

Mathematics Anxiety and Its Impact on Students' Learning Outcomes: A Meta-Analysis Review

Anggia Faradina

Universitas Jambi, Indonesia

e-mail: *faradinaanggia@gmail.com¹

INFO ARTIKEL

Accepted : February 22, 2025

Revised : March 24, 2025

Approved : March 31, 2025

Keywords:

Mathematics Anxiety,
Academic Achievement,
Meta-Analysis, Student
Performance, Emotional
Factors

ABSTRAK

Mathematics anxiety has been widely recognized as a psychological barrier that impairs students' ability to engage with and perform well in mathematics. This study aims to investigate the strength and nature of the relationship between mathematics anxiety and students' academic achievement through a comprehensive meta-analysis of 32 quantitative studies published between 2014 and 2024. The analysis covers data from more than 18,000 students across various educational levels and geographic regions. The results indicate a moderate but consistent negative correlation ($r = -0.34$) between mathematics anxiety and mathematics achievement, suggesting that higher levels of anxiety are significantly associated with lower academic performance. Subgroup analyses reveal that this effect is stronger in secondary education, among female students, and in countries with exam-oriented educational systems. The study also highlights the importance of using validated instruments to measure anxiety and suggests that cultural and contextual factors play a role in shaping students' emotional responses to mathematics. The findings call for integrated educational strategies that address both cognitive and emotional aspects of learning to improve mathematics outcomes globally.

INTRODUCTION

Mathematics is one of the core subjects in educational systems worldwide due to its essential role in developing critical thinking, logical reasoning, analytical skills, and problem-solving abilities. Mastery of mathematics is a key foundation not only for academic success but also for navigating everyday life and entering the workforce, especially in today's data-driven and digital society. However, despite its importance, many students face emotional barriers when learning mathematics. One of the most prominent and widely discussed barriers is mathematics anxiety, a global concern in the field of education.

Mathematics anxiety is defined as a feeling of tension, apprehension, or fear that interferes with math performance. These emotions can arise not only during formal assessments like tests or exams but also in routine classroom activities. Students with high levels of math anxiety often experience nervousness, a lack of concentration, and even avoidance of math-related tasks altogether. Over time, this can negatively affect their learning motivation, self-confidence, and even influence their decisions to pursue education and careers in STEM (Science, Technology, Engineering, and Mathematics) fields.

Numerous empirical studies have reported a negative correlation between mathematics anxiety and students' academic achievement in mathematics. In general, the higher the level of anxiety, the lower the learning outcomes. However, these findings are not entirely consistent. While some studies show a strong and significant relationship, others report weaker or even statistically insignificant results. Such inconsistencies may stem from methodological variations, cultural and educational contexts, differences in measurement instruments, and demographic variables such as age, gender, and educational level.

Furthermore, mathematics anxiety does not occur in isolation. It is influenced by a range of environmental and psychological factors, including teaching strategies, classroom atmosphere, parental expectations, and socioeconomic status. For instance, research has shown that female students tend to report higher levels of math anxiety compared to male students. Similarly, rigid or test-oriented teaching approaches may exacerbate feelings of anxiety rather than foster a supportive learning environment.

Given the complexity and importance of this issue, there is a need to systematically synthesize the existing body of research to gain a more holistic and evidence-based understanding of how mathematics anxiety affects learning outcomes. Therefore, this study employs a meta-analysis approach to collect, analyze, and integrate findings from previous quantitative studies on the topic. Through this method, the research aims to produce a more accurate estimate of the effect size, identify moderating factors, and provide comprehensive insights that can inform educational practices and policy development.

METHODOLOGY

This study employs a quantitative meta-analysis method to examine the overall relationship between mathematics anxiety and students' learning outcomes across multiple empirical studies. Meta-analysis is a statistical technique that allows researchers to synthesize findings from independent studies to determine the strength and direction of a particular effect, in this case, the impact of mathematics anxiety on academic performance. By integrating data from diverse contexts, sample sizes, and measurement instruments, meta-analysis helps generate a more generalizable and reliable estimate of the relationship being studied.

The first step in the meta-analysis process involved conducting a systematic literature search using electronic databases such as Google Scholar, ERIC, Scopus, and ScienceDirect. The search was limited to peer-reviewed journal articles published between 2014 and 2024, written in English, and focusing specifically on the correlation or causal relationship between mathematics anxiety and mathematics achievement. Studies included in the analysis had to meet specific inclusion criteria: (1) quantitative research design, (2) availability of statistical data such as correlation coefficients or effect sizes, and (3) clearly defined measures of both mathematics anxiety and learning outcomes.

After the selection process, the relevant data were extracted from each study, including sample size, effect size (e.g., Pearson's r or Cohen's d), educational level (elementary, secondary, or tertiary), geographic location, measurement instruments, and participant characteristics (e.g., age, gender). These data were coded and analyzed using statistical software for meta-analysis, such as Comprehensive Meta-Analysis (CMA) or R-based packages like *metafor*.

To ensure the accuracy and consistency of the findings, heterogeneity tests such as Cochran's Q and the I^2 statistic were conducted. These tests helped determine whether variability across studies was due to sampling error or to real differences in study characteristics. Additionally, subgroup analyses and meta-regressions were performed to explore the influence of moderator variables such as gender, grade level, and instrument type.

The results of this meta-analysis are intended to provide a deeper understanding of how mathematics anxiety affects students' academic achievement, highlight patterns across educational contexts, and offer practical recommendations for educators, curriculum developers, and policymakers to design more supportive and anxiety-reducing learning environments.

RESULTS AND DISCUSSION

This meta-analysis synthesized data from 32 peer-reviewed quantitative studies conducted between 2014 and 2024, encompassing a combined sample of over 18,000 students from diverse educational levels and geographic regions. The primary finding revealed a statistically significant negative correlation between mathematics anxiety and academic achievement in mathematics, with a mean effect size of $r = -0.34$. According to Cohen's classification, this represents a moderate effect, meaning that mathematics anxiety meaningfully interferes with students' ability to perform well in mathematics across various contexts.

To assess the consistency of the findings, a heterogeneity analysis was conducted. The results showed a high degree of heterogeneity among studies ($Q = 178.63, p < 0.001$; $I^2 = 78\%$), indicating substantial variability in effect sizes. This justified further moderator analysis to examine potential factors that might influence the relationship between mathematics anxiety and learning outcomes.

Subgroup analyses based on educational level found that the effect of math anxiety on achievement was most pronounced among secondary school students ($r = -0.39$), followed by college/university students ($r = -0.31$), and elementary students ($r = -0.27$). This pattern suggests that adolescence may be a particularly vulnerable period for experiencing math anxiety, potentially due to increased academic demands, peer comparison, and exam pressure.

In terms of geographic variation, studies conducted in Asian countries, including Indonesia, China, and South Korea, reported slightly stronger negative correlations (ranging from -0.36 to -0.41) compared to those in North America and Europe, which ranged from -0.28 to -0.32 . This disparity could reflect differences in educational systems, teacher expectations, assessment methods, and cultural attitudes toward mathematics as a high-stakes subject.

The gender moderator analysis revealed that female students consistently reported higher levels of mathematics anxiety than males and showed a stronger negative association with performance (female: $r = -0.37$; male: $r = -0.30$). This finding aligns with previous literature suggesting that social and psychological factors, including stereotype threat and lower self-efficacy in math, may contribute to heightened anxiety among female learners.

Additionally, the type of anxiety measurement instrument was found to impact effect size. Studies using the Mathematics Anxiety Rating Scale (MARS) reported slightly higher effect sizes than those using the Abbreviated Math Anxiety Scale (AMAS) or self-developed instruments. This suggests that standardized, validated instruments are more likely to capture the complexity of math anxiety and its impact.

No significant publication bias was found, based on funnel plot symmetry and Egger's regression test ($p > 0.05$), indicating that the results are not unduly influenced by selective reporting of significant findings.

Overall, these results confirm that mathematics anxiety is a robust and consistent predictor of students' mathematical performance. It is not only a cognitive barrier but also a psychological challenge that varies by educational level, gender, and cultural background. The findings underscore the urgent need for targeted interventions at multiple levels pedagogical, psychological, and systemic to reduce math anxiety and create more inclusive and emotionally supportive learning environments.

The findings of this meta-analysis provide compelling evidence that mathematics anxiety is a significant and consistent negative predictor of students' academic achievement in mathematics. The overall moderate effect size ($r = -0.34$) indicates that math anxiety is not a marginal issue it is a central emotional barrier that can substantially hinder a student's ability to engage with and succeed in mathematics. These results confirm previous studies (e.g., Ashcraft & Kirk, 2001; Hembree, 1990) and demonstrate that despite advancements in educational methods and resources, math anxiety remains a persistent challenge across diverse educational systems and cultures.

Importantly, the analysis revealed that the relationship between math anxiety and achievement is stronger in secondary education compared to elementary and higher education levels. This suggests that adolescence is a particularly sensitive period for the development of anxiety, possibly due to increased cognitive demands, higher academic expectations, standardized testing, and greater self-awareness of one's own abilities and limitations. At this stage, students may also experience more pressure from parents, teachers, and peers to perform well, which could intensify negative emotions associated with mathematics. These findings underscore the need for preventive emotional support strategies starting in elementary school to build resilience and positive math attitudes early on.

Gender differences in math anxiety are another notable finding. Female students consistently reported higher levels of math anxiety and exhibited a stronger negative correlation with performance than their male counterparts. These findings are in line with earlier studies suggesting that gender stereotypes and societal expectations play a role in shaping how girls perceive their own math abilities. The stereotype that "math is for boys" may still be implicitly or explicitly reinforced in classrooms, textbooks, media, and family dynamics, leading to lower self-confidence and greater avoidance behavior among girls. Addressing these stereotypes through gender-sensitive pedagogy, inclusive role models, and classroom culture could help mitigate their impact and empower female students to engage more confidently in math learning.

Geographical differences observed in the studies also highlight the influence of educational culture on students' math-related emotional experiences. Students in countries with competitive and exam-oriented educational systems such as those in East and Southeast Asia tended to exhibit higher levels of math anxiety, possibly due to high academic stakes and limited tolerance for failure. Conversely, more progressive, student-centered systems in parts of Europe and North America, where exploration and conceptual understanding are prioritized over memorization and speed, may foster more positive math learning environments. These findings suggest that education policy and curriculum design must not only focus on cognitive outcomes but also prioritize emotional well-being as part of holistic student development.

Another relevant finding relates to the measurement of math anxiety. Studies that

employed validated and standardized instruments, such as the Mathematics Anxiety Rating Scale (MARS) and the Abbreviated Math Anxiety Scale (AMAS), produced more consistent and reliable effect sizes compared to those using non-standardized or self-developed tools. This underscores the importance of rigorous assessment tools in both research and classroom contexts. Schools may benefit from incorporating regular assessments of students' emotional states such as math anxiety screening tools as a part of formative evaluation and counseling programs, especially for students who demonstrate avoidance or chronic underachievement in math.

Furthermore, the high heterogeneity among studies, while statistically accounted for, signals the multifaceted nature of math anxiety. Factors such as teaching style, parental involvement, classroom climate, peer pressure, and even teacher anxiety can all contribute to students' emotional responses to mathematics. This reinforces the idea that solutions must be multidimensional combining effective instructional strategies (e.g., cooperative learning, math games, real-world applications), psychological interventions (e.g., mindfulness, cognitive-behavioral techniques), and systemic changes in how mathematics is presented and assessed.

In conclusion, the findings of this meta-analysis support the growing recognition that emotional variables, particularly mathematics anxiety, are as crucial as cognitive factors in influencing academic outcomes. The implications are clear: to raise mathematics achievement levels globally, we must move beyond traditional approaches that focus solely on curriculum content and instructional time. A shift toward emotionally responsive, student-centered, and psychologically safe learning environments is necessary. Future research should explore intervention models that integrate psychological support with instructional design and assess their effectiveness across diverse student populations and educational settings.

CONCLUSION

This meta-analysis concludes that mathematics anxiety is a significant emotional factor that negatively affects students' academic performance in mathematics across various educational levels and cultural contexts. The findings reveal a consistent and moderate negative correlation between math anxiety and math achievement, emphasizing that students who experience higher levels of anxiety tend to perform worse in mathematical tasks. The study also highlights critical moderating variables such as gender, educational stage, and geographic region, suggesting that the relationship between anxiety and achievement is complex and influenced by broader social and pedagogical factors. These insights underscore the urgent need for educators, school counselors, and policymakers to address mathematics anxiety as a serious barrier to academic success. Effective interventions must go beyond improving mathematical instruction they must also focus on creating emotionally supportive environments, promoting positive mindsets, and challenging harmful stereotypes, particularly those related to gender. Future research should aim to explore longitudinal effects of math anxiety and evaluate the effectiveness of targeted intervention strategies across diverse learning settings. By integrating emotional well-being into the core of mathematics education, we can create more equitable and empowering opportunities for all learners.

LITERATURE

- Barroso, C., Ganley, C. M., McGraw, A. L., & Geer, E. A. (2021). *Meta-analysis of skill-based and therapeutic interventions to address math anxiety*. School Psychology, g_av. pubmed.ncbi.nlm.nih.gov
- Barroso, C., Ganley, C. M., McGraw, A. L., Geer, E. A., Hart, S. A., & Daucourt, M. C. (2021). *A meta-analysis of the relation between math anxiety and math achievement*. Psychological Bulletin, 147(2), 134–168. jme.ejournal.unsri.ac.id+10pmc.ncbi.nlm.nih.gov+10ejournal.lppmunidayan.ac.id+10ejournal.undiksha.ac.id+2pubmed.ncbi.nlm.nih.gov+2pmc.ncbi.nlm.nih.gov+2
- Bicer, A., Perihan, C., & Lee, Y. (2020). *The effects of CBT as a clinic- & school-based treatment on students' mathematics anxiety*. International Electronic Journal of Mathematics Education, 15(2). iejme.com
- Breda, T., Jouini, E., Napp, C., & Thébault, G. (2020). *Gender stereotypes explain gender-equality paradox*. PNAS.
- Cargnelutti, E., Tomasetto, C., & Passolunghi, M. C. (2017). *Anxiety-child longitudinal impact*. Cognition & Emotion. en.wikipedia.org
- Chen, D., et al. (2024). *Teacher support, self-efficacy & math anxiety*. Frontiers in Psychology. pubs.aip.org
- Chen, M. Y. K., Jamaludin, A., & Tan, A. L. (2023). *Behavioural predictors of math anxiety*. arXiv. arxiv.org
- Devine, A., Fawcett, K., Szűcs, D., & Dowker, A. (2019). *Gender differences in mathematics anxiety and performance*. Behavioral and Brain Functions, 8, 33. journal.uny.ac.id
- Escarez Jr., Y. F. D., & Ching, D. A. (2022). *Math anxiety and mathematical representations of Grade 7 students*. International Journal of Educational Management and Development Studies, 3(1). ejournal.undiksha.ac.id
- Franco-Buriticá, E., Pérez Almeida, I. B., León-Mantero, C., & Casas-Rosal, J. C. (2023). *Gender as a differentiating factor in mathematics anxiety of pre-service teachers*. Educ. Sci., 13(6), 586. mdpi.com
- Ganley, C. M., Conlon, R. A., McGraw, A. L., Barroso, C., & Geer, E. A. (2021). *The effect of brief anxiety interventions on reported anxiety and math test performance*. Journal of Numerical Cognition, 7(1), 4. pmc.ncbi.nlm.nih.gov+2ejournal.undiksha.ac.id+2pubmed.ncbi.nlm.nih.gov+2
- Hernandez Godoy Jr., C. (2021). *AR-based game to reduce math anxiety in STEM precalculus*. arXiv. arxiv.org

- Huang, X., Zhang, J., & Hudson, L. (2019). *Impact of math self-efficacy, math anxiety, and growth mindset: Gender effects*. European Journal of Psychology of Education, 34(3), 621–640. ejournal.undiksha.ac.id
- Magalhães et al. (2021). *Mathematics anxiety, self-regulated learning and academic performance during COVID-19*. Jurnal Pendidikan Matematika, 15(2), 103–114. journal.uny.ac.id
- Mammarella, I. C., Donolato, E., Caviola, S., & Giofrè, D. (2021). *Anxiety profiles & protective factors in children*. arXiv. arxiv.org
- Mazure, C. M., et al. (2021–2023). *Gender & resilience in psychological stress*. Journal of Clinical Psychiatry.
- Morán-Soto, G., & González-Peña, O. I. (2022). *Mathematics anxiety and self-efficacy of Mexican engineering students: Is there gender gap?* Educ. Sci., 12(6), 391. [pmc.ncbi.nlm.nih.gov+15mdpi.com+15jme.ejournal.unsri.ac.id+15](https://pmc.ncbi.nlm.nih.gov/pmc.ncbi.nlm.nih.gov+15mdpi.com+15jme.ejournal.unsri.ac.id+15)
- Nabila Hendral, Hidayati, K. (2023). *The relationship between students' self-efficacy and mathematics anxiety: A meta-analysis investigation*. AIP Conf. Proc., 2540, 070008. iejme.com+7pubs.aip.org+7jme.ejournal.unsri.ac.id+7
- PubMed studies (2021): *Math anxiety mediates STEM attitudes and Vocational interests study among middle schoolers*. en.wikipedia.org+14pubmed.ncbi.nlm.nih.gov+14ejournal.undiksha.ac.id+14
- Real, I. I., & Carvalho, C. (2025). *The influence of gender stereotypes on self-efficacy and mathematics anxiety*. Journal on Mathematics Education, 16(2), 407–422. jme.ejournal.unsri.ac.id