Dean&Francis

ISSN 2959-6149

Exploring Internal Factors of Gender Disparity in STEM Courses and Majors: A Case Study of Hong Kong

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Abstract:

STEM education plays a crucial role in developing innovative solutions to complex global challenges, yet women remain significantly underrepresented in these fields, particularly in colleges and universities. According to the National Center for Science and Engineering Statistics, while women comprise over 50% of college students, they represent only 20% in engineering and 19% in computer science of the STEM workforce, highlighting a significant gender gap in STEM courses and majors. (NCSES, 2023).This study examines the psychological and social mechanisms underlying female underrepresentation in STEM education in Hong Kong, specifically focusing on class and major enrollments. By reviewing academic literature and survey data, the study identifies three critical internal factors that contribute to this specific gender disparity: negative self-perceptions fostered by traditional gender stereotypes, diminished sense of belonging due to the underrepresentation of female role models, and reduced interest in STEM subjects stemming from internalized societal expectations. Through examining these interconnected psychological barriers, this study provides insights into how gender stereotypes are internalized and shape female students' academic choices suggesting possible interventions to create a more inclusive STEM educational environment in Hong Kong.

Keywords: Gender disparity: STEM, class and major enrollment, female underrepresentation, educational barriers, role models

1. Introduction

STEM is an educational approach consisting of four subjects: science, technology, engineering, and mathematics. Rather than treating these disciplines as separate domains, STEM emphasizes their integrated application in addressing global challenges. Studies demonstrate that integrated STEM education has significant economic implications. According to the U.S. Bureau of Labor Statistics (2023), 75% of the fastest-growing occupations require comprehensive STEM skills across multiple disciplines, and professionals with integrated STEM expertise earn starting salaries 26% higher than those with single-discipline specializations. Given STEM's crucial role in driving innovation and economic growth, governments and institutions worldwide have prioritized STEM education through increased funding and initiatives, with global STEM education spending reaching $385 billion in 2021 (World Economic Forum, 2022). However, women remain significantly under-represented in STEM, comprising only 28% of the workforce in science and engineering positions globally (UNESCO, 2021). This gender disparity is particularly pronounced in fields such as computer science and engineering, where women represent merely 25% and 15% of the workforce, respectively (National Science Foundation [NSF], 2022). This underrepresentation suggests that despite STEM's critical importance and growing opportunities, significant barriers continue to prevent women from fully participating in these essential fields.

While external barriers such as institutional biases and workplace discrimination play important roles in creating gender disparity, this study explores how internal factors affect women's underrepresentation in STEM, and how these factors interact with each other. Wang and Degol (2017) define internal barriers as individual psychological elements shaped by social expectations and self-perceptions. Recent studies have identified various internal barriers, including stereotype threat, belonging uncertainty, academic self-concept, and confidence-interest relationships (Ertl & Hartmann, 2019; Master & Meltzoff, 2020; Pietri & Ozgumus, 2020). These internal factors serve as primary determinants of female participation in STEM and contribute significantly to the persistent gender gap. However, there is an ongoing debate about the relative impact and interconnectedness of these invisible barriers. While some scholars argue that early socialization and stereotype threat are the primary drivers of gender disparity (Sebastián-Tirado et al., 2023), others contend that identity formation and role model effects may be more fundamental (Herrmann et al., 2016). Additionally, researchers continue to debate whether these psychological barriers operate independently or form self-reinforcing cycles that require holistic intervention approaches.

Building on this ongoing discourse, this research synthesizes these various perspectives by examining three key internal factors that consistently emerge across studies as fundamental to understanding gender disparity in STEM: (1) negative self-perceptions created by traditional gender stereotyping, (2) the lack of self-identity due to the under-representation of female role models, and (3) an overall lack of interest among women in STEM-related subjects, which may be influenced by the previous two factors. Given the complex interconnectedness of these psychological elements and their potential impact on female participation in STEM education, this study aims to provide a comprehensive understanding of how these barriers interact and reinforce each other, and it tries to investigate: What internal factors contribute to gender disparity in STEM enrollment, and how do these factors influence female students' decisions to pursue STEM classes and majors?

By addressing these questions, this study aims to challenge the traditional deficit-focused approach to gender disparity in STEM. Understanding interrelated internal factors is crucial not only for theoretical advancement but for transforming educational systems and institutional practices to nurture female students' STEM aspirations. This research ultimately seeks to contribute to creating sustainable pathways for women's increasing participation in shaping technological innovations and scientific discoveries in the near future.

2. Stereotyping and Self-Perception

Stereotyping and self-perception both play crucial roles in shaping women's participation in STEM fields. While stereotyping, defined as the process of attributing generalized characteristics to groups of people regardless of individual variations, affects women from an external perspective, it often transforms into internalized self-perception. This self-perception, defined as an individual's understanding and evaluation of their own abilities and characteristics (Pietri & Ozgumus, 2020), influences them from the inside. These psychological constructs interact to create powerful barriers to women's STEM engagement. Historically, females have been considered innately less capable in mathematical and logical thinking, a perception that continues to influence their participation in STEM fields (Master & Meltzoff, 2020). Social stereotypes often suggest inherent differences between males and females, but extensive neurobiological research showing no significant gender differences in STEM-related cognitive abilities, these assumed differences persist in shaping academic and professional environments. As Sebastián-Tirado et al. (2023) explain, the experimental activation of stereotypes about women's lower math capabilities can significantly affect their performance and persistence in STEM activities, highlighting the process by which stereotypes are internalized and affect academic outcomes.

Such gender biases manifest through traditional socialization practices that reinforce gender stereotypes from

ISSN 2959-6149

an early age. Those internalized beliefs, rather than actual abilities, significantly shape female students' academic choices regarding class and major enrollments. Pietri and Ozgumus (2020) found that by age 6.65% of girls have already internalized messages about STEM being "masculine" domains. Their longitudinal study revealed that teachers spend 39% less time engaging girls in complex mathematical problems and are 23% more likely to attribute girls' STEM successes to "hard work" rather than innate ability. Such gender stereotypes emerge early when society implicitly assigns different capabilities to boys and girls, associating mathematical and scientific aptitude with males while directing females toward more nurturing or humanities-focused pursuits (Ertl & Hartmann, 2019). Contemporary research by Herrmann et al. (2016) demonstrates how early experiences profoundly shape women's academic trajectories. Their longitudinal study revealed that female students exposed to strong gender stereotypes in elementary school were 42% less likely to enroll in advanced STEM courses by high school, an effect that persisted even when controlling for academic performance.

The deeply entrenched gender stereotypes end up leading to women's negative self-perceptions about their performance inSTEM. This psychological phenomenon often presents as "imposter syndrome," defined as persistent feelings of intellectual fraudulence despite evident success (Clance & Imes, 1978). While Cokley et al. (2015) first documented the prevalence of this syndrome among women in STEM fields, more recent studies by Chan and Wong (2022) have quantified its impact: 75% of female STEM students experience persistent feelings of intellectual fraudulence, compared to 45% of their male counterparts. These internalized beliefs create significant barriers, deterring many women with the capability to pursue advanced STEM courses in their lives.

Societal stereotypes and internalized negative self-perceptions greatly influence women's academic choices. Recent data from Hong Kong universities illustrates this impact: even when female students outperform their male counterparts in STEM-related examinations, they are 32% less likely to pursue STEM majors (Chan & Wong, 2022). Consequently, female students often underestimate their STEM capabilities and gravitate toward fields where they believe they are "naturally" suited to excel, perpetuating the gender disparity in STEM enrollment and participation.

3. Underrepresentation of Female Role Models in STEM

The persistent underrepresentation of women in STEM fields creates a self-perpetuating cycle that affects both current and future generations of female scientists and engineers. While women's participation in STEM education has shown modest improvements, with bachelor's degree attainment increasing from 25% in 1995 to 34% in 2019 (Pietri & Ozgumus, 2020), their representation dramatically decreases at each subsequent career stage. This attrition is particularly evident in leadership positions, where women occupy less than 15% of senior roles across academic and industry settings (Herrmann et al., 2016). This section examines how this underrepresentation manifests in both academic and non-academic settings, analyzing its impact on women's low STEM participation.

3.1 Underrepresentation in Academic Settings

Women's underrepresentation in academic STEM settings is evident at every educational level. At the undergraduate level, despite women comprising over 50% of college students overall, their presence in STEM majors is markedly low. Recent data reflects that women make up only 26% of degrees in mathematics and computer sciences and 24% in engineering at the bachelor's level. This trend of disparity persists into graduate education, where women earn 42% of mathematics PhDs and 35% of chemistry PhDs, but their representation drops significantly in fields like physics (20% of PhDs) and computer science (19% of PhDs) (National Science Foundation, 2023).

The academic career ladder reveals further attrition at a successive postdoctoral research stage. Among postdoctoral researchers in STEM fields, women represent 31% of positions, but this percentage drops significantly at faculty levels. Women hold only 15% of engineering faculty positions, with percentages ranging from 10% in mechanical engineering to 23% in biomedical engineering. In science departments, female representation spans from 16% in physics to 38% in biology. Most concerning is the severe underrepresentation in senior academic positions - women comprise only 12% of full professors in engineering and 18% in physical sciences (Master & Meltzoff, 2020). This pattern, often referred to as the "leaky pipeline," which is a metaphor describing how women drop out of STEM fields at higher rates than men as they progress through their academic careers, demonstrates how gender disparity worsens at each stage of academic advancement.

Furthermore, leadership positions in academic institutions show even starker disparities in gender representation. Women occupy only 36% of senior university positions, such as full professors, deans, and university leaders (Bothwell et al., 2022). Additionally, only two of the 42 federally funded research and development centers are directed by women (AWIS, 2023). This significant underrepresentation at decision-making levels has profound implications for institutional policies, resource allocation, and mentorship opportunities for female students and junior faculty.

3.2 Underrepresented in Non-academic Settings

Women's underrepresentation in professional STEM settings reveals a complex pattern of disparities across different career stages and sectors. At entry-level positions, recent data from Stem Women (2023) shows significant variation across fields: in technology, women comprise only 19% of software developers, 26% of data scientists, and 22% of artificial intelligence professionals. The engineering sector shows even greater disparities, with women making up only 8% of mechanical engineers and 13% of electrical engineers, rising slightly to 22% in chemical engineering and 34% in environmental engineering.

This gender disparity widens considerably at the management and executive levels. Herrmann et al. (2016) report that while women hold 25% of entry-level STEM positions in industry, they represent only 15% of senior technical roles and merely 9% of executive positions in STEM-focused companies. The "glass ceiling" effect is particularly pronounced in technology companies, where women occupy just 11% of corporate board positions and 8% of CEO positions in Fortune 500 tech companies. Also, the wage structure in STEM industries reveals another dimension of gender inequality. Chan and Wong (2022) document that even in equivalent positions, women earn an average of 82 cents for every dollar earned by their male counterparts. This disparity compounds over career progression: female STEM professionals receive 28% fewer promotions than their male peers within the first five years of employment, and their salary growth rate is 35% slower.

These disparities are further exacerbated by workplace culture and societal expectations. The persistent "ideal mother" stereotype continues to influence hiring and promotion decisions. According to Baird (2018), expectations that women should prioritize family responsibilities lead to discriminatory practices: hiring managers are 35% less likely to advance female candidates to senior positions, citing concerns about long-term commitment. This bias creates a self-perpetuating cycle where women's underrepresentation in leadership positions reinforces existing gender disparities and limits mentorship opportunities for emerging female STEM professionals.

It is not the inherent challenge of the work itself but rather the significant underrepresentation of female scholars in both academic and professional settings that deters girls from STEM majors. Herrmann et al. (2023) emphasize that "in male-dominated fields, the presence of same-sex role models is crucial for fostering a sense of belonging and professional identity" (p. 472). When female students routinely experience self-doubt caused by stereotypical gender beliefs, same-sex role models provide both psychological support and tangible evidence of possible success. Master and Meltzoff (2020) found that female role models are particularly effective because they facilitate authentic mentoring relationships and provide concrete examples of successful career trajectories in STEM fields.

This impact also extends to academic performance: David's study (2002) demonstrated that female teachers could positively impact girls' math test performance, not only through diverse pedagogical approaches but "particularly in situations where a negative stereotype about women's math ability is made salient" (p.1184). It proved that having female role models buffers the negative effects of stereotypical gender bias against girls. Thus, in a predominantly masculine environment that lacks same-sex role models, female students' negative self-perception deters their interest in STEM, thereby further decreasing their interest in studying STEM majors and the possibilities that they will enter the field.

4. Overall Lack of Interest in STEM Among Female Students in Hong Kong

Besides the institutionalized gender stereotypes and lack of female role models, the divergence of boys' and girls' own interests in STEM subjects could also lead to a wide gap within the STEM field. The apparent lack of interest in STEM subjects among female students may not emerge from their inherent preferences, but rather from external factors. Recent research reveals several critical factors that shape girls' engagement with STEM subjects during their formative years, particularly the influence of parenting styles (Master & Meltzoff, 2020), educational resources (Herrmann et al., 2016), and critical developmental transitions (Hughes, Nzekwe, & Molyneaux, 2013; Pietri & Ozgumus, 2020).

Parental influence and early socialization practices play fundamental roles in shaping girls' initial engagement with STEM subjects. Master and Meltzoff (2020) found that gendered parenting practices emerge as early as ages 4-6, with parents spending significantly more time on mathematical activities with boys than girls. Their longitudinal study revealed that parents unconsciously reinforce gender stereotypes through toy selection and activity choices, dedicating three times more STEM-focused interaction time to sons than daughters. Kang and Kim (2021) further documented how parents' implicit biases affect

ISSN 2959-6149

their expectations: despite equal performance metrics, parents consistently rated their sons' mathematical abilities higher than their daughters', creating an early foundation for differential STEM engagement.

Educational resource allocation and accessibility compound these early influences. Herrmann et al. (2023) identified systematic disparities in STEM education delivery, noting that female students receive significantly less hands-on experience in elementary school science activities and face reduced participation opportunities in middle school mathematics classes. These structural inequities often coincide with critical developmental periods when students begin forming academic identities and interests. As students transition into middle school, these early educational experiences can lead to a key point where girls' engagement with STEM subjects declines sharply. Hughes, Nzekwe, and Molyneaux (2013) identified this crucial phase, observing that it aligns with a period of increased sensitivity to social pressures and gender expectations. Pietri and Ozgumus (2020) expanded on this finding, demonstrating that girls' confidence in mathematical abilities often decreases during this period despite maintained or superior academic performance. This decline in self-efficacy not only reduces their participation in voluntary STEM activities but also increases their susceptibility to stereotype threats in classroom settings, reinforcing the cycle of underrepresentation in STEM.

5. Women in STEM: A Case Study of Hong Kong

Hong Kong's rapid development as a global financial center has created a unique educational landscape where traditional Chinese values intersect with modern professional demands. While the territory has made substantial investments in STEM education—with government funding reaching HKD 8.3 billion in 2022 (Education Bureau, 2023)—its gender dynamics in STEM fields reveal complex patterns of progress and persistent barriers. Deeply rooted gender norms, influenced by Confucian ideals and traditional expectations, continue to shape perceptions of appropriate career paths for women. These norms often position men as innovators and leaders in technical fields while steering women toward roles seen as more aligned with family responsibilities. This cultural backdrop contributes to a striking paradox highlighted by the University Grants Committee (2022): despite women comprising 53% of Hong Kong's university students and showing strong representation in some STEM areas (65% in biological sciences, 52% in chemistry), they remain significantly underrepresented in others (24% in physics, 25% in engineering, and 21% in computer science).

5.1 Gender Stereotyping and Self-Perception in Hong Kong's Context

Traditional Chinese values, particularly filial piety and gender norms, deeply influence female students' self-perception in Hong Kong's STEM fields. While Confucian ideals promote academic excellence, they often go against cultural norms, positioning women as caretakers rather than as innovators in science and technology. Therefore, this value is echoed within family settings, where women are often subtly discouraged from pursuing STEM careers based on the belief that these fields may not align well with familial responsibilities. Shen et al. (2019) illustrate how these norms shape gender roles and career aspirations, creating psychological pressures. Parents, as Lee and Wong (2020) reveal, often hold high academic expectations for daughters yet view STEM as better suited for males, fostering self-doubt. This is further evidenced by Chan and Wong (2022), who find that high-performing female STEM students in Hong Kong frequently underestimate their abilities and report heightened anxiety, reflecting the profound impact of traditional norms on self-perception.

5.2 Role Model Underrepresentation in Hong Kong's STEM Fields

The lack of visible female leaders and mentors discourages younger women from pursuing or persisting in STEM careers, creating a self-perpetuating cycle of underrepresentation in Hong Kong. This pattern is clearly demonstrated in Hong Kong's universities: While initial university enrollment shows women comprising significant percentages in some STEM fields (65% in biological sciences, 52% in chemistry), these numbers sharply decline along the career pipeline. Herrmann et al. (2016) found that only 42% of female STEM graduates in Hong Kong enter STEM careers, compared to 68% of their male counterparts. Even in biological sciences, where women dominate undergraduate enrollment, only 31% of senior research positions and 28% of biotechnology industry leaders are women. The professional sector shows similar attrition, with women holding only 18% of senior STEM positions in technology companies and 15% in engineering firms (Yeung & Li, 2023). This underrepresentation is particularly impactful in Hong Kong's cultural context, where mentorship and professional networks are vital for career development. Chan and Wong (2022) found that female STEM students with access to same-gender mentors were three times more likely to persist in their chosen fields and reported significantly higher levels of career confidence. The scarcity of female role models thus places women at a distinct disadvantage in a culture that heavily relies on guidance and sponsorship for career progression. Without visible same-sex role models, many women lack the encouragement and support necessary to envision and achieve long-term careers in STEM, further reinforcing the systemic cycle of underrepresentation.

5.3 Lack of Interest in Hong Kong's Education System

Hong Kong's education system, known for its highly structured curriculum and intense examination culture, significantly influences the STEM interest development among female students. Yeung and Li's (2023) analysis of Hong Kong Diploma of Secondary Education (HKDSE) results revealed that while girls perform comparably or better than boys in early secondary science and mathematics, only 34% opt for physics by the 4th year, compared to 68% of male students. This suggests that the examination-focused environment encourages strategic academic choices that align with gender expectations, often steering girls away from STEM despite their capabilities. Chan and Wong (2022) further illustrate that despite girls' strong performances, they are 38% more likely to select humanities subjects, perceived as "safer" choices for university admission. This strategic shift away from STEM is exacerbated by parental investment practices. Tam (2021) notes that parents spend 42% more on mathematics and physics tutoring for sons than for daughters. This differential support not only impacts young women's immediate educational choices but also shapes their long-term career trajectories in STEM fields. Together, these elements form a barrier that not only discourages female students from pursuing demanding STEM subjects but also perpetuates gender disparities within these fields.

6. Conclusion

The University Grants Committee (2022) highlights that despite high academic achievement in mathematics and the sciences, female enrollment remains low in engineering (25%) and computer science (21%). This discrepancy reflects the persistent impact of traditional gender roles and cultural expectations within contemporary education. This research explores the internal factors contributing to gender disparity in STEM within Hong Kong, focusing on negative self-perceptions, the underrepresentation of female role models, and a generally low interest among women in STEM-related subjects. The study aims to identify these barriers and has successfully provided actionable data that highlight the urgency of addressing these issues.

The findings indicate significant academic and practical implications, emphasizing the need for a comprehensive approach to reform the education system in Hong Kong. The implications extend beyond academia, suggesting that the Hong Kong government should increase funding for female-centric STEM initiatives and consider quotas for women in senior academic and industry roles. Additionally, industry leaders must commit to equitable hiring practices and adopt family-friendly workplace policies that accommodate the unique cultural context of Hong Kong. Addressing these recommendations will require concerted efforts from multiple stakeholders, including educational authorities, government bodies, and industry leaders, to dismantle the systemic barriers that perpetuate gender disparity in STEM fields in Hong Kong.

However, the research is limited by a lack of empirical investigation into individual experiences, which could provide deeper insight into the personal and social dynamics at play. Therefore, future research should explore the effects of specific interventions, such as targeted mentorship programs and the recruitment of female STEM faculty, to determine their efficacy in more complicated contexts. It is also imperative for educational institutions to adopt systematic changes, including the revision of career counseling methods to ensure equal access to STEM opportunities for all students.

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