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The influence of gender stereotypes on self-efficacy and mathematical anxiety in Peruvian students aspiring to STEM careers

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Abstract

Despite increasing global efforts to promote gender equity in education, gender stereotypes continue to pose significant barriers to female students' engagement and achievement in mathematics, particularly within pathways leading to STEM careers. Prior studies have established the detrimental effects of such stereotypes, yet there remains a limited understanding of the mediating role these beliefs play in the relationship between mathematical self-efficacy and mathematics anxiety, especially among pre-university students in developing countries. Addressing this gap, the present study investigates the mediating influence of gender stereotypes on the link between self-efficacy and mathematics anxiety among Peruvian pre-university students pursuing STEM-related fields. A total of 304 participants (116 males and 188 females), aged 16 to 35, were drawn from science (n = 38), technology (n = 26), engineering (n = 142), and mathematics (n = 98) disciplines. Quantitative analyses revealed that female students reported significantly higher levels of perceived gender stereotype threat, lower mathematical self-efficacy, and elevated mathematics anxiety compared to their male counterparts. Mediation analysis further demonstrated that stereotype-induced identity threat undermines self-efficacy, thereby intensifying anxiety related to mathematics. However, the study acknowledges limitations, including gender and field imbalances within the sample and the limited scope of variables examined. These findings underscore the urgent need for educational interventions that address stereotype threats and foster equitable learning environments. The results contribute to the broader discourse on gender equity in mathematics education and inform strategies to support female students' sustained participation in STEM trajectories.

Keywords: Gender Differences, Math Achievement, Math Anxiety, Mathematics Self-Efficacy, STEM Education

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Globally, the gender gap in science, technology, engineering, and mathematics (STEM) fields remains a persistent and well-documented issue (Freedman et al., 2023; Zając et al., 2024). Women continue to be underrepresented in STEM education, accounting for only 35% of STEM graduates—a figure that has remained stagnant for over a decade (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2025a). This disparity extends beyond the educational domain and into the professional realm, where women encounter significant barriers to employment and advancement in STEM careers (McNeill & Wei, 2023). Although regions such as Latin America and the Caribbean, followed by Europe and Central Asia, report relatively balanced enrollment rates between genders in STEM education, women remain significantly underrepresented in positions of scientific leadership and management (Correa et al., 2025). In response to these challenges, UNESCO (2020) has initiated global research to identify the root causes of gender inequality in STEM careers. It has also implemented advocacy efforts, such as establishing the "International Day of Women and Girls in Science," to encourage greater female participation in STEM disciplines (UNESCO, 2025b).

These efforts align with broader international goals, including the promotion of social justice and the fulfillment of the 2030 Agenda for Sustainable Development, particularly Sustainable Development Goals (SDGs) related to quality education and gender equality (Organization for Economic Cooperation and Development [OECD], 2023; UNESCO, 2023). Despite these initiatives, one of the most persistent barriers remains the prevalence of gender stereotypes, which are deeply rooted in educational and societal inequalities (Santana-Vega et al., 2023). Gender stereotypes contribute to negative academic self-perception among women, leading to increased anxiety in mathematics learning contexts (Justicia-Galiano et al., 2023), diminished confidence in scientific capabilities (Álvarez, 2017), and overall feelings of academic undervaluation (Gallegos et al., 2022). Consequently, these psychological and social constraints discourage women from pursuing careers in STEM fields (Xie & Liu, 2023), with evidence suggesting that gender stereotypes exert a particularly harmful effect on women's aspirations in science-related disciplines (Kasturi et al., 2021; Reiner, 2017).

Gender Stereotypes and Their Influence on Mathematics Learning

Gender stereotypes refer to socially constructed and typified behaviours associated with individuals based on their gender (González & Rodríguez, 2020). These stereotypes often attribute characteristics such as strength, courage, and intelligence to males—portrayed as the "stronger sex"—and qualities such as agreeableness and peacefulness to females—viewed as the "weaker sex" (Duarte & Machado, 2019). Such notions are internalized from early childhood (Conlon et al., 2023) and are further reinforced through educational experiences (Ross et al., 2023). For example, students frequently encounter the belief that "only male scientists are formally recognised for their work" (Ross et al., 2023, p. 243) or that "women are not good at math/science" (Xie & Liu, 2023, p. 1). These messages significantly shape students' self-perceptions and academic behaviours, particularly in science, thereby widening gender disparities in STEM fields (Deemer et al., 2016; Zając et al., 2024). Consequently, many girls and women are constrained by prevailing prejudices and sociocultural expectations, which influence both their academic subject choices (UNESCO, 2025b) and their performance in mathematics (Justicia-Galiano et al., 2023; Vos et al., 2023). These underscores growing concerns regarding the impact of gender stereotypes in mathematics education (Kasturi et al., 2021). These concerns are heightened by the fact that teaching mathematics effectively within STEM pathways poses a significant challenge for university instructors (Albeshree et al., 2020), especially given that mathematics constitutes a foundational component of all STEM disciplines (Mathieson & Homer, 2021; McAlinden & Noyes, 2019). As such, it is critical to investigate the root causes of difficulties in learning mathematics (Karagiannakis et al., 2016).

Addressing these issues necessitates a multifaceted exploration of mathematics education, including the influence of gender stereotypes (Czocher et al., 2019; Kasturi et al., 2021; Justicia-Galiano et al., 2023). First, during early education, students are exposed to a lack of visible female role models in mathematics teaching, which limits the normalization of women's participation in mathematical fields (Correa et al., 2025). Second, classroom interactions in primary and secondary education often favour male students, reinforcing the false perception that mathematics is more suited to males (Navarro et al., 2024; Xie & Liu, 2023). Third, by the end of secondary schooling, these stereotypes negatively influence female students' confidence and career decisions, discouraging them from pursuing STEM-related studies (Santana-Vega et al., 2023). Finally, at the tertiary level, there remains a low representation of women in high-ranking academic positions within scientific disciplines, which perpetuates implicit messages about gender roles through what is often described as a hidden curriculum (Pehlivanli-Kadayifci, 2019). This hidden curriculum further shapes students' perceptions of gender roles in science and engineering, contributing to inequities in mathematics learning outcomes (Vos et al., 2023).

Gender Stereotypes and Their Influence on Self-Efficacy and Math Anxiety

It is well established that gender stereotypes influence behaviour (Pehlivanli-Kadayifci, 2019), particularly affecting students' engagement and performance in STEM disciplines (Freedman et al., 2023; McNeill & Wei, 2023). These influences justify the growing academic interest in investigating how gender stereotypes impact mathematical performance (Justicia-Galiano et al., 2023). A key element in this context is the concept of the mathematical profile, which refers to a combination of cognitive and affective factors relevant to mathematics learning (Karagiannakis et al., 2016). Among these factors, mathematical self-efficacy plays a pivotal role, as it significantly shapes students' ability to learn and apply mathematical knowledge (Czocher et al., 2019; Lyakhova & Joubert, 2022).

The concept of self-efficacy originates from Albert Bandura's Social Cognitive Theory (Hackett & Betz, 1989). Initially introduced as general self-efficacy—referring to one's belief in their capacity to perform tasks (Bandura, 1997)—it later evolved into more domain-specific forms, including mathematical self-efficacy. This refers to a learner's confidence in their ability to understand and solve mathematical problems (Usher & Pajares, 2009; Kasturi et al., 2021). Empirical studies have consistently shown gender disparities in mathematical self-efficacy. For example, Peters (2013) found that male students in elementary education demonstrated higher levels of mathematical self-efficacy than their female counterparts, a pattern also observed in pre-university education in Peru.

Self-efficacy is thus critical for success in STEM fields (Czocher et al., 2019), yet it is negatively influenced by gender stereotypes (Arens et al., 2020). These stereotypes heighten mathematics-related anxiety and reduce confidence among female students (Justicia-Galiano et al., 2023; Vos et al., 2023). Conversely, students with high levels of mathematical self-efficacy tend to experience lower levels of math anxiety (Hiller et al., 2021). Math anxiety—defined as a feeling of tension or fear that interferes with mathematics learning and performance (Reiner, 2017)—is another central component of students' mathematical profiles. Studies have found that math anxiety is more prevalent among female students than males (Justicia-Galiano et al., 2023; Vos et al., 2023). This indicates a clear link between gender stereotypes, self-efficacy, and math anxiety (Arens et al., 2020; Al Umairi, 2024), thereby underscoring the importance of examining affective variables in mathematics education, especially during the critical pre-university stage (Lake et al., 2016). The pre-university period represents a transitional phase that bridges secondary education and university-level STEM programs (Lyakhova & Neate, 2021). Although female students in Peru perform similarly to males in mathematics assessments, pervasive gender stereotypes often erode their confidence in pursuing scientific disciplines (Iraola-Real et al., 2021; Mego-Sánchez et al., 2020). These stereotypes are rooted in long-standing cultural norms in Peru, where misogynistic attitudes continue to marginalize women's academic aspirations. Common perceptions include the erroneous belief that women's primary role is domestic, or that they are more suited to clerical tasks than academic or scientific pursuits (Gallegos et al., 2022). Such biases contribute significantly to the persistent underrepresentation of women in STEM careers in Peru (Medina-Neira et al., 2025). These beliefs discourage girls from engaging with mathematics, lowering their self-efficacy (Kasturi et al., 2021; Reiner,

2017) and increasing their susceptibility to math anxiety (Justicia-Galiano et al., 2023).

Study Objectives and Hypotheses

The present study aims to analyse the influence of gender stereotypes (gender identity threat) as mediators between self-efficacy and mathematics anxiety in Peruvian pre-university students pursuing STEM careers. Thus, the novelty of the present research is that it contributes to the study of gender stereotypes when studying science (Deemer et al., 2016) in a pre-university context in Peru, which is very little studied (Iraola-Real et al., 2022). According to the objective, the following hypotheses are intended to be confirmed:

1. Gender stereotypes (gender identity threat) are related to self-efficacy and mathematical anxiety in Peruvian pre-university students pursuing STEM careers.
2. In addition, gender stereotypes (gender identity threat) mediate the effects of self-efficacy on mathematical anxiety in Peruvian pre-university students aspiring to STEM careers.

METHODS

Design and Procedures

This study employed a quantitative research design incorporating exploratory, comparative, and predictive analyses to investigate the relationships among gender identity threat, mathematical self-efficacy, and mathematics anxiety in Peruvian pre-university STEM students. Exploratory data analysis (EDA) was initially conducted to identify general patterns and particular cases within the dataset (Hu, 2020). Box plot analyses were used to detect outliers and extreme values that may inform further research (see Figures 2 and 3). Subsequently, a comparative analysis was carried out to examine mean differences across gender groups for each variable, following the procedures outlined by Esser and Vliegenthart (2017). Correlational analyses were then conducted to determine the strength and direction of relationships between variables. Upon identifying statistically significant correlations, a predictive mediation model was proposed.

Multiple linear regression analyses were employed to test the proposed mediation relationships (Ali & Younas, 2021). The mediation model was examined using the Baron and Kenny (1986) approach within the Statistical Package for the Social Sciences (SPSS) software (IBM, 2023). The mediation procedure involved four steps: (1) regression of gender identity threat on self-efficacy, (2) regression of gender identity threat on mathematics anxiety, (3) regression of self-efficacy on mathematics anxiety, and (4) multiple regression including gender identity threat and self-efficacy as predictors of mathematics anxiety. These analyses tested the hypothesized mediating role of gender identity threat in the relationship between self-efficacy and mathematics anxiety.

Participants

A non-probabilistic convenience sampling method was employed to recruit 304 pre-university students enrolled in STEM programs (Stratton, 2021). The sample comprised 116 males (38.2%) and 188 females (61.8%), with ages ranging from 16 to 35 years (M = 19.64, SD = 3.94). Participants were distributed across various professional domains: science (n = 38, 12.5%), technology (n = 26, 8.6%), engineering (n = 142, 46.7%), and mathematics (n = 98, 32.2%).

Instruments

Due to the limited use of these instruments in Peruvian pre-university contexts, psychometric validation was conducted prior to analysis. Exploratory Factor Analysis (EFA) was applied to confirm the factor structure of each scale. The following instruments were used:

1. Stereotype Threat in Science Scale-Gender (STSS-G) (Deemer et al., 2016): This survey analyses how people perceive certain levels of threat when studying science because of their gender. The original scale has 7 items but, in this study, we use the sub-scale of the dimension called "gender identity threat in science" which has 4 items. For example, the fourth item indicates, "I am afraid that if I do poorly in this class, it will confirm the stereotype that members of my gender group cannot be good in science". Thus, the participant has 5 response options ranging from *strongly disagree* to *strongly agree*. As a first step, the sub-scale was validated by expert judgment (Colson & Cooke, 2018). In the process, teachers specialized in education and psychology were consulted after the application of the instrument, with Exploratory Factor Analysis (EFA). Thus, the results showed that in the Kaiser Meyer and Olkin test (KMO) and Bartlett's test was significant. That is, a KMO value of 0.70 (≥ 0.70 to be valid) was achieved (Field, 2018). Then, in the internal consistency analysis, Cronbach's Alpha coefficient (α) was 0.83 (≥ 0.70 to be reliable) (Conchado et al., 2017) (see Table 1).

Table 1. Instrument validity and reliability

Properties Analyzed	Validity		Reliability (α)	
Statistical analysis	KMO	Bartlett Test	Cronbach	Item-total
Optimal Values	≥ 0.70	$p < 0.05$	≥ 0.70	≥ 0.30
Gender Identity Threat in Science	0.70	0.000	0.83	0.62 – 0.71
Mathematical Self-Efficacy Scale	0.87	0.000	0.92	0.68 – 0.88
Math Anxiety Scale	0.88	0.000	0.89	0.40 – 0.78

Note: The Kaiser-Meyer-Olkin (KMO) value must be greater than or equal to 0.70 to be valid (Field, 2018). In addition, Cronbach's Alpha coefficient must be greater than or equal to 0.70 to show reliability (Conchado et al., 2017).

2. Mathematical Self-Efficacy Scale (Reiner, 2017): This scale assesses the degree of confidence students feel about their ability to learn and solve mathematical problems. This is an adapted version of 5 items. For example, the first item indicates, "I consider myself sufficiently capable to successfully cope with any mathematical task". Faced with these questions, the respondent can choose from 7 response options ranging from *strongly disagree* to *strongly agree*. Initially, the translation and adaptation processes were carried out based on judges' criteria (Colson & Cooke, 2018) (like the Stereotype Threat in Science Scale-Gender). After the application of the instrument, validity was performed, and adequate levels of validity were achieved. A KMO value of 0.87 (≥ 0.70 to be valid) (Field, 2018) was achieved, as well as adequate levels of reliability with a Cronbach's Alpha coefficient of 0.92 (≥ 0.70 to be reliable) (Conchado et al., 2017). This demonstrates that the scale is valid and reliable (see Table 1).
3. Math Anxiety Scale (Reiner, 2017): This scale analyses the levels of fear, tension or worry that students experience when studying mathematics. This is an adapted version of 7 items. For example, the fifth item indicates, "Mathematics makes me panic". Then, the respondent can choose from 7 response options ranging from *strongly disagree* to *strongly agree*. This was validated by expert judgment (Colson & Cooke, 2018). Then, the EFA was applied, achieving adequate levels of validity. The KMO value was 0.88 (≥ 0.70 to be valid) (Field, 2018). In addition, it was analyzed with the internal consistency method, showing adequate levels of reliability, with a

Cronbach's Alpha coefficient of 0.89 (≥ 0.70 to be reliable) (Conchado et al., 2017) (see Table 1).

Ethical Procedures

Ethical procedures were strictly followed throughout the study. All participants received an informed consent form outlining the voluntary and anonymous nature of their participation. The survey did not solicit personal identifiers, ensuring participant confidentiality. Moreover, students were informed of their right to withdraw at any time without penalty, in compliance with ethical research guidelines (Wolff-Michael & von Unger, 2018). The study adhered to Peru's Personal Data Protection Law (Law No. 29733). Special attention was given to the inclusion of students aged 16 and 17, who are considered minors under Peruvian law. However, according to the Peruvian Code of Children and Adolescents (Law No. 27337), individuals in this age group are recognized as having the autonomy to make decisions regarding their participation in research. Therefore, they were included in the sample with full ethical compliance.

RESULTS AND DISCUSSION

Gender Differences

After confirming the validity and reliability of the instruments, mean differences by gender were analysed. This analysis was performed with Student's *t*-test through which the differences that demonstrated significance values below 0.05 ($p<0.05$) were confirmed (see Table 2). This showed that females reported higher levels of feeling threatened because of their gender when studying science (*Mmen = 2.65, SDmen = 0.92; Mwomen = 3.11, SDWomen = 0.95; p < 0.01*). Next, males reported higher levels of mathematical self-efficacy than females (*Mmen = 4.84, SDmen = 1.33; Mwomen = 4.16, SDwomen = 1.46; p < 0.01*). In addition, females reported higher levels of math anxiety (*Mmen = 4.14, SDMen = 1.34; Mwomen = 4.97, SDwomen = 1.21; p < 0.01*).

Table 2. Group statistics by gender (female and male)

Variables	Gender	Mean	SD	*t*	Sig. *(p)*
Gender Identity Threat in Science	Men	2.65	0.92	-2.987	0.003
	Women	3.11	0.95	-3.006	0.003
Mathematical Self-Efficacy	Men	4.84	1.33	2.905	0.004
	Women	4.16	1.46	2.969	0.004
Math anxiety	Men	4.14	1.34	-3.951	0.000
	Women	4.97	121	-3.857	0.000

Note: The significance value of p ≤ 0.05 confirms statistical differences according to gender.

Exploratory Analysis

Once the mean differences between men and women were confirmed, exploratory analyses were performed. In this way, boxplots were applied to identify particular cases in relation to the response ranges of the scales. For example, Figure 1 analyses the threat of gender identity in the sciences. In this survey, the response options were 5 (1 strongly disagree - 5 strongly agree). In Figure 1, it is observed that 25% of the ***women*** (approximately 47) oscillate between values 4 and 5, which means that they "agree" and "strongly agree" that they feel threatened by stereotypes when studying science. Then, 50% (approximately 94) perceive themselves as "disagreeing" and "agreeing". In addition, 25% (approximately 47) of them "disagree". In the case of ***males***, approximately 75% (approximately 146) oscillate between values 1 and 3, indicating they "totally disagree" and are "undecided" in feeling this threat. An additional

25% (approximately 29) indicate being “undecided” and “totally agree”.

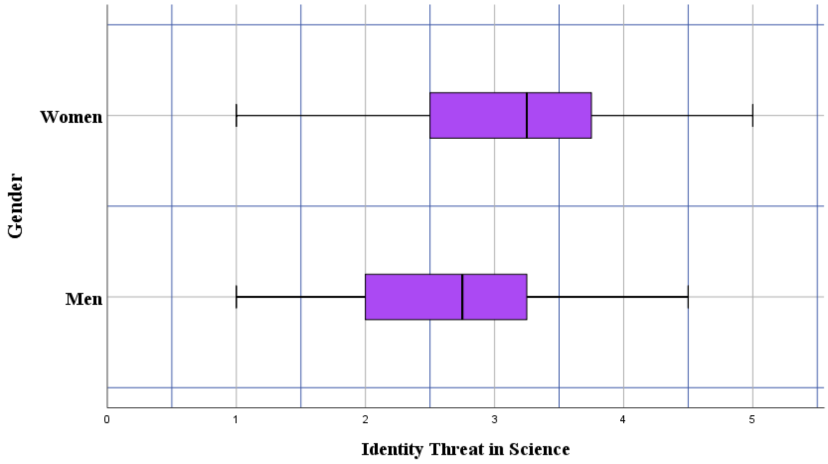

Figure 1. Boxplot of identity threat in science exploring the cases by gender

Figure 2 analyses mathematical self-efficacy. In this survey, the response options were 7 (1 totally disagree - 7 totally agree). Thus, it is observed that 25% of the ***women*** (approximately 47) oscillate between values 5 and 7. That is, they are in “relative agreement” and “totally agreement” in feeling confident to study mathematics. The remaining 75% (approximately 146) range from “relative agreement” to “totally disagree”. In the case of ***males***, approximately 50% (approximately 58) oscillate between values 5 and 7, showing that they are in “relative agreement” and “totally agree” in having confidence in their mathematical abilities. The additional 50% (approximately 58) range from “relatively agree” to “disagree”. In this gender, there are three outliers who “disagree” and “strongly disagree”.

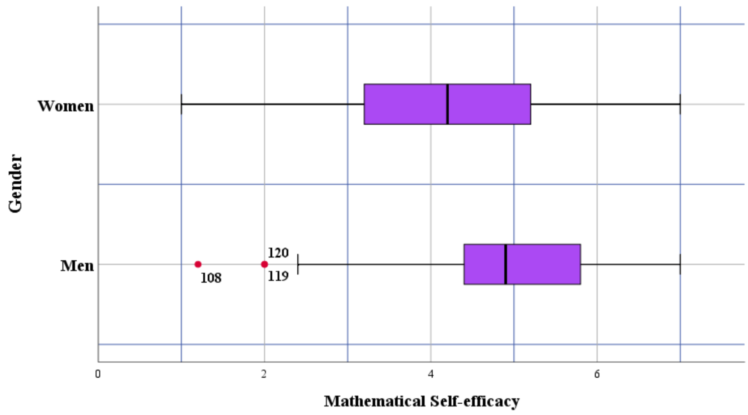

Figure 2. Boxplot of mathematical self-efficacy exploring the cases by gender

Then, Figure 3 analyses mathematical anxiety. In this survey, the response options were 7 (1 totally disagree - 7 totally agree). Thus, it is observed that 25% of the women (approximately 47) oscillate between values 6 and 7. This means that they “agree” and “strongly agree” in feeling fearful, worried and tense when studying mathematics. Likewise, 25% (approximately 47) are perceived to “relatively agree” and “agree”. 50% (approximately 94) of them are “undecided” and “in relative disagreement”. There are two atypical cases of women, who indicate that they are “in disagreement”. In the case of males, approximately 25% (approximately 29) “disagree” and “strongly agree” in feeling mathematical anxiety.

Then 50% (approximately 58) are in “relative agreement” and “relative disagreement”. Moreover, 25% (approximately 29) “totally disagree” and are “undecided”.

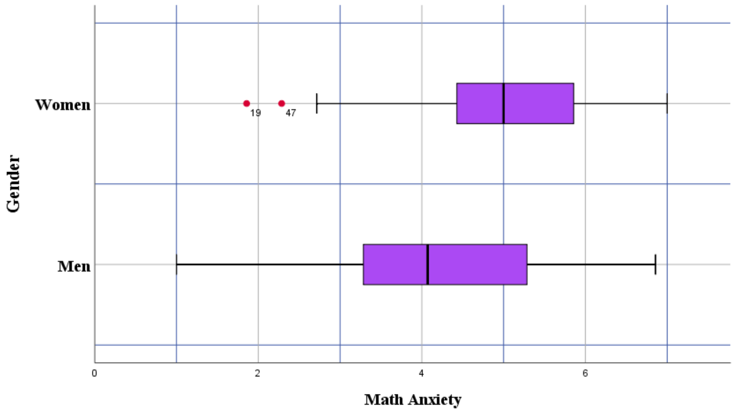

Figure 3. Boxplot of math anxiety exploring the cases by gender

Relation between Variables

The following analyses identify moderate (0.24 – 0.36) and strong (0.37 and above) relationships between the variables (Cohen, 1988). Thus, Table 3 shows that gender identity threat in science is moderately and negatively related to math self-efficacy (*r=-0.31***; p<0.001*) and has a strong relationship with math anxiety (*r= 0.42***; p<0.001*). In other words, if the perception of the threat of gender identity is high, self-efficacy will be lower, and mathematical anxiety will be greater. In addition, math self-efficacy is moderately and negatively related to math self-efficacy (*r=-0.58***; p<0.001*). This means that if students have greater confidence in their abilities to study mathematics, they have less anxiety about studying it (and vice versa). Being moderate and strong relationships, they have the statistical power to study a multivariate predictive model.

Table 3. Relationship between variables

	Variables	1	2
1	Gender Identity Threat in Science	1	
2	Mathematical Self-Efficacy	*r* = -0.31***	1
3	Math anxiety	*r* = 0.42***	*r* = -0.58***

Note. 1 is gender identity threat in science, 2 is mathematical self-efficacy, and 3 is math anxiety. Then ***r*** is the Pearson coefficient. Finally, **p* < 0.05, ***p* < 0.01, ****p* < 0.001.

Predictive Mediation Model

Thus, the multiple linear regression analysis reports on the predictive level between variables and provides the beta coefficients (*β*) to observe the predictive relationship between the variables. Thus, Table 4 shows that math self-efficacy negatively predicts gender identity threat in science (*β =-0.31***, p <0.001*) and math anxiety (*β =-0.58***, p <0.001*). Then, gender identity threat in science predicted math anxiety (*β = 0.42***, p <0.001*). However, by applying the four steps of Baron and Kenny (1986) for mediation models, it was observed the prediction coefficients of the predictor and mediator variables vary when both (gender identity threat and mathematical self-efficacy) predict mathematical anxiety simultaneously. Thus, when both variables were calculated together, it was observed that mathematical self-efficacy had a lower prediction coefficient (from *β = -0.58**** to *β = -0.50****), and so did the threat of gender identity in science (from *β = 0.42**** to *β = 0.26****) (see Figure 4 and Table 4).

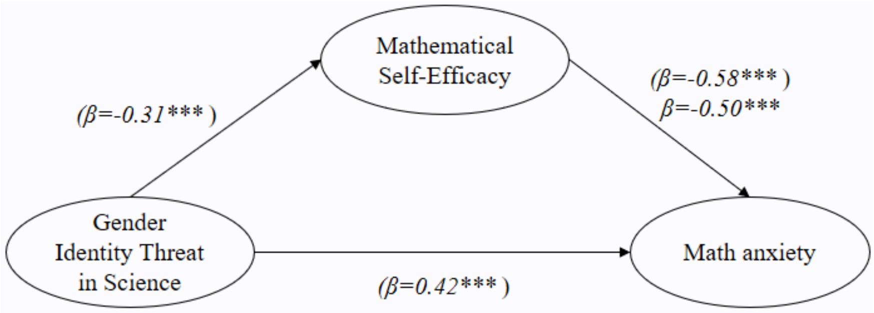

Figure 4. The predictive mediation

The mediation model was further analyzed using the Sobel Test (Sobel, 1982), which confirmed the presence of a significant indirect effect. The test yielded a statistic of -2.79 with a standard error of 0.03 ($p < 0.01$), indicating that the effect of mathematical self-efficacy (predictor variable) on mathematics anxiety (outcome variable) is significantly mediated by gender identity threat in science (mediator variable). The observed reduction in the beta coefficient for self-efficacy when the mediator was included suggests that gender identity threat diminishes students' self-efficacy, thereby exacerbating their anxiety toward mathematics. These results validate the proposed hypothesis, demonstrating that the protective effect of mathematical self-efficacy in reducing mathematics anxiety is contingent upon a lower perception of gender stereotype threat in scientific domains.

Table 4. Linear regressions effects

	Effects	***R***	***F***	***β***	**Sig. (*p*)**
1	Gender Identity Threat in Science - Math anxiety	0.173	31.303	*0.42****	0.000
2	Mathematical Self-Efficacy - Gender Identity Threat in Science	0.096	15.983	*-0.31****	0.000
3	Mathematical Self-Efficacy - Math anxiety	0.341	77.557	*-0.58****	0.000
4	Mathematical Self-Efficacy + Gender Identity Threat in Science - Math anxiety	0.402	49.999	*-0.50****	0.000

Note. *β* is the prediction coefficient. Finally, **p* < 0.05, ***p* < 0.01, ****p* < 0.001.

Discussion

In this context, the aim is to achieve the fifth Sustainable Development Goal (SDG), which proposes achieving gender equity (UNESCO, 2023). Given this goal, studying the challenges related to gender gaps that women face in STEM careers is highly relevant (Freedman et al., 2023), as is the analysis of educational inequities and labor inequalities within these scientific fields (Zając et al., 2024). This gender disparity is alarming because it affects the quality of education that women receive and restricts their participation in STEM careers, thereby limiting innovation, social welfare, and sustainable development (UNESCO, 2025a). Furthermore, it is relevant to analyze other associated aspects, such as the teaching of mathematics as the foundation of STEM careers (Mathieson & Homer, 2021; McAlinden & Noyes, 2019), as well as the role that gender stereotypes play in performance, self-efficacy, and mathematics anxiety (Justicia-Galiano et al., 2023; Vos et al., 2023). For these reasons, this study was guided by the objective of analyzing the influence of gender stereotypes (gender identity threat) as mediators between self-efficacy and mathematics anxiety in Peruvian pre-university students pursuing STEM careers. The sample was selected because the pre-university population in Peru is under-researched (Iraola-Real et al., 2022), despite being situated in a national context where gender stereotypes hinder women's access to higher education (Gallegos et al., 2022). Additionally, difficulties in learning mathematics during pre-university education have significant repercussions for university-level success (Lake et al., 2016).

This study examines socially constructed gender roles (González & Rodríguez, 2020) that erroneously attribute strength and intelligence to males (Duarte & Machado, 2019) while underestimating female capacities in science (Xie & Liu, 2023). Therefore, comparative and exploratory analyses were conducted regarding gender stereotypes, self-efficacy, and mathematics anxiety. The results revealed that, unlike male students, female students reported a greater sense of threat from gender stereotypes. This may be due to the internalized pressure to prove that they possess equal abilities and the fear of confirming negative gender-based stereotypes (Deemer et al., 2016). Moreover, within the Peruvian context, women face patriarchal norms that confine them to domestic roles or emphasize motherhood (Gallegos et al., 2022), which may intensify anxiety among pre-university female students.

It was observed that female students perceived themselves as less efficacious in mathematics, corroborating findings from studies conducted in the United States involving 15 teachers and 326 college students, which revealed that male students reported significantly higher levels of mathematical self-efficacy than their female counterparts (Peters, 2013). Similarly, research conducted in China demonstrated that gender stereotypes held by both parents and students had a significant impact on mathematical performance, yielding positive effects for male students and negative effects for female students (Xie & Liu, 2023). These patterns are also consistent with the findings of Mego-Sánchez et al. (2020), who, in analyzing a comparable sample of Peruvian pre-university students, identified lower levels of mathematical self-efficacy among females. The recurrence of this trend across different cultural and educational contexts may be explained by the findings of Czocher et al. (2019), which suggest that mathematical self-efficacy is developed through sustained interest and persistence in learning mathematics. However, this development process may be disrupted by gender stereotypes that influence the academic choices of female students, ultimately limiting their engagement and participation in STEM disciplines (UNESCO, 2025a). Conversely, not all studies have found gender-based differences. For instance, Kasturi et al. (2021), in a study involving 226 secondary school students, reported no significant differences in mathematical self-efficacy between male and female students. In this case, most participants—regardless of gender—exhibited adequate levels of self-efficacy, and female students demonstrated high performance and confidence in completing mathematical tasks. These contrasting findings underscore the importance of conducting more nuanced investigations into the educational contexts and pedagogical conditions that foster the development of mathematical self-efficacy among female students. Replicating and scaling successful interventions may be key to narrowing the gender gap in mathematics-related fields.

It was consistently observed that female students experience greater mathematics anxiety compared to their male peers. This finding aligns with Justicia-Galiano et al. (2023), who reported that among 257 high school students, females were significantly more prone to mathematical anxiety. Similarly, Vos et al. (2023) examined a cohort of young adults aged 18 to 35 and identified that women exhibited higher levels of math anxiety, which in turn adversely affected their academic performance. In the Peruvian context, Iraola-Real et al. (2021) found that among 122 pre-university students pursuing engineering, females reported increased fear and tension when engaging with mathematics.

These heightened anxiety levels in women may be explained by the pervasive influence of gender stereotypes, which generate feelings of threat, stress, and apprehension. Females often experience pressure to validate their competence as equal to males, a psychological burden linked to stereotype threat theory (Deemer et al., 2016). Moreover, women face systemic challenges in Peru, where entrenched societal norms restrict their access to higher education and perpetuate discriminatory expectations (Gallegos et al., 2022).

This sustained exposure to stereotype threat exacerbates math anxiety, which consequently undermines female students' mathematical self-efficacy. Such findings underscore the urgent need for educational policies and psycho-pedagogical interventions aimed at mitigating gender disparities in mathematics-related affective domains. The mediation analysis further substantiates the study's hypotheses, demonstrating that gender identity threat significantly mediates the relationship between mathematical self-efficacy and mathematics anxiety. Specifically, when gender stereotypes activate feelings of threat, the protective effect of self-efficacy in reducing math anxiety diminishes. This suggests that suppressing the perception of stereotype threat enhances students' confidence and decreases their anxiety when engaging with mathematics. This mediation effect reinforces existing literature indicating that gender stereotypes negatively influence scientific performance by eroding confidence in mathematical abilities and increasing anxiety (Xie & Liu, 2023; Kasturi et al., 2021; Justicia-Galiano et al., 2023). The current results reaffirm gender as a critical factor in mathematics performance, particularly illustrating how stereotypes disproportionately affect females by undermining their self-confidence (Vos et al., 2023). In the Peruvian pre-university setting, despite comparable arithmetic performance between genders, females exhibit lower confidence in their mathematical skills (Mego-Sánchez et al., 2020), which raises concern given the well-documented role of self-efficacy in academic achievement (Arens et al., 2020; Hiller et al., 2021).

Consequently, mathematical self-efficacy emerges as a pivotal element in addressing challenges in mathematics education within STEM fields. Consistent with UNESCO's recommendations (2025a), this study highlights the necessity for further research and the development of educational policies that actively counteract gender stereotypes and promote equitable skill development in science and mathematics. Implementing targeted educational strategies to combat stereotype threat has the potential to enhance self-efficacy and reduce mathematics anxiety, thereby fostering improved academic outcomes for female students. To effectively realize these goals, interdisciplinary approaches are essential. Collaboration among educators, psychologists, and policymakers can deepen understanding of students' diverse needs and drive innovation in STEM education tailored to mitigate gender-based barriers (Albeshree et al., 2020; Lake et al., 2016; McAlinden & Noyes, 2019).

CONCLUSIONS

This study provides empirical evidence supporting the influence of gender-based stereotype threat on female students' mathematical self-efficacy and anxiety levels within the context of STEM education. Specifically, the results demonstrate that female students perceive a greater sense of threat from prevailing gender stereotypes in mathematics and STEM-related fields compared to their male counterparts. This heightened sense of threat negatively impacts their self-efficacy beliefs and contributes to elevated levels of mathematics anxiety. Furthermore, the study establishes a predictive relationship whereby the perceived threat of gender stereotypes lowers self-efficacy, which in turn increases mathematical anxiety. These insights underscore the importance of addressing psychological and sociocultural factors that hinder female participation and persistence in STEM pathways.

Furthermore, the study is subject to several methodological limitations. Firstly, the sample is limited to a specific geographic area—students from the city of Lima—thereby restricting the generalizability of the results to other regions or demographic groups across Peru. Secondly, there is an imbalance in gender representation, as well as a relatively small sample size, which limits the statistical robustness and interpretability of the gender-based comparisons. Additionally, the study considers only a limited set of psychological variables, which may not capture the full complexity of the factors influencing self-efficacy and anxiety in mathematics. A more comprehensive investigation involving a broader array of variables and a more diverse participant pool is necessary to validate and extend the present findings.

Finally, future research should adopt expanded and context-sensitive methodologies, such as action research or mixed-method approaches, to deepen the understanding of gender disparities in STEM education. Researchers are encouraged to include larger and more demographically diverse samples, particularly incorporating students from underrepresented regions and a greater number of women actively enrolled in engineering or other STEM fields. Moreover, collaboration with educational institutions and policy makers is essential to design and implement targeted interventions that promote gender equity. Such interventions could involve teacher training programs, inclusive curricular reforms, and outreach initiatives that actively encourage female students to pursue and persist in STEM careers. These recommendations aim not only to enrich academic discourse but also to drive systemic change toward a more equitable and inclusive STEM education landscape.

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REFERENCES

Albeshree, F., Al-Manasia, M., Lemckert, C., Liu, S., & Tran, D. (2020). Mathematics teaching pedagogies to tertiary engineering and information technology students: a literature review. *International Journal of Mathematical Education in Science and Technology, 53*(6), 1609–1628. https://doi.org/10.1080/0020739X.2020.1837399

Ali, P., & Younas, A. (2021). Understanding and interpreting regression analysis. *Evidence-Based Nursing, 24*(4), 116-118. https://doi.org/10.1136/ebnurs-2021-103425

Álvarez, M. (2017). *Autoeficacia según el género y su influencia en el ámbito científico-tecnológico.* [Master Thesis - Universidad de Salamanca, España]. Repositorio institucional US. http://hdl.handle.net/10366/132350

Al Umairi, K. (2024). Mediating effect of mathematics cognitive domain in the relationship between mathematics self-efficacy and mathematics achievement. *EURASIA Journal of Mathematics, Science and Technology Education, 20*(9), 1-21. https://doi.org/10.29333/ejmste/14990

Arens, K., Frenzel, C., & Goetz, T. (2020). Self-Concept and Self-Efficacy in Math: Longitudinal Interrelations and Reciprocal Linkages with Achievement. *The Journal of Experimental Education, 90*(3), 615–633. https://doi.org/10.1080/00220973.2020.1786347

Bandura, A. (1997). *Self-efficacy: the exercise of control*. Freeman.

Baron, M., & Kenny, A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology, 51*(6), 1173–1182. https://doi.org/10.1037/0022-3514.51.6.1173

Cohen, J. (1988). *Statistical power and analysis for the behavioral sciences*. Academic Press.

Colson, A., & Cooke, R. (2018). Expert Elicitation: Using the Classical Model to Validate Experts' Judgments, *Review of Environmental Economics and Policy*, *12*(1), 113–132, 2018. http://doi.org/10.1093/reep/rex022

Conchado, A., Martón, I., Alcover, R., Villanueva, F., Bás, C., Vázquez, E., Sánchez, I., Carrión, A., & Carot, M. (2017). Reliability analysis in scoring rubrics for assessing problem solving. pp. 6031-6037. http://doi.org/10.21125/edulearn.2017.2367

Conlon, R. A., Barroso, C., & Ganley, C. M. (2023). Young children's career aspirations: Gender differences, STEM ambitions, and expected skill use. *The Career Development Quarterly, 71*(1), 15–29. http://dx.doi.org/10.1002/cdq.12312

Correa, A., Glas, M., & Opara, J. (2025). Females in higher education and leadership: insights from a multi-method approach. *Frontiers in Education, 9*(1485395), 1-18. https://doi.org/10.3389/feduc.2024.1485395

Czocher, A., Melhuish, K., & Kandasamy, S. (2019). Building mathematics self-efficacy of STEM undergraduates through mathematical modelling, *International Journal of Mathematical Education in Science and Technology, 51*(6), 807–834. https://doi.org/10.1080/0020739X.2019.1634223

Deemer, E., Lin, Ch., Graham, R., & Soto, C. (2016). Development and Validation of a Measure of Threatening Gender Stereotypes in Science: A Factor Mixture Analysis, *Journal of Career Assessment, 24*(1) 145-161. https://doi.org/10.1177/1069072714565772

Duarte, G., & Machado, L. M. (2019). Estereótipos de gênero, divisão sexual do trabalho e dupla jornada. *Revista Sociais e Humanas*, *32*(2). https://doi.org/10.5902/2317175836316

Esser, F., & Vliegenthart, R. (2017). Comparative research methods. In: Matthes, Jörg. *International Encyclopedia of Communication Research Methods*. Wiley Blackwell, pp. 1-22. https://www.zora.uzh.ch/id/eprint/149435/1/EsserVliegenthart_NCCRWP86_revisedFeb2017.pdf

Field, A. (2018). *Discovering statistics using SPSS*. 5ta ed. Sage Publications.

Freedman, G., Green, M.C., Kussman, M., Drusano, M., & Moore, M. (2023). "Dear future woman of STEM": letters of advice from women in STEM. *International Journal of STEM Education, 10*(20). https://doi.org/10.1186/s40594-023-00411-0

Gallegos, A., Luna, F., Alberca, N. E., Blanco, L. F., & Malpartida, F. (2022). Lucha de las mujeres por el acceso a la Universidad, Latinoamérica: caso Perú. *Revista Universidad y Sociedad, 14*(1), 242-250. http://scielo.sld.cu/pdf/rus/v14n1/2218-3620-rus-14-01-242.pdf

González, E., & Rodríguez, Y. (2020). Estereotipos de género en la infancia. *Pedagogía Social Revista Interuniversitaria*, 36, 25-138. https://doi.org/10.7179/PSRI_2020.36.08

Hackett, G., & Betz, N. (1989). An exploration of the mathematics self-efficacy/ mathematics performance correspondence, *Journal of Research in Mathematics Education, 20*(3), 261–273. https://doi.org/10.5951/jresematheduc.20.3.0261

Hiller, S. E., Kitsantas, A., Cheema, J. E., & Poulou, M. (2021). Mathematics anxiety and self-efficacy as predictors of mathematics literacy. *International Journal of Mathematical Education in Science and Technology, 53*(8), 2133–2151. https://doi.org/10.1080/0020739X.2020.1868589

Hu, K. (2020). Become component within one day in generating Boxplots and violin Plots for a Novice without Prior R Experience, *Methods and Protocols*, *3*(64), 1-30. http://dx.doi.org/10.3390/mps3040064

International Business Machines. (2023). *IBM SPSS statistics*. https://www.ibm.com/es-es/products/spss-statistics

Iraola-Real, I., Huaman, L., Sanchez, C.M., & Andersson, C. (2021). Mathematical Self-efficacy and Collaborative Learning Strategies in Engineering Career Aspirants. In: Botto-Tobar, M., S. Gómez, O., Rosero Miranda, R., Díaz Cadena, A. (eds) Advances in Emerging Trends and Technologies. ICAETT 2020. Advances in Intelligent Systems and Computing, vol 1302. Springer, Cham. https://doi.org/10.1007/978-3-030-63665-4_10

Iraola-Real, I., Matos, L., & Gargurevich, R. (2022). The type of motivation does matter for university preparation. *Estudos de Psicologia* (Campinas), *39*, e190177. https://doi.org/10.1590/1982-0275202239e190177

Justicia-Galiano, J., Martín-Puga, E., Linares, R., & Pelegrina, S. (2023). Gender stereotypes about math anxiety: Ability and emotional components. *Learning and Individual Differences, 105*. https://doi.org/10.1016/j.lindif.2023.102316

Karagiannakis, N., Baccaglini-Frank, E., & Roussos, P. (2016). Detecting strengths and weaknesses in learning mathematics through a model classifying mathematical skills. *Australian Journal of Learning Difficulties, 21*(2), 115–141. https://doi.org/10.1080/19404158.2017.1289963

Kasturi, K., Sulton, S., & Wedi, A. (2021). How Self Efficacy in Mathematic Based on Gender Perspective? *Edcomtech Jurnal Kajian Teknologi Pendidikan,* *6*(1), 36-45. http://dx.doi.org/10.17977/um039v6i12021p036

Lake, W., Wallin, M., Woolcott, G., Boyd, W., Foster, A., Markopoulos, C., & Boyd, W. (2016). Applying an alternative mathematics pedagogy for students with weak mathematics: meta-analysis of alternative pedagogies. *International Journal of Mathematical Education in Science and Technology, 48*(2), 215–228. https://doi.org/10.1080/0020739X.2016.1245876

Ley N° 27337. Código de los Niños y del Adolescentes. (2 de agosto del 2000). Congreso de la República del Perú. *Diario Oficial El Peruano*, https://www.mimp.gob.pe/files/direcciones/dga/nuevo-codigo-ninos-adolescentes.pdf

Ley N° 29733. Ley de Protección de Datos Personales. (21 de junio del 2011). Congreso de la República del Perú. *Diario Oficial El Peruano*, https://diariooficial.elperuano.pe/pdf/0036/ley-proteccion-datos-personales.pdf

Lyakhova, S., & Joubert, M. (2022). Post-16 Further Mathematics blended learning: learner self-regulation, mathematical resilience and technology, *Teaching Mathematics and its Applications: An International Journal of the IMA*, 41(1), 51–68. https://doi.org/10.1093/teamat/hrab005

Lyakhova, S., & Neate, A. (2021). Further Mathematics, student choice and transition to university: part 2—non-mathematics STEM degrees, *Teaching Mathematics and its Applications: An International Journal of the IMA, 40*(3), 210–233. https://doi.org/10.1093/teamat/hrab004

Mathieson, R., & Homer, M. (2021). "I was told it would help with my Psychology": Do post-16 Core Maths qualifications in England support other subjects? *Research in Mathematics Education, 24*(1), 69–87. https://doi.org/10.1080/14794802.2021.1959391

McAlinden, M., & Noyes, A. (2019). Mathematics in the disciplines at the transition to university. *Teaching Mathematics and its Applications: An International Journal of the IMA, 38*(2), 61–73. https://doi.org/10.1093/teamat/hry004

McNeill, F., Wei, L. (2023). Encouraging Young Women into STEM Careers: A Study Comparing Career Intention of Female STEM Students in China and Scotland. *Journal for STEM Education Research*, 1-29. https://doi.org/10.1007/s41979-023-00114-9

Medina-Neira, D., Caira-Chuquineyra, B., Fernandez-Guzman, D. (2025). Gender disparities in application and admission to the medical residency program in Peru: A cross sectional study from 2016 to 2023. *PLoS ONE 20*(1), e0316859. https://doi.org/10.1371/journal.pone.0316859

Mego-Sánchez, C., Huaman-Sarmiento, L., Iraola-Real, I., & Iraola-Arroyo, A. (2020). Niveles de Autoeficacia Matemática en estudiantes mujeres y varones aspirantes a la carrera de ingeniería. *Revista Ibérica de Sistemas e Tecnologias de Informação*, (38), 142-155. https://dialnet.unirioja.es/servlet/articulo?codigo=8574392

Navarro, M., Martin, A., Montoya, M., & Concha, S. (2024). Future primary teachers and pedagogical interactions with boys and girls. *EURASIA Journal of Mathematics, Science and Technology Education, 20*(5), 1-12. https://doi.org/10.29333/ejmste/14468

Organisation for Economic Cooperation and Development. (June 30, 2023). *Equity and Inclusion in Education: Finding Strength through Diversity*. OECD Publishing. https://doi.org/10.1787/e9072e21-en

Pehlivanli-Kadayifci, E. (2019). Exploring the Hidden Curriculum of Gender in Engineering Education: A Case of an Engineering Faculty in Turkey. *International Journal of Engineering Education, 35*(4), 1194–1205.

Peters, M. L. (2013). Examining the relationships among classroom climate, self-efficacy, and achievement in undergraduate mathematics: A multi-level analysis. *International Journal of Science and Mathematics Education*, *11*, 459-480. https://doi.org/10.1007/s10763-012-9347-y

Reiner, S. (2017). *Students' Mathematics Self-Efficacy, Anxiety, and Course Level at a Community College*. [Doctoral thesis, Walden University], Mineápolis. https://scholarworks.waldenu.edu/dissertations/3579

Ross, K., Galaudage, Sh., Clark, T., Lowson, N., Battasti, A., Adam, H., Ross, A. & Sweaney, N. (2023). Invisible women: gender representation in high school science courses across Australia. *Australian Journal of Education, 67*(3), 231-252. https://doi.org/10.1177/00049441231197245

Santana-Vega, L., Ruiz-Alfonso, Z., & Feliciano-García, L. (2023). Gender stereotypes and vocational variables in secondary education female students. *Revista de Educación,* 400, 265-294. https://doi.org/10.4438/1988-592X-RE-2023-400-578

Stratton, S. (2021). Population Research: Convenience Sampling Strategies. *Prehospital and Disaster Medicine, 36*(4), 373-374. https://doi.org/10.1017/S1049023X21000649

Sobel, M. (1982). Asymptotic confidence intervals for indirect effects in Structural Equation Models, *Sociological Methodology*, 13, 290–312. http://dx.doi.org/10.2307/270723

United Nations Educational Scientific and Cultural Organization. (2020). Las Mujeres en Ciencias, Tecnologías, Ingeniería y Matemáticas en América Latina y el Caribe. https://lac.unwomen.org/es/digiteca/publicaciones/2020/09/mujeres-en-ciencia-tecnologia-ingenieria-y-matematicas-en-america-latina-y-el-caribe

United Nations Educational Scientific and Cultural Organization. (2023). Inclusion and gender equality: brief on inclusion in education. https://unesdoc.unesco.org/ark:/48223/pf0000387889

United Nations Educational Scientific and Cultural Organization. (2025a). Girls' and women's education in science, technology, engineering and mathematics (STEM). https://www.unesco.org/en/gender-equality/education/stem#:~:text=They%20are%20particularly%20under%2Drepresented,and%20consequently%2C%20in%20STEM%20careers.

United Nations Educational Scientific and Cultural Organization. (2025b). 2025 International Day of Women and Girls in Science. https://www.unesco.org/en/articles/2025-international-day-women-and-girls-science

Usher, E., & Pajares, F. (2009). *Sources of self-efficacy in mathematics: A validation study, Contemporary Educational Psychology*, 34(1), 89–101. https://doi.org/10.1016/j.cedpsych.2008.09.002

Vos, H., Marinova, M., De León, S., Sasanguie, D., & Reynvoet, B. (2023). Gender differences in young adults' mathematical performance: Examining the contribution of working memory, math anxiety and gender-related stereotypes. *Learning and Individual Differences, 102*. https://doi.org/10.1016/j.lindif.2022.102255

Wolff-Michael, R., & von Unger, H. (2018). Current Perspectives on Research Ethics in Qualitative Research. *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research, 19*(3), 1-12. https://doi.org/10.17169/fqs-19.3.3155

Xie, G., & Liu, X. (2023). Gender in mathematics: how gender role perception influences mathematical capability in junior high school. *The Journal of Chinese Sociology, 10*(10), 1-23. https://doi.org/10.1186/s40711-023-00188-3

Zając, T., Magda, I., Bożykowski, M., Chłoń-Domińczak, A., & Jasiński, M. (2024). Gender pay gaps across STEM fields of study. *Studies in Higher Education*, 1–14. https://doi.org/10.1080/03075079.2024.2330667