. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

____
Name of Participant

______________________________________ ____________________
Signature of Participant Date

SIGNATURE OF INVESTIGATOR

These are the terms under which I will conduct research.

_____________________________________ ____________________

Signature of Investigator Date

Appendix C: Questionnaire

Interview Questions

For three STEM students

1. What are you studying in the university?

2. Why did you choose your major?

3. Do you enjoy your major?

4. What's your parents' expectation of your study for you during you grew up?

5. Did you ever experience mathematics anxiety in school?

6. If so, what did you do when you faced mathematics anxiety?

7. What does STEM mean for you?

8. Did anyone influence you to consider STEM when you were in secondary school? What did they say?

9. Did you ever receive any encouragement or discouragement from parents/teachers/mentors regarding to choosing STEM as your major?

10. If so, did they ever link STEM to gender?

11. Did they equally treat boys and girls regarding STEM?

12. Did you have any unfair experience with peers when you faced STEM challenges?

13. Would your teachers suggest different disciplines between male and female when they have similar problem on STEM's study?

14. Did your teachers ever suggest anything about pursuing a career in STEM or non-STEM?

15. Do you think your teachers reinforce or challenge gender stereotypes?

16. What are your parents' educational backgrounds?

17. Are you from urban or rural China?

For three non- STEM students

1. Are you from urban or rural China?

2. What are you studying in university?

3. Are you enjoy your major?

4. Why did you choose your major?

5. What's the parents' expectation of your study and career for you during you grew up?

6. What is your parents' education background?

7. What is STEM means for you? (confidence/ enjoy/ no confidence/ self - doubt/ don't like…) Do you like it?

8. What are some of the reasons that you chose to study the humanities?

9. Do you have mathematics anxiety when you were in secondary school?

10. What did you do when you faced mathematics anxiety in secondary school?

11. What kind of encouragement or discouragement did you receive from adults/mentors/guidance counselors when you study STEM?

12. Did they ever make links between gender and STEM or non-STEM?

13. Did any of these people encourage or discourage to consider STEM when you were in secondary school? How did they say?

14. Did you have any unfair experience with peers when you faced STEM challenges?

15. Did teachers reinforce/challenge gender stereotypes?

16. What disciplines did teachers male/female friends choose when you have same STEM study problem?

17. What did teachers or parents say about pursuing a career in STEM and non-STEM?

VITA AUCTORIS

NAME: Yixin Qiao

PLACE OF BIRTH: Jingzhou, Hubei, China

YEAR OF BIRTH: 1994

EDUCATION: Huanggang Normal University, B. A., Huanggang, Hubei, China, 2017

University of Windsor, M. Ed., Windsor, ON, 2021