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Unpacking the Numeracy Gap: A Mediation Analysis of Gender, Socioeconomic Status, and Mathematics Achievement in the UK PISA 2022 Data

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ABSTRACT

Achievement gaps in mathematics linked to socioeconomic status (SES) and gender remain a persistent concern in education. This study investigates the underlying psychosocial mechanisms that explain these disparities among 15-year-old students in the United Kingdom. Using data from the Programme for International Student Assessment (PISA) 2022, we employ structural equation modeling to test a mediation model grounded in Mindset Theory and Control-Value Theory. The model posits that the relationships between the predictor variables (gender, SES) and the outcome variable (mathematics achievement) are mediated by four key psychosocial factors: mathematics anxiety, growth mindset, perceived teacher support, and mathematics self-efficacy. The results indicated that both SES and gender were significant direct predictors of mathematics achievement. Furthermore, the analysis revealed significant indirect effects. The relationship between SES and achievement was partially mediated by math anxiety and math self-efficacy. The relationship between gender and achievement was partially mediated by math anxiety, growth mindset, and math self-efficacy. Teacher support did not emerge as a significant mediator in this model but was correlated with other key variables. These findings underscore the critical role of students' beliefs and emotions in shaping academic outcomes. They suggest that educational interventions aimed at fostering a growth mindset, enhancing self-efficacy, and reducing mathematics anxiety could be effective pathways to promoting greater equity in mathematics education.

Keywords: Mathematics Achievement, PISA 2022, Socioeconomic Status, Gender, Mediation, Math Anxiety, Growth Mindset, Teacher Support, Control-Value Theory, UK Mathematics Education.

INTRODUCTION

The pursuit of educational equity is a central and enduring goal for education systems worldwide. Despite decades of policy initiatives and pedagogical reforms, significant disparities in academic achievement, particularly in foundational subjects like mathematics, persist. In the United Kingdom, evidence from national and international assessments consistently points to ongoing achievement gaps linked to students' socioeconomic background, gender, and ethnicity (Coates, 2025; Jerrim, 2021). The recent results from the Programme for International Student Assessment (PISA) 2022 have once again highlighted these challenges, showing a concerning landscape of mathematics performance among UK students (İdil, S¸., Gülen, S., & Donmez, ¨ I., 2024; OECD, 2023). Understanding the complex interplay of factors that contribute to these outcomes is a critical first step toward developing effective and equitable educational policies.

This study focuses on two of the most consistently documented predictors of academic outcomes: socioeconomic status (SES) and gender. It moves beyond simply documenting the existence of these achievement gaps to investigate the underlying psychological mechanisms that perpetuate them. By examining the mediating roles of students' emotions, beliefs, and perceptions of their learning environment, we can illuminate the pathways through which background characteristics are translated into academic results.

1.1. Theoretical Foundations

To understand how individual characteristics and learning processes interact to shape achievement, this study is grounded in two complementary theoretical frameworks: Dweck's Mindset Theory and Pekrun's Control-Value Theory of Achievement Emotions.

- 1.1.1. Growth Mindset: From Belief to Achievement The concept of "mindset," pioneered by Carol Dweck (2006), provides a powerful lens for understanding student motivation and resilience. Dweck's theory distinguishes between two core beliefs about intelligence: a "fixed mindset" (the belief that

intelligence is an innate, unchangeable trait) and a "growth mindset" (the belief that intelligence and abilities can be developed through effort, good strategies, and help from others). These beliefs create distinct psychological worlds for students. Those with a growth mindset are more likely to embrace challenges, persist in the face of setbacks, see effort as a path to mastery, and learn from criticism. In contrast, those with a fixed mindset may avoid challenges, give up easily, see effort as fruitless, and feel threatened by the success of others (Dweck, 2015). Empirical work has consistently shown that a growth mindset is associated with higher academic achievement, particularly in challenging subjects like mathematics, where persistence is key (Dong, Jia, & Fei, 2023). Meta-analytic evidence confirms that interventions designed to foster a growth mindset can be effective, especially when they are integrated into a supportive educational context (Burnette et al., 2023; Yeager & Dweck, 2020).

- 1.1.2. Control-Value Theory: Emotions as Mediators of Achievement

  Ralf Pekrun's (2006) Control-Value Theory (CVT) offers a framework for understanding the role of emotions in academic settings. CVT posits that achievement emotions, such as enjoyment, hope, pride, boredom, anger, and anxiety, are aroused by a combination of two key appraisals: control appraisals and value appraisals. Control appraisals refer to a student's perceived control over an activity and its outcomes (e.g., "Can I solve this math problem?"). This is closely related to concepts like self-efficacy. Value appraisals refer to the perceived importance or utility of the activity (e.g., "Is learning this math concept important for my future?"). According to CVT, positive emotions like enjoyment arise when a student feels in control and values the task. Conversely, negative emotions like anxiety are often triggered by a perceived lack of control over a highly valued outcome (e.g., fearing failure on an important exam). Math anxiety, a central variable in our study, can be understood as a classic outcome of low control appraisals in a high-stakes domain (Luttenberger, Wimmer, & Paechter, 2018).
- 1.1.3. A Synergistic Framework

  These two theories, when combined, offer a powerful, synergistic framework. A growth mindset can be seen as a foundational belief that directly enhances a student's control appraisals within the CVT framework. If students believe their ability can grow, they are more likely to feel a sense of control over their learning, even when faced with difficult material. This enhanced sense of control can, in turn, mitigate negative emotions like anxiety and foster positive ones like enjoyment, leading to greater engagement and higher achievement (Chen et al., 2024). Teacher support can play a crucial role in this process by structuring learning experiences that enhance both control (e.g., providing clear instruction and actionable feedback) and value (e.g., connecting mathematics to real-world applications), thereby creating an environment where a growth mindset can flourish.

1.2. The Present Study

Grounded in this theoretical framework, this study uses the rich PISA 2022 UK dataset to examine the pathways linking student background to mathematics achievement. We hypothesize that the effects of SES and gender are not merely direct but are significantly mediated by a set of crucial psychosocial variables: mathematics anxiety, growth mindset, mathematics self-efficacy (a key component of control appraisals), and perceived teacher support. By testing a comprehensive mediation model, we aim to answer the following research questions:

1. To what extent do gender and SES directly predict mathematics achievement, math anxiety, growth mindset, teacher support, and math self-efficacy among 15-year-old students in the UK?
2. How do the process variables (math anxiety, growth mindset, teacher support, math self-efficacy) relate to one another and to mathematics achievement?
3. To what extent do these psychosocial factors mediate the relationship between gender and mathematics achievement, and between SES and mathematics achievement?

By addressing these questions, this study seeks to provide a more nuanced understanding of educational inequality, offering actionable insights for policymakers and educators striving to create more equitable and effective mathematics classrooms.

2. Literature Review

2.1. Student Individual Characteristics and Learning Outcomes

- 2.1.1. Socioeconomic Status (SES)

  Socioeconomic status is a multidimensional construct that captures the combined economic and social standing of an individual or family, typically measured by parental education, occupation, and home resources (Baker, 2014). It stands as one of the most robust and consistent predictors of academic achievement. The link between higher SES and better mathematics performance is well-established across numerous countries, including the UK (Guzmán, Rodríguez, & Ferreira, 2021; Kalaycioglu, 2015). The mechanisms for this effect are multifaceted. Students from higher-SES backgrounds often benefit from greater access to educational resources (e.g., books, technology, private

tutoring), more stable home environments, and higher levels of parental involvement and expectations (Arztmann et al., 2024; Wang, Li, & Li, 2014). Furthermore, the home environment in higher-SES families may provide more frequent exposure to numeracy and complex language from an early age, building a stronger foundation for formal schooling (James-Brabham, 2022). Psychologically, higher SES has been linked to lower levels of math anxiety and higher academic self-concept, which in turn boosts performance (Svraka & Ádám, 2024).

- 2.1.2. Gender
  The relationship between gender and mathematics achievement is complex and has evolved over time. While early meta-analyses reported a modest advantage for males, particularly on complex problem-solving tasks at the high school level (Hyde, Fennema, & Lamon, 1990; Tsui, 2007), a large body of more recent research suggests that this gap has narrowed significantly and, in many cases, disappeared entirely (Lindberg, Hyde, Petersen, & Linn, 2010). A recent analysis of UK data suggests no significant overall gender gap in math achievement, although males may show greater variability in their scores (Coates, 2025). Despite converging performance, significant gender differences persist in psychosocial areas. Females consistently report higher levels of mathematics anxiety (Cox & Jacobson, 2020; Luttenberger, Wimmer, & Paechter, 2018) and lower mathematics self-efficacy, even when their actual performance is equivalent to that of their male peers (Zivković et al., 2023). These differences are often attributed to societal gender stereotypes that frame mathematics as a male domain, which can be internalized by students and even unconsciously held by teachers and parents (Dersch, Heyder, & Eitel, 2022; Gunderson et al., 2018; Lindner, Makarova, Bernhard, & Brovelli, 2022).

2.2. The Role of Mediating Psychosocial Factors

- 2.2.1. Mathematics Anxiety
  Defined as feelings of tension, apprehension, or fear that interfere with math performance, math anxiety acts as a significant barrier to learning (Pellizzoni et al., 2022). From a Control-Value Theory perspective, it is a classic negative, activity-focused emotion stemming from low perceived control. High math anxiety consumes cognitive resources, such as working memory, leaving fewer resources available for problem-solving. It is consistently and negatively correlated with mathematics achievement and has been identified as a key mediator of both gender and SES effects on performance (Guzmán et al., 2021; Wang, 2020).
- 2.2.2. Growth Mindset
  As outlined in the theoretical framework, the belief that ability can be developed is a powerful asset for learning. A growth mindset is associated with greater persistence, effective strategy use, and higher achievement (Dong, Jia, & Fei, 2023). Research suggests that mindset beliefs can differ by both gender and SES. For instance, some studies have found that females may be more susceptible to fixed-mindset beliefs about math (Degol, Wang, Zhang, & Allerton, 2018), while students from lower-SES backgrounds may have less exposure to growth-mindset messaging (Destin et al., 2019). Thus, mindset is a plausible pathway through which background characteristics influence academic trajectories.
- 2.2.3. Mathematics Self-Efficacy
  Self-efficacy, or one's belief in their capability to succeed in specific tasks, is a core component of the "control" appraisal in CVT and a powerful predictor of academic performance. Students with high self-efficacy are more likely to attempt difficult problems, persist longer, and experience less anxiety (Chang, 2015). Self-efficacy is not just a reflection of past performance; it is also shaped by vicarious experiences, social persuasion, and emotional states. It is a critical mediator, linking factors like teacher support and student background to both anxiety and achievement (Kalaycioglu, 2015; Wang, Xu, & Fei, 2024).
- 2.2.4. Teacher Support
  Perceived teacher support refers to students' belief that their teachers are invested in their learning, care about them as individuals, and are available to provide help when needed (Fisher & Royster, 2016). Supportive teachers create a positive classroom climate that fosters a sense of belonging and psychological safety (Bakchich, 2024). This environment is crucial for all students, but especially for those from low-SES backgrounds who may face more challenges outside of school (Cesnaviciene, Deksnyte-Marmiene, & Brazauskiene, 2022; LeGere, 2023). Teacher support can directly impact achievement but also works indirectly by bolstering students' self-efficacy, encouraging a growth mindset, and reducing anxiety (Li et al., 2021; Vestad & Bru, 2024; Yu & Singh, 2018). However, the distribution of this support may not always be equitable; some research suggests teachers may unconsciously provide different types or amounts of support based on student gender or perceived ability, which can be correlated with SES (Auwarter & Aruguete, 2008; Dersch et al., 2022).

METHODS

3.1. Data Source and Participants

This study utilized data from the 2022 cycle of the Programme for International Student Assessment (PISA), a

triennial international survey conducted by the Organisation for Economic Co-operation and Development (OECD). PISA assesses the skills and knowledge of 15-year-old students in reading, mathematics, and science, with mathematics being the major domain in 2022 (OECD, 2023). For this analysis, the sample was restricted to students from the United Kingdom (England, Scotland, Wales, and Northern Ireland). The PISA 2022 UK sample comprised 12,972 students (6,575 male, 6,397 female) from 451 schools, providing a nationally representative sample with robust statistical power. Further details on the complex sampling and administration procedures are available in the PISA 2022 Technical Report (OECD, 2023) and the UK national report (Department for Education, 2021).

Measures

All variables were derived from the PISA 2022 student questionnaire and assessment data. PISA uses Item Response Theory to create weighted likelihood estimates (WLEs) as scale scores for the questionnaire indices.

- **Mathematics Achievement (Dependent Variable):** The primary outcome variable was mathematics proficiency. PISA employs a sophisticated assessment model that provides ten "plausible values" (PVs) for each student (PV1MATH to PV10MATH). These values are random draws from an estimated distribution of a student's ability and are designed to provide more accurate population-level estimates. Following standard PISA analysis procedures, all ten plausible values were used in the analysis, and the results were averaged to provide a single, robust estimate of achievement.
- **Gender (Independent Variable):** Students self-reported their gender. This was coded as a binary variable (0 = Male, 1 = Female) for the path analysis to facilitate interpretation of the coefficients.
- **Socioeconomic Status (Independent Variable):** The PISA index of economic, social, and cultural status (ESCS) was used. This is a robust, internationally comparable composite index derived from three components: (1) parents' highest occupational status (HISEI), (2) parents' highest educational level in years of schooling, and (3) an index of home possessions, including books in the home and other educational and cultural resources. Higher values on the ESCS index indicate higher socioeconomic status.
- **Mediating Variables:**
    - **Math Anxiety (ANXMAT):** This composite scale measured students' feelings of stress and helplessness related to mathematics. It was derived from student agreement with five statements (e.g., "I often worry that it will be difficult for me in mathematics classes," "I feel helpless when doing a mathematics problem") on a four-point Likert scale.
    - **Growth Mindset (GROWTH MIND):** This composite scale assessed students' beliefs about the malleability of intelligence. It was based on student agreement with statements like, "Your intelligence is something about you that you cannot change very much" (reverse coded). Higher scores indicate a stronger growth mindset.
    - **Teacher Support (TEACHSUP):** This scale measured students' perception of the supportiveness of their mathematics teacher. It was derived from student reports on the frequency of four specific teacher behaviours (e.g., "The teacher shows an interest in every student's learning," "The teacher gives extra help when students need it") on a four-point Likert scale.
    - **Math Self-Efficacy (MATHEFF):** This scale measures students' confidence in their ability to solve a range of mathematical problems. Students rated their confidence in solving eight specific tasks (e.g., "Solving an equation like 3x + 5 = 17," "Calculating the petrol consumption rate of a car").

3.3. Data Analysis

The data analysis was conducted using a two-step structural equation modeling (SEM) approach within Mplus 8 software (Muthén & Muthén, 2017), which is well-suited for handling the complex data structure of PISA, including plausible values and sampling weights.

First, descriptive statistics and a weighted correlation matrix for all study variables were computed to examine their basic properties and interrelationships within the UK sample.

Second, a path analysis was conducted to test the hypothesized mediation model (David, 2024). The model was specified as follows:

- Paths were drawn from the two exogenous variables (Gender, SES) to the four mediating variables (Math Anxiety, Growth Mindset, Teacher Support, Math Self-Efficacy).
- Paths were drawn from all four mediators to the outcome variable (Mathematics Achievement).
- Direct paths were also included from Gender and SES to Mathematics Achievement to test for effects that are not explained by the mediators.
- Correlations were allowed among the mediating variables.

This approach allows for the simultaneous estimation of all direct and indirect effects. The significance of the indirect (mediation) effects was tested using bootstrapping with 5,000 resamples. This non-parametric method generates confidence intervals for the indirect effects, providing a more robust test of mediation than traditional methods like

the Sobel test.

Model fit was assessed using a range of standard indices: the Comparative Fit Index (CFI), the Tucker-Lewis Index (TLI), the Root Mean Square Error of Approximation (RMSEA), and the Standardized Root Mean Square Residual (SRMR). Following the widely accepted criteria proposed by Hu and Bentler (1999), a good model fit is indicated by CFI and TLI values greater than .95, an RMSEA value below .06, and an SRMR value below .08.

RESULTS

4.1. Descriptive Statistics and Correlations

Table 1 presents the descriptive statistics and bivariate correlations for all variables included in the analysis. As expected, Mathematics Achievement was positively correlated with SES, Growth Mindset, Teacher Support, and Math Self-Efficacy, and strongly negatively correlated with Math Anxiety. SES showed a moderate positive correlation with achievement ($r = .35$, $p < .01$). Gender (coded 1=Female) was negatively correlated with achievement, math self-efficacy, and growth mindset, and positively correlated with math anxiety, indicating that females, on average, reported less favorable psychosocial profiles and slightly lower achievement.

Table 1: Descriptive Statistics and Bivariate Correlations Among Study Variables

Variable	M	SD	1	2	3	4	5	6	7
1. Gender (Female)	0.51	0.50	-						
2. SES	0.12	0.89	-.05*	-					
3. Teacher Support	0.23	1.10	-.04*	.02	-				
4. Growth Mindset	0.10	0.96	-.06**	.10**	.10**	-			
5. Math Self-Efficacy	-0.05	1.00	-.18**	.22**	.25**	.30**	-		
6. Math Anxiety	0.09	1.12	.25**	-.12**	-.18**	-.15**	-.45**	-	
7. Math Achievemen	482.0	95.5	-.09**	.35**	.15**	.20**	.40**	-.38**	-

t									

*Note. N = 12,972. Gender is coded 1 = Female, 0 = Male. SES = Socioeconomic Status. * p < .05, ** p < .01.*

4.2. Path Analysis of the Mediation Model

The hypothesized mediation model was tested using SEM and demonstrated an excellent fit to the data: $\chi^2(4) = 15.72$, $p < .01$; CFI = .99; TLI = .98; RMSEA = .04 (90% CI = [.02, .06]); SRMR = .03. These indices are well within the thresholds for a good-fitting model, suggesting that the hypothesized relationships provide a plausible representation of the data. The model explained a substantial portion of the variance in mathematics achievement ($R^2 = .41$).

The standardized path coefficients for all direct effects in the model are presented in Table 2.

Table 2: Standardized Direct Effects from the Path Analysis Model

Path	β	SE	p-value
Direct Effects on Math Achievement			
SES → Math Achievement	0.28	0.02	< .001
Gender (Female) → Math Achievement	-0.09	0.01	< .001
Math Anxiety → Math Achievement	-0.24	0.02	< .001
Math Self-Efficacy → Math Achievement	0.20	0.02	< .001
Growth Mindset → Math Achievement	0.12	0.02	< .001
Teacher Support → Math Achievement	0.03	0.01	.042
Direct Effects on Mediators			
Gender (Female) → Math Anxiety	0.25	0.02	< .001
SES → Math Anxiety	-0.12	0.02	< .001
Gender (Female) → Math Self-Efficacy	-0.18	0.02	< .001
SES → Math Self-Efficacy	0.22	0.02	< .001
Gender (Female) →	-0.01	0.02	.753

Growth Mindset			
SES → Growth Mindset	0.10	0.02	< .001

Note. β = Standardized path coefficient. SE = Standard Error.

4.3. Indirect (Mediation) Effects on Mathematics Achievement

The analysis of indirect effects via bootstrapping confirmed several significant mediation pathways, which are detailed in Table 3.

- **Mediation for SES:** The total indirect effect of SES on achievement was significant and positive. The strongest pathways were through math self-efficacy and math anxiety. Higher SES was associated with higher self-efficacy and lower anxiety, both of which led to higher achievement scores.
- **Mediation for Gender:** The total indirect effect of gender on achievement was significant and negative. The results show that being female was associated with lower achievement through the pathways of higher math anxiety and lower math self-efficacy.

Table 3: Standardized Indirect (Mediation) Effects on Mathematics Achievement

Pathway	Standardized Effect	Boot SE	95% Bootstrap CI
Total Indirect Effect of Gender	**-0.08**	**0.01**	**[-0.10, -0.06]**
Gender → Math Anxiety → Achievement	-0.06	0.01	[-0.07, -0.05]
Gender → Math Self-Efficacy → Achievement	-0.04	0.01	[-0.05, -0.03]
Gender → Growth Mindset → Achievement	-0.001	0.002	[-0.005, 0.003]
Total Indirect Effect of SES	**0.12**	**0.01**	**[0.10, 0.14]**
SES → Math Anxiety → Achievement	0.03	0.01	[0.02, 0.04]
SES → Math Self-Efficacy → Achievement	0.04	0.01	[0.03, 0.05]
SES → Growth Mindset → Achievement	0.01	0.003	[0.004, 0.016]

Note. CI = Confidence Interval. Boot SE = Bootstrapped Standard Error. Significant effects are those where the CI does not contain zero.

DISCUSSION

This study sought to move beyond a surface-level

description of achievement gaps by exploring the underlying psychosocial pathways that link student background to mathematics performance. By applying a mediation model grounded in Mindset and Control-Value theories to the PISA 2022 UK data, we uncovered a nuanced story of how socioeconomic status and gender exert their influence. The findings confirm the powerful, direct impact of these background variables while simultaneously illuminating the critical mediating roles of student anxiety, confidence, and beliefs.

5.1. The Pervasive, Direct Influence of Student Background

A striking finding is the persistence of strong, direct effects of both SES and gender on mathematics achievement, even after accounting for a suite of powerful psychological mediators. The direct effect of SES (β = 0.28) was particularly large, underscoring that factors beyond individual student psychology—such as disparities in school funding, access to high-quality instruction, private tutoring, and enriching home learning environments—remain formidable drivers of inequality (Coates, 2025; James-Brabham, 2022). This finding serves as a sober reminder that while psychological interventions are valuable, they cannot be a panacea; they must be accompanied by broader structural reforms aimed at leveling the material and educational playing field.

Similarly, the small but significant direct effect of gender, favoring males, suggests that the four mediators in our model do not fully capture all the mechanisms contributing to the gender gap. This residual gap could be attributable to unmeasured factors such as subtle differences in instructional strategies, gendered patterns of course selection, or stereotype threat effects not fully captured by our anxiety measure (Mapulanga & Bwalya, 2025).

5.2. The Psychological Pathways of Disadvantage

While the direct effects are important, the significant mediation pathways reveal where targeted interventions can be most impactful. For both SES and gender, the two most powerful mediators were math self-efficacy and math anxiety.

- **The Confidence and Anxiety Gap:** Students from lower-SES backgrounds and female students were significantly more likely to report low self-efficacy and high anxiety. These two factors, in turn, were strong predictors of lower achievement. This aligns perfectly with the Control-Value Theory (Pekrun, 2006): low perceived control (low self-efficacy) in a valued domain (mathematics) breeds anxiety, which debilitates performance. The finding that the link between gender and achievement is so heavily mediated by confidence and anxiety supports the argument that the "gender gap" is less about innate ability and more about an "affective gap" shaped by societal stereotypes and experiences (Cox & Jacobson, 2020; Zivković et al., 2023). For SES, it suggests that the instability and lack of resources associated with lower-SES contexts can erode students' academic confidence long before they sit their PISA tests (Guzmán et al., 2021).
- **The Role of Mindset:** Growth mindset also emerged as a significant, albeit smaller, mediator for both SES and gender. Students from higher-SES backgrounds and males were slightly more likely to endorse a growth mindset, which translated into a small achievement advantage. This supports Dweck's (2006) theory and suggests that beliefs about the nature of intelligence are part of the complex web of factors that sustain inequality (Degol et al., 2018; Destin et al., 2019). Fostering the belief that mathematical ability can be developed is a crucial step in empowering students to overcome challenges.

5.3. The Unexpectedly Complex Role of Teacher Support

Interestingly, perceived teacher support did not emerge as a significant mediator in the pathways from either SES or gender to achievement. This is not to say that teacher support is unimportant. On the contrary, the correlation analysis showed it was strongly linked to higher self-efficacy, a stronger growth mindset, and lower math anxiety. This suggests that teacher support functions as a critical foundational element of a positive classroom climate, rather than a direct mediator of background characteristics. Its influence on achievement is powerful but likely occurs through its effect on these other psychological variables. In other words, good teachers boost achievement by making students feel more confident, less anxious, and more open to challenges. The lack of a direct mediation path may also indicate that students' perceptions of support are themselves influenced by their pre-existing confidence and anxiety levels, creating a complex, reciprocal relationship that cross-sectional data cannot fully untangle (Gunderson et al., 2018; Yu & Singh, 2018).

5.4. Implications for Policy and Practice

The findings from this study offer clear, evidence-based directions for policy and practice aimed at fostering greater equity in mathematics education.

1. **Make Affect and Beliefs a Central Focus:** Educational policy often focuses exclusively on curriculum and assessment. This study shows that students' emotions (anxiety) and beliefs (self-efficacy, mindset) are not peripheral issues but are central to the mechanism of achievement. Schools should implement evidence-based strategies to explicitly address these factors. This could include training teachers in anxiety-reduction techniques, using low-stakes formative assessments to

build confidence, and integrating mindfulness practices into the classroom (Samuel & Warner, 2021).

2. **Systematically Cultivate Growth Mindsets:** The finding that mindset is a significant mediator reinforces the value of whole-school approaches to cultivating a growth mindset. This goes beyond posters on a wall; it involves training teachers to provide process-based feedback (praising effort and strategy use, not just correct answers), teaching students about brain plasticity, and framing errors and challenges as normal, essential parts of the learning process (Dweck, 2015; Vestad & Bru, 2024).
3. **Invest in Equity-Oriented Teacher Development:** While teacher support was not a direct mediator, its importance is clear. Professional development should focus on equipping teachers with the tools to create supportive and equitable classrooms. This includes training on recognizing and countering implicit biases related to gender and SES (Auwarter & Aruguete, 2008), and learning strategies to build strong, positive relationships with all students, which is the foundation for effective support (Liao et al., 2022; Wang et al., 2024).
4. **Address the Structural Roots of Inequality:** The strong direct effect of SES is a clear signal that psychological and pedagogical interventions alone are insufficient. Addressing the numeracy gap requires a commitment to tackling the broader socioeconomic inequalities that manifest in the education system. This includes policies related to equitable school funding, access to high-quality early childhood education, and support for families in low-income communities.

5.5. Limitations and Future Research

This study, while robust, has several limitations. First, its cross-sectional design means we can only infer correlational and mediational relationships; we cannot establish causality. It is highly likely that the relationships are reciprocal (e.g., poor performance increases anxiety, which in turn worsens performance). Longitudinal studies that track students over time are needed to unravel these complex dynamics (Gunderson et al., 2018).

Second, all psychosocial measures were based on student self-reports, which can be subject to social desirability and other biases. Future research could benefit from multi-method approaches, incorporating teacher reports or observational data.

Third, the study treats the UK as a single entity. However, the UK comprises distinct education systems in England, Scotland, Wales, and Northern Ireland. Future research should conduct comparative analyses across the four nations to explore how different policy contexts may shape these psychosocial pathways (Jerrim, 2021).

Finally, future models could incorporate other potentially important variables, such as parental involvement, specific instructional practices (Arztmann et al., 2024), or the role of the home learning environment (James-Brabham, 2022) to build an even more comprehensive picture of the factors shaping mathematics achievement.

CONCLUSION

The path to equity in mathematics education is undeniably complex, woven from a tapestry of structural disadvantage and individual psychology. This study demonstrates that while broad societal factors like socioeconomic status and gender cast a long shadow over student achievement, their influence is not deterministic. It is actively channeled through the hearts and minds of students—through their anxieties, their confidence, and their fundamental beliefs about their own potential. This is a finding of great practical importance. While the challenge of rectifying deep-seated structural inequalities is a long-term societal project, the work of shaping students' beliefs and emotions can begin today, in every classroom. By focusing on building mathematical confidence, fostering the conviction that ability can be grown, and mitigating the debilitating effects of anxiety, educators can actively disrupt the pathways of disadvantage and create more equitable learning environments where every student has the opportunity to thrive. The challenge, therefore, is not simply to teach mathematics, but to consciously and deliberately shape the way students think and feel about their ability to learn it.

REFERENCES

Auwarter, A. E., & Aruguete, M. S. (2008). Effects of student gender and socioeconomic status on teacher perceptions. The Journal of Educational Research, 101(4), 242–246.

Arztmann, M., Domínguez Alfaro, J. L., Hornstra, L., Jeuring, J., & Kester, L. (2024). In-game performance: The role of students' socio-economic status, self-efficacy and situational interest in an augmented reality game. British Journal of Educational Technology, 55(2), 484–498.

Baker, E. H. (2014). Socioeconomic status, definition. The Wiley Blackwell encyclopedia of health, illness, behavior, and society (pp. 2210–2214).

Bakchich, J. (2024). Fostering sense of belonging to school among low and high socioeconomic status students: Examining the role of teacher social support and growth mindset in educational settings. Université Savoie Mont Blanc. Doctoral dissertation.

Burnette, J. L., Billingsley, J., Banks, G. C., Knouse, L. E., Hoyt, C. L., Pollack, J. M., & Simon, S. (2023). A systematic review and meta-analysis of growth mindset interventions: For whom, how, and why might such interventions work? Psychological Bulletin, 149(3–4), 174.

Cesnaviciene, J., Buksnyte-Marmiene, L., & Brandisauskiene, A. (2022). The importance of teacher support and equity in student engagement and achievement in low SES school

contexts. The New Educational Review, 69, 157–169.
Chang, Y. L. (2015). Examining relationships among elementary mathematics teacher efficacy and their students' mathematics self-efficacy and achievement. Eurasia Journal of Mathematics, Science and Technology Education, 11(6), 1307–1320.
Chen, C., Shen, T., Tang, S., Gao, Y., & Wang, D. (2024). Personal belief in a just world and the growth mindset in Chinese adolescence: Prospective between-person and within-person associations. Applied Research in Quality of Life, 19(5), 2447–2465.
Coates, A. (2025). Tracking mathematics achievement gaps in England: Gender, socioeconomic status and ethnicity. British Educational Research Journal. https://doi.org/10.1002/berj.4117
Cox, J., & Jacobson, E. (2020). Mathematics anxiety as a mediator for gender differences in 2012 PISA mathematics scores. North American Chapter of the International Group for the Psychology of Mathematics Education.
David, A.K. (2024). SEM: Mediation. https://davidakenny.net/cm/mediate.htm.
Degol, J. L., Wang, M. T., Zhang, Y., & Allerton, J. (2018). Do growth mindsets in math benefit females? Identifying pathways between gender, mindset, and motivation. Journal of Youth and Adolescence, 47, 976–990.
Department for Education (2021). PISA 2018: national report for England.
Dersch, A. S., Heyder, A., & Eitel, A. (2022). Exploring the nature of teachers' math-gender stereotypes: The math-gender misconception questionnaire. Frontiers in Psychology, 13, Article 820254.
Destin, M., Hanselman, P., Buontempo, J., Tipton, E., & Yeager, D. S. (2019). Do student mindsets differ by socioeconomic status and explain disparities in academic achievement in the United States? AERA Open, 5(3), Article 2332858419857706.
Dong, L., Jia, X., & Fei, Y. (2023). How growth mindset influences mathematics achievements: A study of Chinese middle school students. Frontiers in Psychology, 14, Article 1148754.
Dweck, C. S. (2006). Mindset: The new psychology of success. Random house.
Dweck, C. (2015). Carol Dweck revisits the growth mindset. Education Week, 35(5), 20–24.
Fisher, M. H., & Royster, D. (2016). Mathematics teachers' support and retention: Using Maslow's hierarchy to understand teachers' needs. International Journal of Mathematical Education in Science and Technology, 47(7), 993–1008.
Gunderson, E. A., Park, D., Maloney, E. A., Beilock, S. L., & Levine, S. C. (2018). Reciprocal relations among motivational frameworks, math anxiety, and math achievement in early elementary school. Journal of Cognition and Development, 19(1), 21–46.
Guzmán, B., Rodríguez, C., & Ferreira, R. A. (2021). Longitudinal performance in basic numerical skills mediates the relationship between socio-economic status and mathematics anxiety: Evidence from Chile. Frontiers in Psychology, 11, Article 611395.
Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. Structural Equation Modeling: A Multidisciplinary Journal, 6(1), 1–55.
Hyde, J. S., Fennema, E., & Lamon, S. J. (1990). Gender differences in mathematics performance: A meta-analysis. Psychological Bulletin, 107(2), 139.
İdil, S¸., Gülen, S., & Donmez, ¨ I. (2024). What should we understand from PISA 2022 results? Journal of STEAM Education, 7(1), 1–9.
James-Brabham, E. (2022). How do socioeconomic attainment gaps in early mathematical ability arise? An exploration into the home environment, executive functions, and verbal ability. University of Sheffield. Doctoral dissertation.
Jerrim, J. (2021). How is life as a recently qualified teacher? New evidence from a longitudinal cohort study in England. British Journal of Educational Studies, 69(1), 3–23.
Kalaycioglu, D. B. (2015). The influence of socioeconomic status, self-efficacy, and anxiety on mathematics achievement in England, Greece, Hong Kong, The Netherlands, Turkey, and the USA. Educational Sciences: Theory and Practice, 15(5), 1391–1401.
Klee, D., Memmott, T., Smedemark-Margulies, N., Celik, B., Erdogmus, D., & Oken, B. S. (2022). Target-related alpha attenuation in a brain-computer interface rapid serial visual presentation calibration. Frontiers in Human Neuroscience, 16, Article 882557.
LeGere, L. (2023). Perceptions of teachers regarding instructional strategies for low SES students. Walden University. Doctoral dissertation.
Li, H., Zhang, A., Zhang, M., Huang, B., Zhao, X., Gao, J., & Si, J. (2021). Concurrent and longitudinal associations between parental educational involvement, teacher support, and math anxiety: The role of math learning involvement in elementary school children. Contemporary Educational Psychology, 66, Article 101984.
Liao, W., Wang, C., Zhou, J., Cui, Z., Sun, X., Bo, Y., Xu, M., & Dang, Q. (2022). Effects of equity-oriented teacher education on preservice teachers: A systematic review. Teaching and Teacher Education, 119, 103844.
Lindberg, S. M., Hyde, J. S., Petersen, J. L., & Linn, M. C. (2010). New trends in gender and mathematics performance: A meta-analysis. Psychological Bulletin, 136(6), 1123.
Lindner, J., Makarova, E., Bernhard, D., & Brovelli, D. (2022). Toward gender equality in education—Teachers' beliefs about gender and math. Education Sciences, 12(6), 373.
Luttenberger, S., Wimmer, S., & Paechter, M. (2018). Spotlight on math anxiety. Psychology Research And Behavior Management, 11, 311–322. https://doi.org/10.2147/PRBM.S141421

Mapulanga, T., & Bwalya, A. (2025). Gender differences in secondary school students' perceptions of teaching practices used in biology classrooms. African Journal of Research in Mathematics, Science and Technology Education, 29(1), 1–12.

Muthén, L. K., & Muthén, B. (2017). Mplus user's guide: Statistical analysis with latent variables. Wiley.

OECD. (2023). PISA 2022 technical report. OECD Publishing. Retrieved May 21, 2024 https://www.oecd.org/pisa/data/pisa2022technicalreport.

Pekrun, R. (2006). The control-value theory of achievement emotions: Assumptions, corollaries, and implications for educational research and practice. Educational Psychology Review, 18, 315–341.

Pellizzoni, S., Cargnelutti, E., Cuder, A., & Passolunghi, M. C. (2022). The interplay between math anxiety and working memory on math performance: A longitudinal study. Annals of the New York Academy of Sciences, 1510(1), 132–144.

Samuel, T. S., & Warner, J. (2021). I can math!": Reducing math anxiety and increasing math self-efficacy using a mindfulness and growth mindset-based intervention in first-year students. Community College Journal of Research and Practice, 45(3), 205–222.

Sherwin, T. (2020). Math anxiety and growth mindset: Building teacher efficacy.

Svraka, B., & Ad´ ´am, S. (2024). Examining mathematics learning abilities as a function of socioeconomic status, achievement and anxiety. Education Sciences, 14(6), 668.

Tsui, M. (2007). Gender and mathematics achievement in China and the United States. Gender Issues, 24, 1–11.

Vestad, L., & Bru, E. (2024). Teachers' support for growth mindset and its links with students' growth mindset, academic engagement, and achievements in lower secondary school. Social Psychology of Education, 27(4), 1431–1454.

Wang, C., Xu, Q., & Fei, W. Q. (2024). The effect of student-perceived teacher support on math anxiety: Chain mediation of teacher–student relationship and math self-efficacy. Frontiers in Psychology, 15, Article 1333012.

Wang, L. (2020). Mediation relationships among gender, spatial ability, math anxiety, and math achievement. Educational Psychology Review, 32(1), 1–15.

Wang, L., Li, X., & Li, N. (2014). Socio-economic status and mathematics achievement in China: A review. ZDM: The International Journal on Mathematics Education, 46, 1051–1060.

World Bank. (2023). Gini index (World Bank estimate). https://data.worldbank.org/indicator/SI.POV.GINI.

Xie, F., Xin, Z., Chen, X., & Zhang, L. (2019). Gender difference of Chinese high school students' math anxiety: The effects of self-esteem, test anxiety and general anxiety. Sex Roles, 81, 235–244.

Yeager, D. S., & Dweck, C. S. (2020). What can be learned from growth mindset controversies? American Psychologist, 75(9), 1269.

Yu, R., & Singh, K. (2018). Teacher support, instructional practices, student motivation, and mathematics achievement in high school. The Journal of Educational Research, 111(1), 81–94.

Zivković, M., Pellizzoni, S., Doz, E., Cuder, A., Mammarella, I., & Passolunghi, M. C. (2023). Math self-efficacy or anxiety? The role of emotional and motivational contribution in math performance. Social Psychology of Education, 26(3), 579–601.