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Research Article:

# Factors Influencing STEM Self-Efficacy Among Primary School Pupils: A Gender Comparison

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## ABSTRACT

This study examines the influence of gender-related beliefs on STEM self-efficacy among primary school pupils in Malaysia, a context shaped by cultural diversity and hierarchical norms. While gender gaps in Science, Technology, Engineering, and Mathematics (STEM) are often associated with early-formed stereotypes and mindsets, their specific influence on children's STEM self-efficacy remains under-explored, particularly in Southeast Asian settings. This study compares male and female pupils' gender stereotypes in STEM, male-power stereotype, perceptions of STEM, growth mindset, and STEM self-efficacy. It also investigates whether the relationships between these factors and STEM self-efficacy differ by gender. A quantitative comparative design was employed, involving 415 primary school pupils aged 8–9 years (Year 2–3). Five instruments were used; the Gender Stereotypes Measure, Gender-Power Attribution Task, Self-Perception Scale in STEM, Growth Mindset Sub-scale from the Implicit Theories of Intelligence Scale for Children (ITIS), and the Self-Efficacy Scale in STEM. Data were analysed using multivariate analysis of variance (MANOVA), Chi-square tests of independence, and multiple regression analysis. Findings revealed that male pupils held stronger gender stereotypes in STEM, while no significant gender differences were found in other variables. Regression analysis showed that a growth mindset and positive perceptions of STEM were significant predictors of STEM self-efficacy. Gender stereotypes in STEM had a weaker but statistically significant positive effect, while male-power stereotype were not significant. Gender does not significantly moderate the relationships between the predictors and STEM self-efficacy. The findings highlight the importance of strengthening growth mindsets and fostering positive perceptions of STEM to support self-efficacy among pupils of both genders. These insights contribute to a deeper understanding of the factors influencing STEM self-efficacy and offer implications for addressing gender disparities in STEM education.

**Keywords:** Gender differences, gender stereotypes, perceptions of STEM, growth mindset, STEM self-efficacy

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## INTRODUCTION

Countries worldwide have embraced the importance of science, technology, engineering, and mathematics (STEM) education, recognising its role in fostering innovation, driving economic growth, and ensuring global competitiveness (Dare et al., 2021). Despite this, the under-representation of females in STEM remains a critical educational concern, often associated with gender stereotypes and beliefs about ability. According to the United Nations Educational, Scientific and Cultural Organisation (UNESCO, 2017), women make up only 35% of students enrolled in STEM disciplines at higher education institutions. Participation is especially low in information and communications technology (ICT) (3%), engineering (8%), and mathematics and sciences (5%). Malaysia reflects a similar trend, where women make up nearly half of the population and tertiary graduates, yet only one-third (34%) complete bachelor's degrees in STEM disciplines (EU-Malaysia Chamber of Commerce and Industry [EUMCCI], 2019). Yet, the influencing factors that related to gender-related belief, perceptions, and growth mindset remain unclear specifically among primary school pupils in Malaysia. Research suggests that females may have lower self-efficacy in STEM compared to males (Alam et al., 2021). Stereotypes, such as the belief that boys are inherently more capable in STEM, can shape young children's self-perceptions of their own abilities. It is essential to confront these beliefs early, as stereotypes formed during primary schooling can have lasting effects on children's confidence, limit their opportunities, reinforce gender inequality, and hinder future success (Chan, 2022). Recent studies have shown that exposure to gender stereotypes in STEM can lead girls to internalise the belief that they are less capable than their male peers, resulting in lower confidence and self-efficacy when faced with academic challenges (Appiah et al., 2022; Callaman & Itaas, 2020; Hamdani et al., 2023). These stereotypes can profoundly shape children's self-beliefs and attitudes toward STEM (Callaman & Itaas, 2020; Appiah et al., 2022). When reinforced by adults, particularly parents and teachers, such messages may be transmitted as children enter formal education and face increasing academic demands (Callaman & Itaas, 2020). Internalising these beliefs may lead children to view themselves as less capable or less deserving, significantly weakening their self-efficacy and limiting their developmental potential (Callaman & Itaas, 2020; Chan, 2022).

In addition to stereotypes, children's perceptions of gender and authority can also influence their self-efficacy. Malaysia has the highest Power Distance Index (PDI, i.e., a general belief in the legitimacy of social hierarchy between groups and the readiness of the less powerful to accept unequal distribution of power) in the world, with a score of 100, according to Hofstede's cultural dimensions (Abdullah et al., 2014; Hofstede, 2001). In highly hierarchical societies like Malaysia, cultural norms may reinforce the idea that males hold more authority or are more competent, particularly in STEM fields. These male-power stereotype can lead females to internalise notions of inferiority in STEM domains, thereby reducing their confidence and belief in their own abilities. Gender often shapes how power is distributed in social settings (Charafeddine et al., 2024). In peer groups and classrooms, especially in STEM subjects, female students are often considered as less capable, while male students are seen as more dominant or competent (Cheryan et al., 2015; Riegle-Crumb et al., 2016). These patterns can reinforce the belief that males are "naturally" better at STEM, which may lead female students to doubt their own abilities and limit their engagement in these fields. Moreover, research suggests that females often view STEM subjects as more difficult than males, likely due to societal gender stereotypes and lower self-efficacy (Chan, 2022). As a result, male students generally exhibit higher self-efficacy in STEM, even when their performance is like or even lower than that of their female counterparts (Appiah et al. 2022; Chan, 2022). Hence, gender differences in STEM-related perceptions at the primary school level remain insufficiently examined.

One factor that may influence these perceptions is students' growth mindset, which is the belief that one's abilities and intelligence can be developed through dedication, effort, and learning over time (Dweck, 2007). A growth mindset has been shown to enhance self-efficacy in STEM, particularly for female students, by helping to counteract the effects of negative stereotypes (Chen & Liu, 2023). However, most studies examining the relationship between growth mindset, gender, and STEM self-efficacy have focused on secondary and tertiary education, with limited attention given to primary school pupils (Mozahem et al., 2021; Mohd Noh & Awi, 2022; Fung et al., 2021). This highlights the need for further research targeting younger learners to better understand how such beliefs develop and how they can be supported early in the educational journey.

Existing research on gender gaps in STEM self-efficacy has primarily focused on older students (Yaacob et al., 2024), leaving a gap in understanding how these differences develop during primary education. Therefore, it is important to explore gender differences in STEM self-efficacy, gender stereotypes in STEM, male-power stereotype, perceptions of STEM, and growth mindset among young learners. Although these factors have been identified as potential influences on self-efficacy, their specific impact on primary school pupils, particularly within the Malaysian context, remains insufficiently understood. In addition, the moderating role of gender in these relationships warrants further investigation. Addressing these gaps is crucial for designing early interventions that strengthen STEM self-efficacy and foster gender-inclusive STEM education.

Taken together, these gaps demonstrate the need for a thorough examination of how gender stereotypes, male-power stereotype, perceptions of STEM, and growth mindset influence STEM self-efficacy among primary school pupils in Malaysia. This study is designed to address these issues by examining the extent of these beliefs, their differences across genders, their predict STEM self-efficacy, and the moderating role of gender. Accordingly, the following research objectives have been formulated.

1. To describe gender stereotypes in STEM, male-power stereotype, perceptions of STEM, growth mindset, and STEM self-efficacy among male and female pupils.

2. To analyse differences between male and female pupils in gender stereotypes in STEM, male-power stereotype, perceptions of STEM, growth mindset, and STEM self-efficacy.

3. To determine whether gender stereotypes in STEM, male-power stereotype, perceptions of STEM, and growth mindset predict STEM self-efficacy.

4. To examine the moderating effect of gender on the relationships between gender stereotypes in STEM, male-power stereotype, perceptions of STEM and growth mindset on STEM self-efficacy.

This research is also significant in light of Malaysia's national policy on STEM and education. The Malaysia Education Blueprint 2013–2025 emphasises that the country must strengthen STEM education by improving student awareness and performance, particularly because student interest in STEM has been declining. The government's 'STEM for All' initiative similarly aims to make STEM education more inclusive for all students, regardless of gender, socio-economic status, or special education needs; this underscores the policy commitment to increasing STEM participation across different groups (Idris & Bacotang, 2023). Finally, under the 12th Malaysia Plan (2021–2025), efforts are in place to strengthen STEM readiness from early years, address gender disparity, and improve educational infrastructure such as science labs and teacher training.

## LITERATURE REVIEW

### Gender Stereotypes and STEM Learning

Gender stereotypes begin shaping children's motivation and beliefs about STEM from an early age. Master (2021) highlights that such stereotypes can emerge as early as preschool and tend to strengthen as children grow older. Evidence consistently demonstrates that children's early images of scientists are predominantly male, with both individual studies (Bozzato et al., 2021) and meta-analyses (Ferguson & Lezotte, 2020) confirming that such stereotypes persist across developmental stages. The Draw-A-Scientist Test (Bernard & Dudek, 2017) has long revealed this trend, but as Toma et al. (2022) argue, these depictions are more than symbolic, they actively discourage students, especially girls, from aspiring toward science-related careers. Similarly, Ellemers (2018) highlights that children internalise such stereotypes early, which in turn shapes their behaviour and academic self-beliefs. Rodríguez-Planas and Nollenberger

(2018) further show that by around age nine, many girls already believe mathematics is "not for them," a striking example of how early stereotypes translate into diminished their STEM self-efficacy. Holistically, this body of work illustrates that gendered images of science are not isolated biases but culturally reinforced assumptions equating science with masculinity. The consistency of findings across contexts and methods also underscores how resistant these stereotypes are to change.

In the Malaysian context, pupils are already beginning to internalise such expectations by primary school. Boys often express higher confidence in mathematics and technology domains, while girls' self-beliefs appear more vulnerable to stereotype influence (Sze et al., 2022). Textbook analyses reveal that Malaysian primary materials frequently reinforce gendered roles, depicting males in leadership and science-related positions while presenting females in more supportive roles (Asmuni, 2023). These patterns likely shape pupils' willingness to engage in STEM activities and influence their long-term aspirations. Therefore, addressing gender stereotypes in the early primary years in Malaysia is crucial, when children's STEM self-efficacy is still developing and can be redirected toward more equitable participation.

**Male-Power Stereotype and STEM Learning**

Previous research consistently shows that children begin associating power and authority with males from an early age, with preschoolers more likely to perceive boys or men as leaders and decision-makers (Charafeddine et al., 2020; Mandalaywala et al., 2020; Reyes-Jaquez & Koenig, 2022; Santhanagopalan et al., 2022). These early male-power associations are not merely descriptive of children's thinking, they influence how boys and girls navigate classroom interactions. For example, in classroom settings where such beliefs persist, boys may be more inclined to take on assertive or dominant roles, while girls may be more hesitant to lead, participate actively, or express their ideas with confidence. These dynamics can, in turn, influence their academic self-efficacy (Aguillon et al., 2020). However, Pesu et al. (2016) found no gender differences in Finland, underscoring that cultural and educational contexts that actively promote equality may mitigate these effects.

In STEM learning, male-power stereotype shape both self-perceptions and aspirations. Boys, socialised to see themselves as natural leaders, often report greater self-efficacy and leadership ambitions, while girls may internalise doubts about their competence (Sobieraj & Krämer, 2019). Comparative studies further reveal that women remain underrepresented in STEM fields and leadership positions, even where they are well represented in other professions such as teaching or healthcare (Dinhof & Willems, 2023; OECD, 2019). This pattern reflects broader cultural norms that privilege male dominance in technical and decision-making domains (Reinking & Martin, 2018). Taken together, this body of research highlights that male-power stereotype are culturally reinforced, context-dependent, and resistant to change. Their early emergence and persistence into higher education suggest that they play a critical role in shaping STEM self-efficacy trajectories. While some contexts show potential to counteract these beliefs, the overall evidence underscores the urgency of addressing male-power stereotype in primary school, before stereotypes solidify into barriers that limit girls' participation and aspirations in STEM.

## Gender Differences in Perceptions of STEM

Perceptions of STEM refer to how children think and perceive the difficulties of STEM subjects. Research consistently shows that perceptions of STEM differ across gender, with girls more likely to view STEM subjects as difficult compared to boys (Ayuso et al., 2021; Botella et al., 2019). These perceptions matter because they influence both motivation and career aspirations. The OECD (2015) reported that females are generally less motivated to pursue STEM fields and less likely to choose related careers. Importantly, self-perceptions often align with achievement. Boys tend to evaluate their abilities in mathematics and science more positively, reinforcing their identity with STEM, whereas girls report weaker self-perceptions even when their performance is comparable (Al-Balushi et al., 2022; Doyle & Voyer, 2016; Wang et al., 2023). This disparity suggests that confidence rather than ability may be a critical driver of gender gaps in STEM. Subtle but persistent stereotypes contribute to this imbalance. For instance, teachers and peers often attribute science and math skills to boys and humanities skills to girls, reinforcing the idea that boys are better at STEM (Hand et al., 2017). Such reinforcement can create a self-fulfilling cycle where girls internalise lower self-efficacy, further discouraging them from STEM pathways (Ahmad et al., 2023).

However, regional evidence provides a more nuanced picture. A study investigating junior high school students in Indonesia found that female students exhibited higher self-efficacy in science subjects compared to male students, suggesting that girls' positive self-perceptions can enhance engagement and motivation in science learning (Ernawati et al., 2021). In contrast, in a comparative study across Indonesia and Thailand, male students generally held more positive attitudes toward STEM subjects than female students, with attitudes also varying by grade level (Vaiqoh et al., 2021). Extending this to a broader regional scale, a study of Year 9 and 10 students across seven SEAMEO countries found boys reporting stronger self-efficacy and attitudes toward science than girls, while younger students expressed more favourable perceptions than older ones (Othman et al., 2022). These mixed findings indicate that gender differences in STEM self-efficacy and attitudes are not uniform; rather, they are shaped by both individual perceptions and contextual factors such as culture, schooling practices, and societal expectations.

## Gender Differences in Growth Mindset in STEM

The concept of "implicit theories," introduced by Carol S. Dweck and Mary Bandura, highlights how children's beliefs about ability, whether viewed as fixed or malleable, shape their interpretation of failure (Bernecker & Job, 2019). Growth mindset, the belief that abilities can be developed, has been shown to enhance persistence and self-efficacy, particularly in math and science (Barroso et al., 2023; Law et al., 2021). Although growth mindset interventions can buffer against stereotypes and improve girls' confidence (Law et al., 2021; Song, 2022), evidence also shows that girls are more likely than boys to adopt fixed beliefs about intelligence, limiting the effectiveness of such interventions (Heyder et al., 2021; Sigmundsson et al., 2020). This contrast suggests a paradox: growth mindset can protect against the harmful effects of gender stereotypes, but girls' stronger endorsement of entity theories means they may benefit less from it. Together, these findings reveal both the promise of growth mindset in reducing gender disparities and the challenges posed by entrenched cultural and social expectations about intelligence. Addressing gender-STEM gaps, therefore, requires not only promoting growth mindset practices but also confronting the broader structural and cultural factors that shape children's beliefs about ability and self-efficacy (Law et al., 2021).

## Gender Differences in STEM Self-efficacy

Self-efficacy, defined as the belief in one's capacity to plan and execute actions toward specific goals (Bandura, 1977), is central to academic motivation and performance across disciplines (Zakariya, 2022). In STEM, it reflects confidence in completing subject-related tasks, with research consistently showing gender disparities, females often report lower self-efficacy, which is linked to weaker interest and sense of belonging compared to males (Chan, 2022; Tellhed et al., 2017). Social Cognitive Theory (SCT) explains these differences through four key sources of self-efficacy (Bandura, 1997). For children aged 8 to 9, these sources operate in distinct ways, for instance:

1. Mastery experiences: Early successes or failures in mathematics and science tasks strongly shape confidence, as children at this stage are beginning to compare their performance with peers.

2. Vicarious experiences: Observing classmates often boys take the lead in problem-solving may reinforce gendered expectations of ability.

3. Verbal persuasion: Encouragement from teachers and parents can boost girls' confidence, but subtle biases (e.g., attributing math success to boys) may undermine it.

4. Physiological/emotional states: Feelings of anxiety or excitement in STEM classrooms become internal cues that signal competence or incompetence, often affecting girls more strongly.

Studies show that self-efficacy predicts STEM achievement, with particular benefits for females; for instance, Aurah (2017) found that girls with high self-efficacy outperformed boys in genetics problem-solving. Yet, the lack of direct gender comparisons at equal efficacy levels limits broader generalisation. This suggests that when girls believe in their capabilities, they can excel beyond boys, but stereotypes and lower average self-efficacy may constrain such outcomes. While much research demonstrates the positive influence of self-efficacy on STEM learning in older students (Casinillo, 2023; Crowder & Whittle, 2022), evidence on primary school children remains scarce (Wenhui & Feng, 2023; Zivkovic et al., 2023).

Regional studies, however, provide critical insight. In Malaysia, Alam et al. (2021) found that female students' STEM self-efficacy is strongly shaped by stereotypes and teacher expectations, while in Indonesia, Manalu and Chang (2025) reported that even primary pupils' STEM attitudes and career aspirations were gendered, with boys showing greater confidence and identification with STEM. These findings underline that disparities in self-efficacy and interest are already present in Southeast Asia at the primary level, not only in secondary or tertiary contexts. Complementing these, Jaafar and Maat's (2020) systematic review of 34 Malaysian studies revealed that mathematics achievement is strongly associated with self-efficacy and motivation, and called for more research at the primary level to address such issues earlier. Taken together, these studies reinforce that self-efficacy is not only a personal belief but also a product of stereotypes and cultural context underscoring the need to examine gendered self-efficacy in Malaysian primary schools, as in the present study.

## Conceptual Framework

Figure 1 shows the conceptual framework of this study, which includes the independent variables (gender stereotypes in STEM, male-power stereotype, perceptions of STEM, and growth mindset), the dependent variable (STEM self-efficacy), and the moderator (gender). The arrows represent the direction of influence, highlighting how these factors interact in the study. This study aimed to examine gender-related factors in STEM among primary school pupils by identifying and comparing gender stereotypes in STEM, male-power stereotype, perceptions of STEM, growth mindset, and STEM self-efficacy between male and female pupils, analysing how these factors influence STEM self-efficacy and exploring whether gender moderates the relationships between these predictors and STEM self-efficacy.

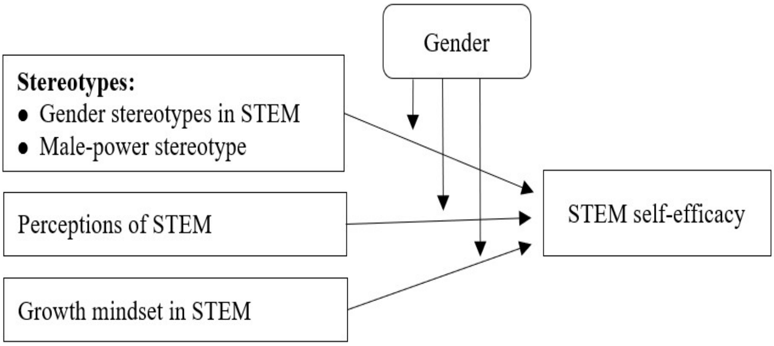


**Figure 1.** Conceptual framework

## METHODOLOGY

### Research Design

This study employed a cross-sectional comparative quantitative design to examine gender stereotypes, male-power stereotype, perceptions of STEM, growth mindset in STEM, and STEM self-efficacy among primary school pupils in Penang, Malaysia.

### Population and Samples

The study population comprised primary school pupils in the state of Penang, Malaysia. According to the Penang State Education Department (2023), there were 44,286 primary school pupils across the five districts of the state (males = 22,167; females = 22,119). Given the size of the population, a minimum sample of 400 pupils was deemed necessary to support the generalisability of the study's findings (Krejcie & Morgan, 1970). Schools were identified in collaboration with the Penang State Education Department to ensure coverage across all five districts. Within each participating school, classes were randomly selected, and all eligible pupils in Year 2 and Year 3 were invited to participate. Informed consent was obtained from headmasters, teachers, parents, and verbal assent was secured from the respondents before data collection. As shown in Table 1, a total of 415 primary school pupils were sampled from the five districts of Penang, Northeast Penang Island, Southwest Penang Island, North Seberang Perai, Central Seberang Perai, and South Seberang Perai, with a relatively balanced gender distribution (males = 206, 49.64%; females = 209, 50.35%). The respondents were lower primary pupils, specifically eight years old (Year 2) and nine years old (Year 3). Year One pupils (seven years old) were excluded, as they were still in the process of adjusting to formal schooling, which may have affected their ability to respond reliably to the study instruments.

**Table 1.** Demographic profile of respondents

| Demographic | Male | | Female | | Total | |
|---|---|---|---|---|---|---|
| Age | *n* | % | *n* | % | *n* | % |
| 8 years | 103 | 24.82 | 92 | 22.17 | 195 | 24.82 |
| 9 years | 103 | 24.82 | 117 | 28.19 | 220 | 24.82 |
| Total | 206 | 49.64 | 209 | 50.36 | 415 | 100% |

**Data Collection and Analysis**

Five research instruments were used to collect data in this study: the Gender Stereotypes Measure (Liben & Bigler, 2002), the Gender-Power Attribution Task (Charafeddine et al., 2020), the Self-Perception Scale in STEM (Boersma et al., 1979), the Growth Mindset Subscale from the Implicit Theories of Intelligence Scale for Children (ITIS) (Dweck, 2007), and the Self-Efficacy Scale in STEM (Sze et al., 2022). All instruments were adapted to ensure age-appropriateness and cultural relevance for primary school pupils in the Malaysian context. The instruments were translated into Malay by native speakers. The Gender Stereotypes Measure (8 items) was adapted from Liben and Bigler (2002). Any responses that indicate the positive items in gender stereotypes, for example, in Item 1: "Both boys and girls are equally good at science", will consider gender stereotypes in STEM absent. The negative items, score will be reversed; for example, in Item 7: "Boys are better than girls in mathematics", it suggests that the respondent has gender stereotypes thinking towards the STEM field. A score of 1 is regarded as a gender stereotype in STEM that is absent, whereas a score of 3 is considered a gender stereotype in STEM that is present. Responses were rated on a three-point Likert scale (1 = disagree, 2 = not sure, 3 = agree), with higher scores reflecting stronger gender stereotypes in STEM favouring boys in STEM-related domains.

The Gender-Power Attribution Task (Charafeddine et al., 2020) was used to assess how children associate gender with dominant and subordinate roles in dyadic interactions. In this task, children were presented with an illustration featuring two gender-neutral characters, one displaying a dominant posture and the other a submissive posture (see Figure 2). To help clarify the roles, a brief narrative was presented to the children:

> These two children are playing. One is saying: "I am the one in charge [boss (*ketua*)], you have to do what I want" [Power statement]. And one is saying: "OK, you are in charge [boss (*ketua*)], I will do as you want" [Subordination statement].

The use of the term *'ketua'* aimed to ensure linguistic and cultural familiarity, as '*ketua*' is a term widely understood by Malay-speaking children to denote authority. Children were then instructed to identify which character matched each statement, based on their posture. The spatial positions of the characters (left vs. right) were counterbalanced across participants to avoid positional bias. Responses were considered correct when children accurately paired the dominant posture with the power statement and the subordinate posture with the subordinate statement. In the second part of the task, children were told that the characters represented a boy and a girl and were asked to identify which was which. When children assigned the dominant posture to the boy and the subordinate posture to the girl, this was interpreted as a reflection of male-power stereotype. This measure captures children's internalised male-power stereotype, perceptions that are particularly relevant in the context of STEM learning, where stereotype beliefs can influence confidence, participation, and leadership aspirations. The task is grounded in validated developmental research showing that children infer social power from nonverbal cues such as body posture and facial expression (Keating & Bai, 1986; Cogsdill et al., 2014; Charafeddine et al., 2020; 2024).

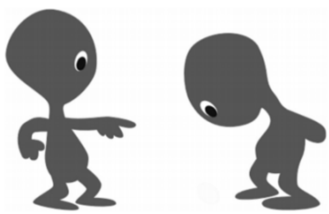

**Figure 2.** Two characters displaying postures of dominance and subordination

Data on self-perception, growth mindset, and STEM self-efficacy were collected using a three-point Likert scale. The Self-Perception Scale in STEM (8 items), adapted from Boersma et al. (1979), measured children's perceptions of science, technology, engineering, and mathematics subjects at the primary school level. The example item: (Item 1) "Science is fun subject", and the reversed item: for instance, (Item 7) "Mathematics is a difficult subject." Average scores of 1 are regarded as negative perception, whereas scores of 3 are considered positive perception. Higher scores indicated stronger self-perceptions of ability and interest in STEM areas. Children's growth mindset was assessed using the Growth Mindset Subscale from the Implicit Theories of Intelligence Scale for Children (ITIS) (8 items) (Dweck, 2007). This scale measures children's implicit beliefs about intelligence, specifically whether they perceive intelligence as a malleable trait that can be developed through effort, reflecting their growth mindset. To show the attitude towards growth, the incremental theory elements are positively phrased (for instance, Item 5: "Creating things can be challenging, but

I love the challenge"), and examples of items that show a fixed mindset are phrased negatively (Item 8: "When doing difficult mathematics questions, I give up because I am simply not good at it"). Higher scores indicate a stronger belief in the ability to improve intelligence through effort in STEM. The Self-Efficacy Scale in STEM (8 items), adapted from the STEM Efficacy for Children Scale (SECS) by Sze et al. (2022), was used to assess children's confidence in their ability to succeed in STEM-related tasks. Example items include "I am good at science" and "I can solve difficult math problems." Higher scores reflected greater self-efficacy in STEM. All instruments used in this study were content-validated and tested for reliability with Malaysian primary school children. The Gender Stereotypes Measure reported a Cronbach's alpha of $\alpha$ = 0.86, the Self-Perception Scale in STEM $\alpha$ = 0.73, the Growth Mindset of Implicit Theories of Intelligence Scale for Children (ITIS) $\alpha$ = 0.82, and the Self-Efficacy Scale in STEM $\alpha$ = 0.72.

After data collection, responses were coded and analysed using Statistical Package for the Social Sciences (SPSS) version 26. Both descriptive and inferential statistical analyses were employed to address the four research objectives. Descriptive statistics, including means and standard deviations, were utilised to address Research Objective 1 by examining the levels of gender stereotypes in STEM, perceptions of STEM, growth mindset, and STEM self-efficacy, as well as the distribution of male-power stereotype according to gender. To address Research Objective 2, a Multivariate Analysis of Variance (MANOVA) was conducted to examine gender differences in the continuous variables: gender stereotypes in STEM, perceptions of STEM, growth mindset, and STEM self-efficacy. Additionally, a Chi-square test was employed to assess the association between gender (male or female) and the categorical variable of male-power stereotype (perceived dominance: male or female). For Research Objectives 3 and 4, multiple regression analyses were employed to examine the predictive relationships between gender stereotypes, male-power stereotype, perceptions of STEM, and growth mindset with STEM self-efficacy, and to determine whether gender moderated these relationships. Although the scales employed three-point Likert response options, the composite scores were treated as continuous in line with common practice in educational and psychological research. Prior studies have shown that Likert-type scales with three or more categories may be analysed as continuous when internal consistency is satisfactory (Carifio & Perla, 2008; Koo & Yang, 2025). Given that all scales in this study achieved acceptable reliability (Cronbach's alpha $\geq$ 0.70), the use of parametric analyses such as MANOVA and regression was considered appropriate.

## Validity and Assumption Checks

Validity demonstrates how appropriate a given test is for a specific research project. A study is considered valid if the results match the research context, explanation, and forecast (Troy, 2020). In this study, all instruments were translated into Malay to ensure age-appropriateness and cultural relevance for primary school pupils. The translation process followed established guidelines: instruments were forward-translated into Malay by two bilingual researchers, and then back-translated into English by an independent bilingual translator to ensure conceptual equivalence. Discrepancies were reviewed and resolved by consensus. Content validity was further established through review by two experts in educational psychology from different universities. The experts assessed the instruments for clarity, language suitability, cultural relevance, and alignment with the constructs being measured. A Content Validity Index (CVI) was calculated, with item-level CVI values ranging from 0.85 to 0.92, indicating high content validity.

Prior to conducting the statistical analyses, assumption checks were performed to ensure the appropriateness of parametric tests. Normality was examined using skewness and kurtosis statistics as well as visual inspection of histograms. The skewness values for the five research variables ranged from –0.575 to 1.52, while the kurtosis values were between –0.294 and 0.33. In addition, histograms indicated that the distributions of gender stereotypes, STEM self-perception, growth mindset, and STEM self-efficacy approximated a normal distribution. Homogeneity of variances was tested using Levene's test, while multicollinearity was assessed through tolerance values and variance inflation factor (VIF). All assumptions were found to be adequately met for the subsequent analyses.

### Ethical Considerations

To collect data from primary school pupils in Penang, permission was first obtained from the Education Planning and Research Division, Ministry of Education, followed by approval from the Penang State Education Department and subsequently from five selected schools across various districts in the state. Class teachers and guardians were approached in person to explain the purpose of the study and to obtain informed consent. Ethical approval was also secured from the Human Research Ethics Committee of Universiti Sains Malaysia, ensuring compliance with all ethical research standards. Data collection was conducted in two parts. In the first session, pupils were given 10 to 15 minutes to complete a questionnaire consisting of the Gender Stereotypes Measure, the Self-Perception Scale and the Growth Mindset Subscale from the Implicit Theories of Intelligence Scale for Children (ITIS). In a separate session, male-power stereotype was assessed individually using the Gender-Power Attribution Task, which also took approximately 10 to 15 minutes per participant.

## RESULTS

### Descriptive Analysis

Descriptive analysis was conducted to address Objective 1, which aimed to determine the levels of gender stereotypes, male-power stereotype, perceptions of STEM, growth mindset, and STEM self-efficacy among male and female pupils. Table 2 presents the descriptive statistics for gender stereotypes, perceptions of STEM, growth mindset, and STEM self-efficacy by gender, while Table 3 presents the statistics for male-power stereotype. As shown in Table 2, both male and female pupils demonstrated moderate levels of gender stereotypes in STEM; males (*M* = 14.44, *SD* = 2.77) and females (*M* = 13.65, *SD* = 2.48). In terms of perceptions of STEM, females recorded scores within the high range (*M* = 18.83, *SD* = 2.36), while males fell within the moderate range (*M* = 18.60, *SD* = 2.51). For growth mindset in STEM, males (*M* = 20.26, *SD* = 2.56) and females (*M* = 20.69, *SD* = 2.17) also recorded scores within the high range. Similarly, both genders reported moderate levels of STEM self-efficacy; males (*M* = 18.27, *SD* = 2.75) and females (*M* = 18.11, *SD* = 2.65). Overall, the descriptive findings suggest that both male and female pupils reported scores within similar ranges across all constructs. Further inferential analysis will be conducted to examine whether these observed differences are statistically significant.

**Table 2.** Descriptive statistics on gender stereotypes in STEM, perceptions of STEM, growth mindset, and STEM self-efficacy by gender

| Variables | Male (*n* = 206) | | Level | Female (*n* = 209) | | Level |
|---|---|---|---|---|---|---|
| | M | SD | | M | SD | |
| Gender stereotypes in STEM | 14.44 | 2.77 | Moderate | 13.65 | 2.48 | Moderate |
| Perceptions of STEM | 18.60 | 2.51 | Moderate | 18.83 | 2.36 | High |
| Growth mindset in STEM | 20.26 | 2.56 | High | 20.69 | 2.17 | High |
| STEM self-efficacy | 18.27 | 2.75 | Moderate | 18.11 | 2.65 | Moderate |

*Note.* *Mean score ranges: Low = 8.00–13.33; Moderate = 13.34–18.66; High = 18.67–24.00.

Table 3 presents the distribution of male-power stereotype according to gender. Overall, 80% (*n* = 332) of the primary school children, both boys and girls, attributed the dominant character to a male, while only 20% (*n* = 83) associated dominance with a female. Among male pupils, 78.16% (*n* = 161) selected the male character as dominant, while 81.82% (*n* = 171) of female pupils did the same. These findings suggest a strong and consistent tendency across genders to associate power with males. This shared perception of linking dominance with masculinity may contribute to girls viewing themselves in more subordinate roles.

A MANOVA was conducted to examine gender differences in gender stereotypes in STEM, perceptions of STEM, growth mindset, and STEM self-efficacy, while a Chi-square test was used to analyse gender differences in male-power stereotype. These analyses were conducted to address Research Objective 2 and the results are presented in two sections accordingly.

**Table 3.** Descriptive analysis of male-power stereotype according to gender

| Gender | Male dominance | | Female dominance | | Total |
|---|---|---|---|---|---|
| | *n* | % | *n* | % | |
| Male | 161 | 78.16 | 45 | 21.84 | 206 |
| Female | 171 | 81.82 | 38 | 18.18 | 209 |
| Total | 332 | 80.00 | 83 | 20.00 | 415 |

## Robustness Checks

Robustness checks were conducted using heteroskedasticity-robust (HC3) standard errors, bootstrap confidence intervals (5,000 resamples), and robust regression (MM-estimator). The results were consistent with the main findings: growth mindset and perceptions of STEM remained significant positive predictors of STEM self-efficacy, gender stereotypes in STEM showed a smaller significant effect, and male-power stereotype remained non-significant. MANOVA results using Pillai's trace confirmed the significant omnibus gender effect, and ordinal logistic regression of male-power stereotype also showed no significant association with gender. Multiple imputation analyses produced results highly consistent with list-wise deletion. Overall, the findings were robust across estimators and sensitivity tests.

## Multivariate Analysis of Variance (MANOVA)

The results of the omnibus test indicated a significant overall effect of gender on the combined dependent variables, Wilks' $\Lambda = .967$, $F(4, 410) = 3.52$, $p = .008$, partial $\eta^2 = .033$. As shown in Table 4, the results of MANOVA revealed a significant gender difference in gender stereotypes in STEM, $F(1, 413) = 9.30$, $p = .002$, partial $\eta^2 = .022$, with males ($M = 14.44$) scoring higher than females ($M = 13.65$). However, no significant gender differences were found for perceptions of STEM, $F(1, 413) = 0.93$, $p = .336$, partial $\eta^2 = .002$; growth mindset in STEM, $F(1, 413) = 3.52$, $p = .061$, partial $\eta^2 = .008$; or STEM self-efficacy, $F(1, 413) = 0.40$, $p = .530$, partial $\eta^2 = .001$.

Overall, male pupils exhibited stronger gender stereotype in STEM compared to female pupils. However, no significant gender differences were found in perceptions of STEM, growth mindset in STEM, or STEM self-efficacy. Although females recorded slightly higher scores than males in perceptions of STEM and growth mindset, and males scored marginally higher in STEM self-efficacy, these differences were not statistically significant.

**Table 4.** Summary of MANOVA results between gender

| Independent variables | Dependent variables | Type III sum of squares | df | Mean square | *F* | *p* | Partial eta squared |
|---|---|---|---|---|---|---|---|
| Corrected model | Gender stereotypes in STEM | 64.12[a] | 1 | 64.12 | 9.30 | .002* | .022 |
| | Perception of STEM | 5.52[b] | 1 | 5.52 | .92 | .336 | .002 |
| | Growth mindset in STEM | 19.77[c] | 1 | 19.767 | 3.516 | .061 | .008 |
| | STEM self-efficacy | 2.88[d] | 1 | 2.879 | .395 | .530 | .001 |
| Intercept | Gender stereotypes in STEM | 81845.54 | 1 | 81845.538 | 11876.334 | .001 | .966 |
| | Perception of STEM | 145306.58 | 1 | 145306.580 | 24441.094 | .000 | .983 |
| | Growth mindset in STEM | 173978.56 | 1 | 173978.562 | 30947.626 | .000 | .987 |
| | STEM self-efficacy | 137284.58 | 1 | 137284.575 | 18846.357 | .000 | .979 |
| Gender | Gender stereotypes in STEM | 64.12 | 1 | 64.122 | 9.304 | .002* | .022 |
| | Perception of STEM | 5.52 | 1 | 5.520 | .928 | .336 | .002 |
| | Growth mindset in STEM | 19.77 | 1 | 19.767 | 3.516 | .061 | .008 |
| | STEM self-efficacy | 2.88 | 1 | 2.879 | .395 | .530 | .001 |
| Error | Gender stereotypes in STEM | 2846.18 | 413 | 6.891 | | | |
| | Perception of STEM | 2455.36 | 413 | 5.945 | | | |
| | Growth mindset in STEM | 2321.77 | 413 | 5.622 | | | |
| | STEM self-efficacy | 3008.46 | 413 | 7.284 | | | |
| Total | Gender stereotypes in STEM | 84727.00 | 415 | | | | |
| | Perception of STEM | 147788.00 | 415 | | | | |
| | Growth mindset in STEM | 176356.00 | 415 | | | | |
| | STEM self-efficacy | 140294.00 | 415 | | | | |

*Note.* * $p < .05$

## Chi-square Test of Independence

Table 5 presents the results of the Chi-square test conducted to examine whether there was a significant association between gender and male-power stereotype. The analysis yielded a Pearson Chi-square value of 1.122 with $p$ = .289. This suggests that both male and female pupils were equally likely to attribute dominance to male figures, reflecting a shared gender stereotype that associates power with masculinity.

**Table 5.** Chi-square test of association between male-power stereotype and gender

| | Value | df | $p$ |
|---|---|---|---|
| Pearson Chi-square | 1.122[a] | 1 | .289 |
| Continuity correction[b] | 0.876 | 1 | .349 |
| Likelihood ratio | 1.123 | 1 | .289 |
| Fisher's exact test | - | - | - |
| Linear-by-Linear association | 1.120 | 1 | .290 |
| N of valid cases | 415 | | |

*Note*. *Fisher's Exact Test was not computed due to the large sample size; [a] 0 cells (0.0%) have expected count less than 5; [b] Continuity correction is computed only for 2 × 2 tables.

## Regression Analysis

To address Research Objective 3, multiple regression analysis was conducted to examine whether gender stereotypes in STEM, male-power stereotype, perceptions of STEM and growth mindset significantly predicted STEM self-efficacy. As shown in Table 6, the overall regression model was statistically significant, $F(4, 410) = 33.915$, $p < .001$, indicating that the predictors significantly contributed to the variance in STEM self-efficacy. The model accounted for approximately 24.9% of the variance in STEM self-efficacy ($R^2 = .249$, Adjusted $R^2 = .241$).

**Table 6.** Model summary of gender stereotypes, male-power stereotype, perceptions of STEM, and growth mindset in STEM

| Model | $R$ | $R^2$ | $\Delta R^2$ | df | F | $p$ |
|---|---|---|---|---|---|---|
| 1 | .499 | .249 | .241 | 4 | 33.915 | < .001 |
| | | | | 410 | | |
| | | | | 414 | | |

*Notes.* *Dependent Variable = STEM Self-efficacy. Predictors: (Constant) = Gender Stereotypes in STEM, Male-power stereotype, Perceptions of STEM, Growth mindset.

As shown in Table 7, the standardised beta coefficients ($\beta$) indicate the relative influence of each predictor on STEM self-efficacy. Growth mindset ($\beta$ = .340, $p$ < .001, 95% CI [.287, .484]) and perceptions of STEM ($\beta$ = .302, $p$ < .001, 95% CI [.239, .430]) had significant positive effects. Gender stereotypes in STEM also showed a smaller, yet statistically significant, positive effect ($\beta$ = .090, $p$ = .038, 95% CI [.005, .178]). In contrast, male-power stereotype was not a significant predictor ($\beta$ = −.036, $p$ = .398, 95% CI [−.325, .817]). Collinearity diagnostics confirmed that all predictors were free of multicollinearity, with VIF values close to 1 (ranging from 1.006 to 1.058). These findings suggest that pupils with stronger growth mindsets and more positive perceptions of STEM tend to report higher STEM self-efficacy, while gender stereotypes in STEM have a weaker but notable influence.

**Table 7.** Regression coefficients of gender stereotypes in STEM, male-power stereotype, perceptions of STEM, and growth Mindset in STEM

| Model | | Unstandardised coefficients | | Standardised coefficient | *t* | *p* | 95% CI for B | VIF |
|---|---|---|---|---|---|---|---|---|
| | | *B* | Std. Error | Beta ($\beta$) | | | | |
| 1 | (Constant) | 2.947 | 1.487 | - | 1.982 | .048 | −.431, 5.341 | - |
| | Gender stereotypes in STEM | .092 | .044 | .090 | 2.086 | .038* | .005, .178 | 1.023 |
| | Male-power stereotype | −.246 | .290 | −.036 | −.846 | .398 | −.325, .817 | 1.006 |
| | Perceptions of STEM | .334 | .048 | .302 | 6.894 | < .001* | .239, .430 | 1.049 |
| | Growth mindset in STEM | .385 | .050 | .340 | 7.717 | < .001* | .287, .484 | 1.058 |

*Note.* *$p$ < .05. Dependent variable = STEM self-efficacy

To enhance interpretability, a coefficient plot of the predictors with 95% confidence intervals is presented in Figure 3. The plot indicates that growth mindset and perceptions of STEM were the strongest positive predictors of STEM self-efficacy, followed by a weaker but significant effect of gender stereotypes in STEM. Male-power stereotype was not a significant predictor.

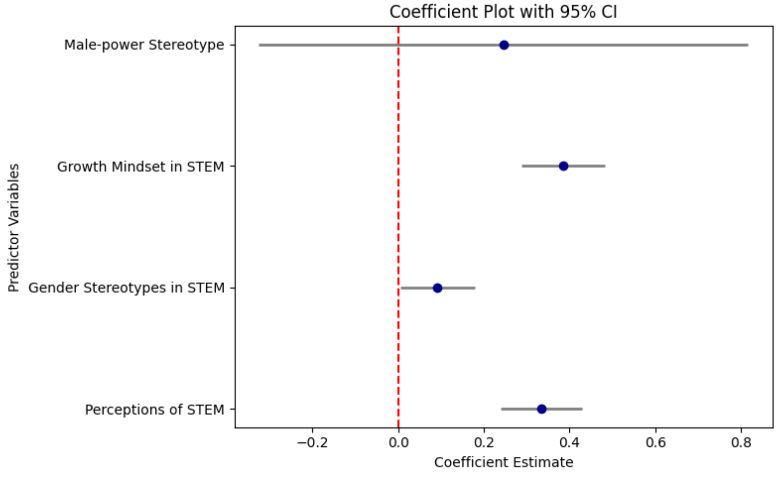


**Figure 3.** Coefficient plot of predictors STEM self-efficacy

## Moderation Analysis

To address Research Question 4, a moderation analysis was conducted to examine whether gender moderated the relationships between gender stereotypes in STEM, male-power stereotype, perceptions of STEM, and growth mindset with STEM self-efficacy (see Table 8). As shown in Table 8, Model 1 (without the interaction effects) showed that perceptions of STEM ($\beta$ = .304, $p$ < .001) and growth mindset ($\beta$ = .344, $p$ < .001) were significant positive predictors of STEM self-efficacy. Gender, gender stereotypes in STEM ($\beta$ = .082, $p$ > .062) and male-power stereotype ($\beta$ = .033, $p$ > .438) were statistically not significant predictors. In Model 2, which included the interaction effects, growth mindset remained a significant predictor ($\beta$ = .336, $p$ = .013), while none of the gender-based interaction effects, Gender × Gender stereotypes in STEM, Gender × Male-power stereotype, Gender × Perceptions of STEM, and Gender × Growth mindset, was statistically significant ($p$ =.068). These results suggest that gender does not significantly moderate the relationships between the predictors and STEM self-efficacy. The effects of gender stereotypes in STEM, male-power stereotype, perceptions of STEM, and growth mindset appear to be consistent across both male and female pupils.

**Table 8.** Regression coefficients for moderation analysis

| | | Coefficients | | | | |
|---|---|---|---|---|---|---|
| | Model | Unstandardised coefficients | | Standardised coefficients | *t* | *p* |
| | | B | Std. error | *β* | | |
| 1 | (Constant) | 2.976 | 1.510 | - | 1.971 | .049 |
| | Gender | –.340 | .234 | –.063 | –1.453 | .147 |
| | Male-power stereotype | .225 | .290 | .033 | .776 | .438 |
| | Gender stereotypes in STEM | .083 | .044 | .082 | 1.875 | .062 |
| | Perceptions of STEM | .336 | .048 | .304 | 6.935 | < .001* |
| | Growth mindset | .391 | .050 | .344 | 7.811 | < .001* |
| 2 | (Constant) | 8.223 | 4.490 | - | 1.831 | .068 |
| | Gender | –3.955 | 2.974 | –.734 | –1.330 | .184 |
| | Male-power stereotype | –.456 | .902 | –.067 | –.506 | .613 |
| | Gender stereotypes in STEM | .064 | .137 | .063 | .468 | .640 |
| | Perceptions of STEM | .124 | .152 | .112 | .815 | .416 |
| | Growth mindset | .382 | .153 | .336 | 2.495 | .013* |
| | Gender × Gender stereotypes in STEM | .014 | .089 | .039 | .154 | .877 |
| | Gender × Male-power stereotype | .470 | .584 | .146 | .805 | .422 |
| | Gender × Perceptions of STEM | .145 | .097 | .550 | 1.489 | .137 |
| | Gender × Growth mindset | .007 | .102 | .031 | .073 | .942 |

*Note.* * $p < .05$; Dependent variable = STEM self-efficacy; Moderator = Gender

To further aid interpretation, predicted margins plots were generated for the interaction terms (see Figure 4). The plots show that although perceptions of STEM and growth mindset positively predicted STEM self-efficacy, the slopes for male and female pupils were largely parallel, reinforcing the non-significant moderation effects found in the regression analysis. Similarly, gender stereotypes and male-power stereotype showed weaker or inconsistent associations with self-efficacy, but again the effects did not differ across gender. Taken together, these findings indicate that the effects of gender stereotypes in STEM, male-power stereotype, perceptions of STEM, and growth mindset on STEM self-efficacy are consistent across both male and female pupils.

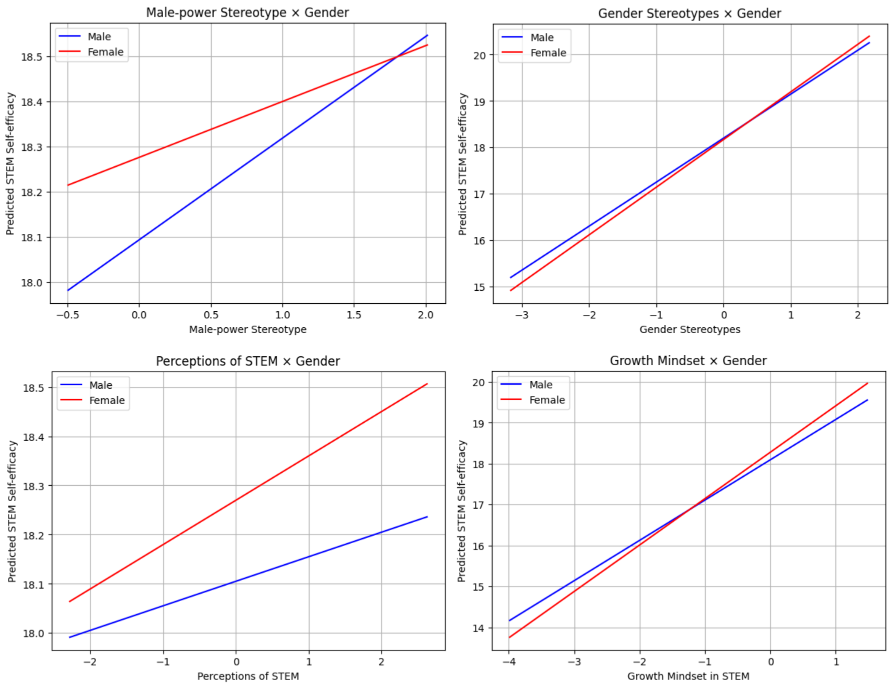


**Figure 4.** Predicted margins plots: Gender × Predictor Effects on STEM self-efficacy

## DISCUSSION

### Stereotypes, Perceptions, Mindset and Self-efficacy in STEM

The descriptive analysis provides valuable insights into the levels of gender stereotypes in STEM, male-power stereotype, perceptions of STEM, growth mindset, and STEM self-efficacy among primary school pupils. This difference suggests that male pupils may be more likely to internalise traditional views about gender roles in STEM, aligning with previous research indicating that such stereotypes remain prevalent from an early age and can shape pupils' academic choices and self-beliefs (Cheryan et al., 2015). In terms of perceptions of STEM, female pupils recorded slightly higher mean scores than their male counterparts, placing them in the high range, while males remained at a moderate level. This suggests that although both genders generally view STEM subjects positively, female pupils hold more favourable perceptions. This finding may reflect growing efforts to promote STEM engagement among girls, as well as the increasing visibility of female role models in STEM-related fields. Positive perceptions are important, as they are closely linked to motivation, interest, and long-term participation in STEM education.

Therefore, sustaining and strengthening these perceptions, particularly among girls, can be a valuable strategy for addressing gender gaps in STEM aspirations and career pathways. These findings are in line with research emphasising the need for inclusive STEM environments to support female engagement (Wang & Degol, 2017). Both male and female pupils demonstrated high levels of growth mindset in STEM, with females again scoring slightly higher confident in their potential to improve, they may not yet feel fully capable of applying their STEM knowledge and skills independently. This finding highlights a potential gap between belief in improvement and belief in performance, which may hinder pupils from fully engaging with challenging STEM tasks. Addressing this gap through targeted instructional strategies, such as providing mastery experiences, specific feedback, and scaffolded opportunities for success, could help translate growth-oriented beliefs into greater self-confidence and persistence in STEM learning (Schunk, 2022). The analysis of male-power stereotype revealed a clear tendency among both male and female pupils to associate dominant roles with males. This finding reflects a commonly held belief that equates power and authority with masculinity. In the Malaysian context, where traditional hierarchies and high-power distance remain culturally embedded, such perceptions are likely shaped by broader societal norms that position males in leadership roles. When internalised from a young age, these beliefs may influence how children perceive gender roles and authority, potentially limiting girls' confidence to lead or pursue ambitions in traditionally male-dominated fields such as STEM. Challenging these early assumptions is crucial for promoting more equitable perceptions of power and encouraging broader participation in STEM-related pathways, regardless of gender.

**Differences According to Gender**

The results of the MANOVA revealed significant gender differences in gender stereotypes related to STEM, with male pupils reporting higher levels than females. This finding supports prior studies by McGuire et al. (2020) and Koenig (2018), which argue that gendered assumptions about ability in STEM remain deeply embedded in many educational and cultural contexts. In Malaysia, these stereotypes are often reinforced by broader societal norms that associate technical competence and leadership with males (Idris et al., 2023). Since children at the primary level are especially receptive to social cues, exposure to such beliefs at an early age can shape their attitudes toward academic subjects and future aspirations. Without early intervention, these stereotypes may persist into adolescence and influence course selection and career intentions, particularly among girls (Idris et al., 2023; Chan, 2022). In contrast, no significant gender differences were found in perceptions of STEM, growth mindset, or STEM self-efficacy. This suggests that, despite underlying stereotypes, boys and girls in this study held similarly positive views of STEM, believed in their capacity to improve, and reported comparable confidence in their abilities. These findings suggest a promising trend: children's attitudes toward learning and effort in STEM may be shaped more by their classroom experiences and cultural values than by gender-based expectations. This is consistent with findings by Sriutaisuk et al. (2024), who noted that growth mindset interventions appeared to have a stronger impact on students in Southeast Asia compared to those in East Asia, possibly due to differences in educational values, classroom practices, and attitudes toward effort. In the Malaysian context, where perseverance and self-improvement are often emphasised, it is possible that such cultural values contribute to more uniform development of growth mindset and self-efficacy across genders. The absence of gender differences in these domains may reflect the influence of shared learning environments that encourage effort over ability, reducing the salience of gender in shaping academic self-concept during the primary years.

The Chi-square test examining gender differences in male-power stereotype revealed no significant difference between male and female pupils, suggesting that both groups similarly associate dominance with males. This reflects a shared perception of power being linked to masculinity, regardless of the child's own gender. These findings are consistent with previous research showing that children from France, Norway, and Lebanon consistently associated power with the male gender (Charafeddine et al., 2020). The absence of gender differences in male-power stereotype suggests that these beliefs may be shaped and reinforced through shared cultural and societal norms. In Malaysia, where traditional hierarchies and gender inequalities remain deeply embedded, children may internalise male-dominant views of leadership and authority from an early age. These early associations between gender and power may shape how children view their own potential and place within STEM fields. When male-associated traits are perceived as more aligned with success in STEM, this can influence children's developing self-efficacy and beliefs about who is more capable in these domains. Introducing early, gender-sensitive educational interventions may be essential to challenging these perceptions and promoting more equitable understandings of power and potential among all pupils.

**Factors that Predict STEM Self-Efficacy**

The multiple regression analysis showed that gender stereotypes in STEM, male-power stereotype, perceptions of STEM, and growth mindset collectively explained 24.9% of the variance in STEM self-efficacy. Among these predictors, growth mindset emerged as the strongest contributor, followed by perceptions of STEM. Gender stereotypes had a smaller but still significant effect, while male-power stereotype was not significant. These findings support Dweck's (2007) argument that pupils who believe their abilities can improve through effort are more likely to persist in challenging domains such as STEM. Likewise, positive perceptions of STEM were associated with higher self-efficacy, suggesting that pupils who find STEM enjoyable and manageable are more confident in their abilities. This result is consistent with Luo et al. (2021) study, which demonstrated that primary students' stereotypical beliefs regarding STEM careers negatively predicted their self-efficacy in STEM activities. From Bandura's (1977) perspective, these findings illustrate that growth mindset and perceptions of STEM function as proximal sources of STEM self-efficacy by facilitating mastery experiences (through persistence with challenging tasks) and vicarious learning (through observing relatable role models). In contrast, gender stereotypes reflect processes of stereotype internalisation, where pupils begin to absorb societal assumptions about who belongs in STEM. Although this influence was smaller, it aligns with research suggesting that stereotypes can shape expectations of competence, particularly when pupils encounter evaluative situations that activate stereotype threat.

Interestingly, the positive beta coefficient for gender stereotype warrants further consideration. One possibility is a suppression effect, where shared variance with other predictors produces an unexpected coefficient. Measurement artefacts may also explain this outcome, such as socially desirable responding or different interpretations of stereotype items. Cultural dynamics could be another factor: in some Malaysian contexts, pupils who endorse stereotypes may also view STEM as a prestigious field, linking it with stronger confidence in their own abilities. This echoes research showing that stereotypes can interact with achievement values in complex, context-dependent ways (Alan et al., 2018). Future research should examine whether this reflects methodological issues or meaningful developmental processes.

By contrast, the non-significant role of male-power stereotype suggests that broader societal beliefs about gender and dominance may not directly influence children's confidence in their STEM learning abilities. However, these beliefs may still shape classroom behaviour, peer dynamics, and participation in STEM-related activities. This interpretation is consistent with findings by Zhang and Gläscher (2020), who argue that implicit social cues can influence attitudes and decision-making even in the absence of changes in explicit self-perception. Within STEM learning environments, such cues may affect how pupils collaborate, respond to feedback, or assume roles during group-based problem-solving, potentially influencing their engagement and long-term development of STEM self-efficacy. This may indicate that while children recognise and articulate cultural norms linking power to masculinity, such schemas have not yet been fully internalised into domain-specific self-concepts like STEM efficacy. Developmental studies suggest that internalisation of abstract gender–power associations occurs earlier than their translation into academic self-beliefs, which may explain the absence of a direct predictive effect at the primary level. Together, these findings contribute to self-efficacy theory by highlighting that proximal cognitive factors (mindset, perceptions) exert stronger and more immediate effects on self-belief than distal sociocultural stereotypes.

The indirect influence of male-power stereotype also deserves attention in classroom contexts. Pupils who associate leadership and authority with males may be more likely to accept boys taking dominant roles in group tasks, decision-making, or class discussions. Such dynamics can limit girls' opportunities to practice leadership or assertiveness in STEM activities, shaping behavioural expressions of confidence even if self-reported efficacy remains unaffected. Over time, subtle differences in participation and peer recognition may accumulate, influencing long-term engagement in STEM. Future studies should investigate how classroom leadership roles, peer interactions, and teacher practices act as mediators of the male-power stereotype's effects on self-efficacy and STEM aspirations.

Although the model was statistically significant, a substantial portion of the variance in STEM self-efficacy remains unexplained. According to Bandura (1977), self-efficacy is influenced by multiple sources, including mastery experiences, vicarious learning, social persuasion, and emotional responses. Additional contributing factors not assessed in this study, but likely to interact with the measured variables, include pupils' actual achievement in STEM subjects, the quality of teacher support and classroom climate, and parental involvement and expectations (Tiew & Abdullah, 2022). Family support, in particular, functions as a form of social persuasion, where encouragement from parents reinforces pupils' belief in their abilities (Manukaram & Abdullah, 2021). These factors should be considered in future research to develop a more comprehensive understanding of what shapes children's STEM self-efficacy. Encouragingly, both male and female pupils in this study reported moderate to high levels of growth mindset and demonstrated similar perceptions of STEM, suggesting relatively balanced attitudes across genders at the primary school level. However, gender stereotypes continue to influence pupils' learning experiences, with boys more likely to display fixed mindsets and girls more frequently demonstrating persistence in the face of challenges. These findings highlight the need for early interventions that not only promote growth-oriented thinking but also address the subtle, enduring impact of gender stereotypes in STEM. Educational strategies that incorporate gender-inclusive STEM curricula highlight diverse and relatable role models, and provide interactive, hands-on learning opportunities can foster both confidence and resilience. Creating supportive classroom environments where all pupils, regardless of gender, can see themselves as capable and enthusiastic STEM learners is crucial for ensuring equitable and sustained participation in STEM fields.

**Moderating Effect of Gender**

The findings of this study indicate that gender does not significantly moderate the relationships between gender stereotypes in STEM, male-power stereotype, perceptions of STEM, and growth mindset with STEM self-efficacy. This implies that these factors influence STEM self-efficacy in similar ways for both male and female pupils. Although males demonstrated higher levels of gender stereotypes in STEM, these beliefs did not appear to differentially impact their self-efficacy. These results are consistent with Rahman and Halim (2022), who also found that gender had no significant effect on self-efficacy. Similarly, work on creative and domain-specific self-efficacy in Malaysian pupils has often reported only small or non-systematic gender differences (Hashim et al., 2022), and national reviews of STEM self-efficacy trends do not provide strong evidence of consistent gender moderation (Idris et al., 2023). This challenges the common assumption that gender stereotypes directly undermine children's confidence in their STEM abilities. The relatively limited influence of gender stereotypes observed in this study may be explained by the stronger role of other self-efficacy sources identified by Bandura (1977), such as mastery experiences, vicarious learning, social persuasion, and emotional responses. This reflects the multifaceted nature of self-efficacy, which is shaped by the dynamic interaction of cognitive, social, and emotional factors rather than by gender-related beliefs alone. Given that the findings highlight the importance of fostering growth mindsets and positive perceptions of STEM among all learners, as these were found to be stronger and more consistent predictors of STEM self-efficacy across genders. These findings are encouraging, as they suggest that strategies to enhance STEM self-efficacy do not need to be gender specific. For example, interventions that promote growth mindset and positive self-perceptions of STEM can benefit all students. This is supported by past studies (e.g., Master, 2021) that mindset- and perception-based interventions had positive effects regardless of gender. In line with these findings, the effectiveness of universal strategies in promoting engagement and confidence in STEM, through inclusive, well-designed approaches that support self-efficacy development regardless of gender, has been reinforced by findings in diverse classroom settings (Zhao et al., 2023).

## CONCLUSION

This study provides novel insights into the belief-based and gender-related factors that influence STEM self-efficacy among primary school pupils. By investigating gender stereotypes in STEM, male-power stereotype, growth mindset, and perceptions of STEM, the findings offer a clearer understanding of how STEM self-efficacy develops during the early years of formal education. Growth mindset and perceptions of STEM emerged as the strongest and most consistent predictors of self-efficacy, underscoring the central role of pupils' cognitive, and motivational beliefs in shaping confidence. These results lend empirical support to theoretical frameworks such as Bandura's (1977) social cognitive theory and Dweck's (2007) mindset theory and demonstrate their relevance in early STEM learning contexts. The consistency of these effects across male and female pupils suggests that strategies aimed at improving STEM self-efficacy through mindset and perception-building are broadly effective, regardless of gender. While gender stereotypes in STEM had a small but significant effect, their influence was notably weaker than that of growth mindset and perceptions of STEM. The non-significant role of male-power stereotype indicates that, although pupils may recognise social associations between gender and authority, these beliefs do not appear to directly shape their academic self-efficacy in STEM. However, such beliefs may still influence how pupils participate in group tasks, assume leadership roles, or interact with peers in STEM learning environments, which were not directly measured in this study.

Several limitations should be acknowledged. First, the cross-sectional design precludes conclusions about causality; longitudinal designs are needed to capture how self-efficacy develops over time. Second, the use of 3-point Likert scales may have constrained the variability in pupils' responses, suggesting future research adopt more sensitive scaling. Third, the sample was drawn from a single state in Malaysia, limiting generalisability across regions with different sociocultural dynamics. Fourth, despite careful back-translation, challenges in adapting items to Malay language for young learners may have influenced how some constructs were understood. Addressing these limitations through longitudinal, multi-level, and cross-regional studies would strengthen the robustness and generalisability of findings.

This study represents the first validated cultural adaptation of a gender-power attribution measure at the primary level in Malaysia, offering a foundation for future research in non-Western contexts. Beyond Bandura's and Dweck's frameworks, the findings can also be interpreted through the lens of the stereotype content model (Fiske et al., 2002), which highlights how warmth competence dimensions shape group perceptions, and developmental social cognition perspectives, which explain how children internalise and act upon cultural norms. By integrating these perspectives, future research can deepen theoretical understanding of how stereotypes, motivation, and self-beliefs interact in shaping STEM trajectories.

The findings carry important implications for classroom practice. Teachers can buffer the effects of gender stereotypes by deliberately promoting inclusive participation, such as rotating leadership roles in group work and highlighting contributions from both boys and girls. Embedding mastery-focused classroom activities, such as setting incremental challenges, providing constructive feedback, and celebrating persistence, can further strengthen pupils' growth mindset and perceptions of STEM. Teacher professional development programs that equip educators with strategies to recognise and counteract stereotype-driven dynamics are also vital.

## CONFLICT OF INTEREST

The authors reported no potential conflict of interest.

## DATA AVAILABILITY

The data from this study have been uploaded to Figshare and are publicly available at https://figshare.com/s/9c04fdd2bf81bb411f79

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## AUTHORS' CONTRIBUTIONS

Noor Shafika Mokhtar: Conceptualisation, methodology, formal analysis, investigation, data curation, writing – Original draft preparation.

Melissa Ng Lee Yen Abdullah: Conceptualisation, methodology, investigation, writing – review and editing, supervision, project administration, funding acquisition.

Hélène Maire: Methodology, writing – review and editing, supervision.

Rawan Charafeddine: Methodology, investigation, writing – review and editing, supervision.

Thomas Castelain: Methodology, investigation, writing – review and editing, supervision.

Jean-Baptiste van der Henst: Methodology, writing – review and editing

## STATEMENT OF ARTIFICIAL INTELLIGENCE (AI) USE

Artificial intelligence tools were used only to improve language clarity, sentence structure, and overall readability. The conceptualisation, data analysis, interpretation, and synthesis were entirely human-authored.

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