International Journal of Science and Healthcare Research
Vol. 9; Issue: 2; April-June 2024
Website: ijshr.com
Review Paper *ISSN: 2455-7587*

‘Math is not for me’. Investigating Mathematics Anxiety in Secondary and Higher Education: A Critical Discussion of Current Practices and Future Recommendations

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DOI: https://doi.org/10.52403/ijshr.20240234

ABSTRACT

Mathematics anxiety is a contemporary issue, characterized by feelings of stress, worry, apprehension, or fear, that interferes with one’s ability to manipulate and resolve mathematical tasks. The challenges of mathematics anxiety are considerable and produce a cascade of cause-effect repercussions. Accordingly, it is imperative to investigate this issue in secondary and higher education, as this educational era seemingly serves as a triggering point for this condition, significantly affecting individuals’ decisions towards education, academic pursues, professional orientation and so on. The main points elucidated by the present study suggest that curriculum and institutional frameworks, instructional strategies, parental influences, and individualized or psychotherapeutic interventions play a central role towards understanding and addressing mathematics anxiety, with their effects ranging across various cognitive, emotional and behavioral paradigms. Recommendations span in similar grounds in which –among other discussion arguments– the importance of improved institutional and parental approaches is strongly highlighted, as it could potentially provide better insights concerning early intervention.

Keywords: Mathematics anxiety, parental influences, institution pressures, teaching strategies, anxiety susceptibility

DESCRIBING AND DISCUSSING MATHEMATICS ANXIETY

Mathematics anxiety is a contemporary issue, characterized by feelings of stress, worry, apprehension, or fear, that interferes with one’s ability to manipulate and resolve mathematical tasks (Szczygieł & Pieronkiewicz, 2022; Cipora et al., 2022; Ashcraft & Ridley, 2005). It is a multidimensional concept that typically elicits a negative loop, in which individuals may feel excessively anxious when presented with the cognitive demands of a numeric problem (Passolunghi et al., 2016), often perform poorly in it (Ashcraft & Krause, 2007), establish negative attitudes about their own math-oriented abilities and problem solving capacity (Rozgonjuk et al., 2020), and ultimately avoid arithmetic courses or calculus-related professions altogether (Choe et al., 2019). Mathematics anxiety can persist throughout the entire lifespan (Jameson & Fusco, 2014); yet

attains its highest prevalence rates, reaching almost 60%, within the university and pre-university educational context (OECD, 2013), in which interaction with mathematical assessments is often viewed by students as "unavoidable" or "unforgiving" (Zanabazar et al., 2023; Daker et al., 2021). Correspondingly, it is imperative to investigate mathematics anxiety in secondary and higher education, as these settings seemingly serve as triggering points for this issue, significantly affecting individuals' decisions towards education, academic pursues, professional orientation and so on (Morán-Soto & González-Peña, 2022; Jenßen, 2022).

The challenges of mathematics anxiety are considerable and produce a cascade of cause-effect repercussions (Samuel et al., 2023; Aldrup et al., 2020). For example, teachers, being the "distributors" of knowledge, potentially have the most critical impact towards the development of dysfunctional attitudes concerning mathematics (Ganley et al., 2019; Bjälkebring, 2019). Literature indicate that teachers or lecturers may indirectly spread the myth, that math ability is inborn, and therefore success is highly dependent on giftedness (Furner & Berman, 2003); promoting a polarized "either you got it, or you do not" mentality to students (Boaler, 2015). Moreover, educators may also project and transfer their own math anxiety to students (Beilock et al., 2010), exhibit negative attitudes towards math in the classroom (Lin et al., 2017), or intentionally promoting the notion that math is hard and unattainable (Kaskens et al., 2020). In turn, these circumstances form the ideal grounds for anxious sentiments associated with fear of failure, to arise (Petronzi et al., 2019; Klee et al., 2022); in which students may experience dread of not succeeding a particular course or feel intimidated and overwhelmed by mathematical concepts (Mehmet & Hulya, 2021). These data pinpoint the decisive role of teachers, and imply that although math anxiety tends to peak during assessments, its onset or intensity, is intricately connected to the math education strategies employed in the classroom (Luttenberger et al., 2018; Ganley & McGraw, 2016).

While the impact of educational approaches is undeniable, additional factors merit consideration (Li et al., 2023; Haase et al., 2019). For instance, parents, may shape educational values and attitudes within the family, as conflicting beliefs about one's math competency or the overall importance of mathematics by significant others, can substantially impact positive self-evaluation, and the general interaction with math; effectively prompting anxious characteristics (Ma et al., 2021; Hart et al., 2016). In similar grounds, mathematics anxiety is also linked with the public perception of mathematics, as within a cultural discourse, it tends to differentiate from country to country (OECD, 2015; Lee, 2009). To illustrate, Asian countries (e.g. Japan, Korea, Thailand), although exhibit higher mathematic competency and performance compared to Western society, they also display significantly higher levels of math anxiety, lower self-concept, and self-efficacy, as they are more likely to set high goals and assess themselves based on strict criteria. Conversely, Western university students have the propensity to embellish their capabilities, mostly due to enhancement bias; which pertains the tendency of some individuals to overestimate the positive qualities of their group or themselves, while underestimating their negative attributes or flaws (Luttenberger et al., 2018; Lee, 2009).

Genetic variables are also recognized as mediating factors (Daches-Cohen et al., 2021; Malanchini et al., 2020). Studies on monozygotic twins sharing 100% of their segregating alleles, indicate that mathematics anxiety retains a hereditary element as well, both in early adolescence (Wang et al., 2014), and early adulthood (Malanchini et al., 2017). On comparable terms, biological gender is also viewed as a mediating factor (Vos et al., 2023), with literature positing that female students

exhibit higher levels of mathematical anxiety than males, both in secondary and higher education (Dowker et al., 2016; Bieg et al., 2015; Else-Quest et al., 2010). Yet, cross-sectional studies attribute this disparity greatly on stereotypical social norms and pressures, as females are almost anticipated to be less interested or adept in STEM (Science, Technology, Engineering, Mathematics) domains; indirectly encouraging them towards alternative academic courses (Rodriguez-Planas & Nollenberger, 2018; Ertl et al., 2017). Lastly, inherited predisposition to elevated levels of anxiety, described as the genetic tendency to perceive relatively mild situations as threatening ones, is significantly linked to fear of mathematics (Luttenberger et al., 2018). Nevertheless, it is important to distinct this issue from other anxious-oriented conditions with similar characteristics such as generalized anxiety disorder or specific phobia, as mathematics anxiety entails its own underlying framework and cannot be comprised of or reduced to other constructs (Cipora et al., 2022).

Accordingly, the structural symptomatology of mathematics anxiety builds up on several notions (Lukowski et al., 2019). Physiologically, when presented with a math-oriented stimuli, individuals may exhibit sweating, muscle tension, nausea, indigestion, shallow breathing, (Pizzie & Kraemer, 2021; Blazer, 2011), or hyper-cardiovascular reactivity (Hunt et al., 2017). On that account, literature attempting to segregate this issue from other forms of anxiety (trait/state anxiety or general anxiety), posit that in many cases, physical symptoms appear to be present solely to the context of mathematics, and absent when non-mathematical, yet stressful stimulants, are at play (Lyons & Beilock, 2012). From a neuro-affective perspective, math anxiety is also related to hyperactivity in the fear and pain cerebral network, involving the insula (Artemenko et al., 2015) and the amygdala (Luttenberger et al., 2018). Strikingly, not the task per se, but the anticipation of it aligns with this neural hyperactivity (Lyons & Beilock, 2012).

Considering cognitive and behavioral aspects, a surplus of studies instigates that worrying, the primary component of math anxiety, requires processing competence from the cognitive structure of working memory, which regulates the process and allocation of information (Živković et al., 2023; Finell et al., 2022; Chow et al., 2021; Eysenck & Derakshan, 2011). Stress, by demanding working memory capacity, interferes with the efficient function of math-oriented tasks, and may elicit difficulty concentrating, frustration, or blanking out; effectively causing apprehension towards mathematical contexts (Passolunghi et al., 2016). Inevitably, these symptoms traverse towards behavioral domains including avoidance, procrastination, and reduced participation to math-related subjects; hence further exacerbating the existing symptomatology (Khasawneh et al., 2021; Paechter et al., 2017).

ADDRESSING MATHEMATICS ANXIETY

In the light of the aforementioned adverse implications of mathematics anxiety towards numerous educational, socio-cultural, and gene-environmental contexts, there is a keen interest of current literature towards strategies that address, prevent, or at least alleviate this complex issue (Klee et al., 2022; Passolunghi et al., 2020; Luttenberger et al., 2018). Psychological theory and research have provided significant insights of these interventions, which can be adopted by institutions and teachers (Marticion, 2021), be parental-wise (Ramirez et al., 2018), or implemented individually by the affected person (Moustafa et al., 2021). Accordingly, the focal point of this section is to critically discuss the proposed strategies of mathematics anxiety in secondary and higher education; considering the complexity of content, developmental changes, broader range of teaching methods,

transitioning to critical thinking, and the overall impact of mathematics on academic and career opportunities in this educational era (Huang et al., 2019; Maass et al., 2019).

Curricular and institutional strategies may offer significant initiatives to address or minimize mathematics anxiety (Furner & Duffy, 2022; Iossi, 2007). Initially, retesting has been hypothesized over a prolonged period (Juhler et al., 1998), as an effective approach, producing striking results, in which 9 out of 10 college students improved their initial performance, and approximately 80% of them reported that re-examination soothed their anxiety levels, even if they did not opt for the retest. This suggest that retesting, by providing an emotional safety net, counterbalances the paralyzing fear of failure. Moreover, self-paced learning, pertaining the idea in which students have more flexibility to set their own schedule and pace regarding upcoming assessments or produce assignments conducted over a period of time, is also viewed as a beneficial educational approach (Morris, 2019; Tang & Huang, 2019). On that account, a recent study by Gabriel and colleagues (2020), entailing a considerable sample size (N=14.481) produced compelling findings, in which institutions encouraging self-regulating learning present significantly lower levels of mathematics anxiety and higher self-concept among their pre-tertiary students. This stands in logical grounds as self-paced learning, driven by autonomy and individualized progress, offers the opportunity for learners to enhance their preparation and gain a deep-seated understanding of mathematical concepts; thus, promoting a learning-centered ideology, over the strict memorization-driven orientation of traditional approaches. Yet, in many cases academic faculties might view retesting or self-paced learning as "not viable options", due to the strict timetables of college curriculums (Fergus & Petrick-Smith 2022).

To counter time limitations, online courses, that gained particular popularity in the Covid and post-Covid era by students, teachers, and the educational system as a whole, have also produced ameliorating effects (Li et al., 2023; Mendoza-Derling et al., 2021). Anonymity, greater control to individualized learning, access to nearly endless resources, and the reduction of in-class performance stress or group pressure, might be some plausible justifications for the reduction of mathematics anxiety (Xhaferi & Xhaferi, 2020). However, while beneficial in certain aspects, online courses simply cannot overtake face-to-face interaction and their correlates, including immediate feedback from tutors, better grasp of mathematical topics, or support from peers (Taylor, 2004). In actuality, online courses might as well prolong mathematical stress, as anxious students could find the ideal opportunity to avoid stressful circumstances such as in-class assessments, tests, or group discussions of mathematical concepts, and consequently, generalize their symptomatology and amplify their difficulties in the long run (Choe et al., 2019). Considering both the advantages and the drawbacks, institutions should approach the "convenient" nature of online courses with a grain of salt, and utilize blended-learning tactics, that capitalize on the benefits of both approaches (Sharma & Sarkar, 2020; Lin et al., 2016).

Instructional strategies employed by teachers, are also acknowledged as fundamental lines of action (Çelik, 2021; Beilock & Willingham, 2014). Students, especially in tertiary and pre-tertiary academic settings in which they are more cognitive developed, allow teachers to implement more sophisticated and nuanced methods to counter mathematics anxiety (Peng & Kievit, 2020). First and foremost, academics can initiate proactive open discussions about math anxiety with students; as at this age individuals might experience stress towards mathematics, without fully comprehending the underlying reasons for feeling this way (Wang et al., 2021; Lorenzen & Lipscomb, 2021). By simply acknowledging the issue, educators create space for students to express their

concerns, and lay the foundation for more effective, tailor-made strategies to be established, such as cognitive restructuring (reframing anxious thoughts into more realistic ones; Ashcraft & Krause, 2007), or selective attentional and cognitive load management (guide students to focus on relevant task-related information; Posner & Rothbart, 2007); thus demystifying the emotional aspects of mathematics. Moreover, teachers should enhance students' interest by relating mathematics to real-life situations (Blazer, 2011), use manipulatives and hands-on devices during learning (Iossi, 2007), and reduce stereotypes by making math interesting to both males and females (Smetackova, 2015). However, although appealing, this form of psychoeducation might be short-lived, if not adopted by the educational system and instructed upon teachers in a way wherein the latter, can correctly assess - and not misidentify - the issue, according to standardized instruments, such as the popular and practical Abbreviated Math Anxiety Scale (AMAS; for a review see Hopko et al., 2003).

Parents are also playing an integral part in mathematics anxiety, as to a great extent students' attitudes towards mathematics are typically a reflection of their parents' mindset and aspirations towards education in general (Kiss & Vukovic, 2021; Maloney et al., 2015). Accordingly, constructive strategies mainly revolve around creating a positive environment and making math-learning an enjoyable and productive experience. To be precise, parents need to inspect and ideally overcome their own possible negative attitudes towards math by seeking support and psycho-educating themselves, and not "pass" their own discomfort and tension to their children; especially in the secondary and higher education era, wherein the complexity of mathematics typically surpasses parental knowledge to the subject. This is of particular importance, as it illustrates how math anxiety can be induced, not genetically which is mostly the case in anxiety-related conditions, but through dysfunctional modelling behaviors (Demirtaş & Uygun-Eryurt, 2022; Passolunghi et al., 2020; Blazer, 2011). Moreover, parents ought to not limit their offspring mathematical potential, but also be mindful of not burden them with unrealistic and demanding expectations for their success (Vanbinst et al., 2020). This balanced approach can facilitate support and encouragement, that positively influences students' attitudes towards mathematics, and their overall potentials to their pragmatic proficiencies (Cavanaugh, 2007). Lastly, parents can also de-escalate the emotional impact of mathematics by demonstrating positive and enjoyable ways that it is used, including sports, gaming, music, or various hobbies; as in most cases math is associated with negative undertones like unpaid bills, depts, failed exams, or boring practicalities (Blazer, 2011).

Be that as it may, not all students have parents, nor all parents possess the adequate skills to implement or even adhere to these propositions, and correspondingly, individualized strategies assume importance, to autonomously aid students (Dowker et al., 2016; Jiang et al., 2021; Luttenberger et al., 2018). One of the most straightforward approaches for students, is to practice math consecutively, as repetition reinforce automation. Under these circumstances, information can be recalled effortlessly and accurately; thus, allaying mathematics anxiety by fostering familiarity and confidence (Blazer, 2011). Still, this is easier said than done, as individuals are naturally and instinctively inclined to avoid, or when pertaining to educational settings, procrastinate situations that stress them. However, it is crucial to be recognized that taking intentional and proactive actions, like addressing negative beliefs, building self-efficacy, and seeking help when necessary, is essential to counter mathematics anxiety (Maghfiroh & Pradipta, 2023). In addition, suitable study techniques, such as reserving adequate time for study throughout the day, resisting distractions, identifying the most

optimal time-of-day for learning, or refraining from over-studying, are also beneficial approaches that alleviate mathematics anxiety, as they create a sense of stability and routine. (Blazer, 2011; Hogan et al., 2009; Furner & Berman, 2003). In essence, most literature in individualized approaches suggest that students should not view mathematics anxiety as an emotional scapegoat, but rather simply keep a positive mindset, acknowledge possible difficulties, and redirect their energy into formulating a plan to overcome them. Yet, although logical, these implications might be an oversimplification of the problem without proper assistance (Iossi, 2007).

Consequently, psychotherapeutic intervention emerges as a strongly suggested approach to aid students alleviate these challenges (Shafiq et al., 2020; Haase et al., 2019). Initially, the key characteristics of mathematics anxiety, including emotional turmoil, helplessness, panic, and cognitive disarray, align with the criteria for specific phobia, and therefore, can be treated accordingly (Cipora et al., 2022; Ashcraft & Ridley, 2005). By viewing math anxiety from this perspective, therapists can utilize significantly effective cognitive-behavioral tactics such as the frequently employed method of systematic desensitization, in which students – within the structured and supportive environment of a therapeutic session – are gradually exposed to stressful math-oriented stimuli, while trying to maintain a relaxed phyco-emotional manner (Aliyu et al., 2023; Akeb-Urai et al., 2020). This notion is backed by recent studies showcasing that, when exposed to numeric problems, students with elevated levels of mathematics anxiety exhibit significantly similar brain activation patterns, observed in individuals with other type of phobias being conferred with their corresponding phobia-associated cues (Pizzie & Kraemer, 2017). Additional approaches may include mindfulness-based interventions that help students being present in-the-moment and accept their emotional responses to mathematics (Cassady, 2011), or expressive therapies in which through art and psychodrama, students may express their emotions in a non-threating way (Zettle, 2003). However, although beneficial, these approaches are considered to have significant time and economic constraints; whereas cognitive-behavioral therapy by addressing the core difficulties of the issue directly, is more inclined towards rapid results (Stiles et al., 2008).

RECOMMENDATIONS

Considering the explored strategies, certain optimal recommendations emerge for educational practitioners to acknowledge, and potentially incorporate into their existing skillset, and consequently, counter the negative impact of mathematics anxiety. Admittedly, as heavily outlined by the current paper, instructional strategies employed by teachers, play a crucial role into ameliorating or when the implementation is flawed, aggravating math anxiety. This argument is grounded in the fundamental notion that teachers serve as linking elements between institutional guidelines and students; and therefore, can affect – to a certain degree – both ways (Dowker et al., 2016). In turn, this levitates them to a standpoint of both responsibility and power, as they can provide guidance and mentorship to students struggling with mathematics anxiety, while fostering a growth mindset. Additionally, by sharing their experiences, insights, and real-life data, teachers can also influence institutional committees to consider, and ideally implement more informed and effective policies to this issue.

Of equal importance, if not greater, parental strategies are highly recommended, as parents are typically the offspring's "first and most sustained teachers" (Maloney et al., 2015). One of the key factors of why parental approaches produce such profound impact to educational attitudes is based on the dynamics of the parent-child relationship and the underlying educational values shaped by it; as they are usually the

models that their children try to imitate and correspondingly, can set expectations, encourage curiosity, and communicate the importance of mathematical education and its value for future opportunities. However, the main reason that teacher and parental approaches towards mathematics anxiety are specifically recommended, is because they can be mutually compatible within the same time-space discourse; meaning that, teachers and parents possess a unique, yet interdependent role to educational upbringing. This is a crucial piece of information for practitioners, as when teachers and parents align their instructional strategies, they foster consistency and continuity which reinforces the protective barriers against mathematics anxiety, both in school and at home. By providing a sense of stability and coherence, these propositions can somewhat balance out the barrage of developmental and social changes of students in secondary and higher educational period.

Future research is recommended to re-evaluate the assumptions proposed in the current study by admitting however, that additional factors deserve exploration. For example, longitudinal studies should investigate this paradigm in order to provide insights concerning the long-term effectiveness, not only of the appropriate remedy measures towards mathematics anxiety, but also of the underlying antecedents that seemingly contribute to its onset. In addition, the cultural context as well as the impact of socio-economic factors should be equally represented in upcoming literature, as worldwide, not all students have access to the same resources or technology integration tools, nor all cultures identify mathematics anxiety as an issue worth considering, let alone addressing.

Lastly, neurological aspects of mathematics anxiety strategies are largely unexplored; yet brain imaging research could be catalytic in understanding the neural correlates of mathematics anxiety, and more importantly how interventions may impact the cerebral structure. This could facilitate a deep-seated understanding of the topic from a pathophysiological perspective. Although briefly touched upon in the present paper, alternative assessment methods, gender differences, or psychotherapeutic interventions may warrant independent examination to fully ascertain their significance. These directions for future research, alongside the implications produced by the current study, suggest that mathematics anxiety is a challenge that conceals hidden depths, and addressing it should be prioritized to enable proactive and early interventions.

Declaration by Authors

Acknowledgement: None
Source of Funding: None
Conflict of Interest: The authors declare no conflict of interest.

REFERENCES

1. Aldrup, K., Klusmann, U., & Lüdtke, O. (2020). Reciprocal associations between students' mathematics anxiety and achievement: Can teacher sensitivity make a difference? Journal of Educational Psychology, 112(4), 735. https://doi.org/10.1037/edu0000398
2. Aliyu, S., Idris, A., Gurkuma, A. L., Saidu, D., & Amako, T. G. (2023). Effects of cognitive restructuring and systematic desensitization techniques on students' mathematics anxiety in senior secondary schools in Gombe Metropolis, Gombe State. *Ilorin Journal of Education*, 43 (2), 1 - 13. https://ije.unilorinedu.sch.ng/index.php/ije/article/view/85/68
3. Artemenko, C., Daroczy, G., & Nuerk, H. C. (2015). Neural correlates of math anxiety–an overview and implications. *Frontiers in psychology*, *6*, 1333. https://doi.org/10.3389/fpsyg.2015.01333
4. Akeb-Urai, N., Kadir, N. B. Y. A., & Nasir, R. (2020). Mathematics anxiety and performance among college students: Effectiveness of systematic desensitization treatment. *Intellectual discourse*, *28*(1), 99-127. DOI: https://doi.org/10.31436/id.v28i1.1567
5. Ashcraft, M. H., & Krause, J. A. (2007). Working memory, math performance, and

math anxiety. Psychonomic bulletin & review, 14, 243-248. https://doi.org/10.3758/BF03194059

6. Ashcraft, M. H., & Ridley, K. S. (2005). Math anxiety and its cognitive consequences: A tutorial review. *The handbook of mathematical cognition*, 315-327. https://doi.org/10.4324/9780203998045
7. Beilock, S. L., & Willingham, D. T. (2014). Math anxiety: Can teachers help students reduce it? ask the cognitive scientist. *American educator*, *38*(2), 28. https://api.semanticscholar.org/CorpusID:261230255
8. Beilock, S. L., Gunderson, E. A., Ramirez, G., & Levine, S. C. (2010). Female teachers' math anxiety affects girls' math achievement. *Proceedings of the National Academy of Sciences*, *107*(5), 1860-1863. https://doi.org/10.1073/pnas.0910967107
9. Bieg, M., Goetz, T., Wolter, I., & Hall, N. C. (2015). Gender stereotype endorsement differentially predicts girls' and boys' trait-state discrepancy in math anxiety. *Frontiers in psychology*, *6*, (1404). 1 – 8. https://doi.org/10.3389/fpsyg.2015.01404
10. Boaler, J. (2015). *Mathematical mindsets: Unleashing students' potential through creative math, inspiring messages and innovative teaching*. John Wiley & Sons.
11. Blazer, C. (2011). Strategies for Reducing Math Anxiety. Information Capsule. *Research Services, Miami-Dade County Public Schools*. 1102, 1 – 8. *Eric. Ed.* https://eric.ed.gov/?id=ED536509.
12. Bjälkebring, P. (2019). Math anxiety at the university: what forms of teaching and learning statistics in higher education can help students with math anxiety?. In *Frontiers in Education*, 4, (30). 1 – 5. https://doi.org/10.3389/feduc.2019.00030
13. Cassady, J. C. (2011). Mindfulness-based interventions with students with learning disabilities: A meta-analysis. *Learning Disability Quarterly*, 34(1), 3-13. https://10.1007/s12671-013-0260-4
14. Cavanaugh, S. (2007). Understanding 'Math Anxiety.' Education Week, February 21, 2007. Retrieved from http://www.edweek.org.
15. Cipora, K., Santos, F. H., Kucian, K., & Dowker, A. (2022). Mathematics anxiety—where are we and where shall we go?. *Annals of the New York Academy of Sciences*, *1513*(1), 10-20. https://doi.org/10.1111/nyas.14770
16. Çelik, M. (2021). Investigation of Teacher Candidates' Teaching Maths Anxiety and Teaching Maths Competencies. *International Journal of Progressive Education*, *17*(6), 158-167. https://doi.org/10.29329/ijpe.2021.382.11
17. Choe, K. W., Jenifer, J. B., Rozek, C. S., Berman, M. G., & Beilock, S. L. (2019). Calculated avoidance: Math anxiety predicts math avoidance in effort-based decision-making. Science advances, 5 (11), eaay1062. https://10.1126/sciadv.aay1062
18. Chow, B. W. Y., Mo, J., & Dong, Y. (2021). Roles of reading anxiety and working memory in reading comprehension in English as a second language. *Learning and Individual Differences*, *92*, 102092. https://doi.org/10.1016/j.lindif.2021.102092
19. Daches-Cohen, L., Korem, N., & Rubinsten, O. (2021). Math anxiety is related to math difficulties and composed of emotion regulation and anxiety predisposition: A network analysis study. *Brain Sciences*, *11*(12), 1609. https://doi.org/10.3390/brainsci11121609
20. Daker, R. J., Gattas, S. U., Sokolowski, H. M., Green, A. E., & Lyons, I. M. (2021). First-year students' math anxiety predicts STEM avoidance and underperformance throughout university, independently of math ability. npj Science of Learning, 6(1), 17. https://doi.org/10.1038/s41539-021-00095-7
21. Demirtaş, A. S., & Uygun-Eryurt, T. (2022). Attachment to parents and math anxiety in early adolescence: Hope and perceived school climate as mediators. *Current Psychology*, *41*(7), 4722-4738. https://doi.org/10.1007/s12144-020-00964-1
22. Dowker, A., Sarkar, A., & Looi, C. Y. (2016). Mathematics anxiety: What have we learned in 60 years?. *Frontiers in psychology*, *7*, (508). 1 – 16 https://doi.org/10.3389/fpsyg.2016.00508
23. Else-Quest, N. M., Hyde, J. S., & Linn, M. C. (2010). Cross-national patterns of gender differences in mathematics: A meta-analysis. *Psychological Bulletin, 136*(1), 103–127. https://doi.org/10.1037/a0018053

24. Ertl, B., Luttenberger, S., & Paechter, M. (2017). The impact of gender stereotypes on the self-concept of female students in STEM subjects with an underrepresentation of females. *Frontiers in Psychology*, *8*, 703. https://doi.org/10.3389/fpsyg.2017.00703
25. Eysenck, M. W., & Derakshan, N. (2011). New perspectives in attentional control theory. *Personality and Individual Differences*, *50* (7), 955-960. https://10.1016/j.paid.2010.08.019
26. Fergus, S., & Petrick Smith, C. (2022). Characteristics of proficiency-based learning and their impacts on math anxiety in the middle grades. *RMLE Online*, *45*(4), 1-19. https://doi.org/10.1080/19404476.2022.2045810
27. Finell, J., Sammallahti, E., Korhonen, J., Eklöf, H., & Jonsson, B. (2022). Working Memory and its mediating role on the relationship of math anxiety and math performance: A meta-analysis. *Frontiers in Psychology*, *12*, 798090. https://doi.org/10.3389/fpsyg.2021.798090
28. Furner, J. M. and Duffy, M. L. (2022). Addressing Math Anxiety in a STEM World: Preventative, Supportive, and Corrective Strategies for the Inclusive Classroom. *European Journal of STEM Education*, 7(1), 11. https://doi.org/10.20897/ejsteme/12645
29. Furner, J. M., & Berman, B. T. (2003). Review of research: math anxiety: overcoming a major obstacle to the improvement of student math performance. *Childhood education*, *79*(3), 170-174. https://10.1080/00094056.2003.10522220
30. Gabriel, F., Buckley, S., & Barthakur, A. (2020). The impact of mathematics anxiety on self-regulated learning and mathematical literacy. *Australian Journal of Education*, *64*(3), 227-242. https://doi.org/10.1177/0004944120947881
31. Ganley, C. M., Schoen, R. C., LaVenia, M., & Tazaz, A. M. (2019). The construct validation of the math anxiety scale for teachers. *Aera Open*, *5*(1), https://doi.org/10.1177/233285841983970
32. Ganley, C. M., & McGraw, A. L. (2016). The development and validation of a revised version of the math anxiety scale for young children. *Frontiers in psychology*, *7*, 1181. https://doi.org/10.3389/fpsyg.2016.01181
33. Haase, V.G., Guimarães, A.P.L., Wood, G. (2019). Mathematics and Emotions: The Case of Math Anxiety. In: Fritz, A., Haase, V.G., Räsänen, P. (eds) International Handbook of Mathematical Learning Difficulties. Springer, Cham. https://doi.org/10.1007/978-3-319-97148-3_29
34. Hogan, M. J., Kelly, C. A., Verrier, D., Newell, J., Hasher, L., & Robertson, I. H. (2009). Optimal time-of-day and consolidation of learning in younger and older adults. *Experimental aging research*, 35 (1), 107 - 128. https://doi.org/10.1080/03610730802545366
35. Hopko, D. R., Mahadevan, R., Bare, R. L., & Hunt, M. K. (2003). The Abbreviated Math Anxiety Scale (AMAS): construction, validity, and reliability. *Assessment*, *10* (2), 178 – 182. https://doi.org/10.1177/1073191103010002008
36. Mendoza-Derling, Cejas Magda, Rivas Gabriela, & Varguillas Carmen (2021). Anxiety as a prevailing factor of performance of university mathematics students during the COVID-19 pandemic. Образование и наука, 23 (2), 94-113. https://10.17853/1994-5639-2021-2-94-113
37. Hart, S. A., Ganley, C. M., & Purpura, D. J. (2016). Understanding the home math environment and its role in predicting parent report of children's math skills. *PloS one*, *11*(12), e0168227. https://doi.org/10.1371/journal.pone.0168227
38. Hunt, T. E., Bhardwa, J., & Sheffield, D. (2017). Mental arithmetic performance, physiological reactivity and mathematics anxiety amongst UK primary school children. *Learning and Individual Differences*, *57*, 129-132. https://doi.org/10.1016/j.lindif.2017.03.016
39. Huang, X., Zhang, J., & Hudson, L. (2019). Impact of math self-efficacy, math anxiety, and growth mindset on math and science career interest for middle school students: The gender moderating effect. *European Journal of Psychology of Education*, *34*,

621-640. https://doi.org/10.1007/s10212-018-0403-z

40. Iossi, L. (2007). Strategies for reducing math anxiety in post-secondary students. In S. M. Nielsen & M. S. Plakhotnik (Eds.), Proceedings of the Sixth Annual College of Education Research Conference: Urban and International Education Section (pp. 30-35). http://coeweb.fiu.edu/research_conference/
41. Jameson, M. M., & Fusco, B. R. (2014). Math anxiety, math self-concept, and math self-efficacy in adult learners compared to traditional undergraduate students. *Adult Education Quarterly*, 64(4), 306-322. https://doi.org/10.1177/0741713614541461
42. Jenßen, L. (2022). A math-avoidant profession?: Review of the current research about early childhood teachers' mathematics anxiety and empirical evidence. *Early Childhood Teachers 'Professional Competence in Mathematics*. 80 – 96. https://10.4324/9781003172529-6
43. Jiang, R., Liu, R. D., Star, J., Zhen, R., Wang, J., Hong, W., ... & Fu, X. (2021). How mathematics anxiety affects students' inflexible perseverance in mathematics problem-solving: Examining the mediating role of cognitive reflection. *British Journal of Educational Psychology*, *91*(1), 237-260. https://doi.org/10.1111/bjep.12364
44. Juhler, S. M., Rech, J. F., From, S. G., & Brogan, M. M. (1998). The Effect of Optional Retesting on College Students' Achievement in an Individualized Algebra Course. *The Journal of Experimental Education*, *66*(2), 125–137. http://www.jstor.org/stable/20152551
45. Kaskens, J., Segers, E., Goei, S. L., van Luit, J. E., & Verhoeven, L. (2020). Impact of Children's math self-concept, math self-efficacy, math anxiety, and teacher competencies on math development. *Teaching and teacher education*, *94*, 103096. https://doi.org/10.1016/j.tate.2020.103096
46. Khasawneh, E., Gosling, C., & Williams, B. (2021). What impact does maths anxiety have on university students?. *BMC psychology*, 9(1), 1-9. https://doi.org/10.1186/s40359-021-00537-2
47. Kiss, A. J., & Vukovic, R. (2021). Exploring educational engagement for parents with math anxiety. *Psychology in the Schools*, 58(2), 364-376. https://doi.org/10.1002/pits.22451
48. Klee, H. L., Buehl, M. M., & Miller, A. D. (2022). Strategies for alleviating students' math anxiety: Control-value theory in practice. *Theory Into Practice*, *61*(1), 49-61. https://doi.org/10.1080/00405841.2021.1932157
49. Lee, J. (2009). Universals and specifics of math self-concept, math self-efficacy, and math anxiety across 41 PISA 2003 participating countries. *Learning and individual differences*, *19*(3), 355-365. https://doi.org/10.1016/j.lindif.2008.10.009
50. Li, D., Liew, J., Raymond, D., & Hammond, T. (2023). Math anxiety and math motivation in online learning during stress: The role of fearful and avoidance temperament and implications for STEM education. *Plos one*, *18* (12), e0292844. https://doi.org/10.1371/journal.pone.0292844
51. Li, T., Chen, C., & Zhou, X. (2023). How are different math knowledge presentations associated with math anxiety?. *Annals of the New York Academy of Sciences*, *1520*(1), 153-160. https://doi.org/10.1111/nyas.14951
52. Lin, Y., Durbin, J. M., & Rancer, A. S. (2017). Perceived instructor argumentativeness, verbal aggressiveness, and classroom communication climate in relation to student state motivation and math anxiety. *Communication Education*, *66*(3), 330-349. https://doi.org/10.1080/03634523.2016.1245427
53. Lin, Y. W., Tseng, C. L., & Chiang, P. J. (2016). The effect of blended learning in mathematics course. *Eurasia Journal of Mathematics, Science and Technology Education*, *13*(3), 741-770. https://doi.org/10.12973/eurasia.2017.00641a
54. Lorenzen, J. K., & Lipscomb, T. J. (2021). The Effects of Instructional Strategies on Preservice Teachers' Math Anxiety and Achievement. Journal of Research in Science, Mathematics and Technology Education, 4(2), 133-151. https://doi.org/10.31756/jrsmte.425
55. Luttenberger, S., Wimmer, S., & Paechter, M. (2018). Spotlight on math

anxiety. *Psychology research and behavior management*, 311-322. https://doi.org/10.2147/PRBM.S141421

56. Lukowski, S. L., DiTrapani, J., Rockwood, N. J., Jeon, M., Thompson, L. A., & Petrill, S. A. (2019). Etiological distinction across dimensions of math anxiety. *Behavior Genetics*, *49*, 310-316. https://doi.org/10.1007/s10519-018-09946-3
57. Lyons, I. M., & Beilock, S. L. (2012). Mathematics anxiety: Separating the math from the anxiety. Cerebral Cortex, 22(9), 2102–2110. https://10.1093/cercor/bhr289
58. Ma, M., Li, D., & Zhang, L. (2021). Longitudinal prediction of children's math anxiety from parent-child relationships. *Learning and Individual Differences*, *88*, 102016. https://doi.org/10.1016/j.lindif.2021.102016
59. Maghfiroh, L. N., & Pradipta, T. R. (2023). The Effect of Math Anxiety on Academic Procrastination of Junior High School Students. Mathline: *Jurnal Matematika dan Pendidikan Matematika,* 8 (3), 1119 - 1132. https://doi.org/10.31943/mathline.v8i3.471
60. Maloney, E. A., Ramirez, G., Gunderson, E. A., Levine, S. C., & Beilock, S. L. (2015). Intergenerational effects of parents' math anxiety on children's math achievement and anxiety. *Psychological science*, *26* (9), 1480 - 1488. https://doi.org/10.1177/0956797615592630
61. Marticion, J. A. (2021). Mathematical anxiety as predictor of learning motivation strategies. *Outheast Asian Mathematics Education Journal*, *11*(1), 1-12. https://doi.org/10.46517/seamej.v11i1.123
62. Malanchini, M., Rimfeld, K., Wang, Z., Petrill, S. A., Tucker-Drob, E. M., Plomin, R., & Kovas, Y. (2020). Genetic factors underlie the association between anxiety, attitudes and performance in mathematics. *Translational psychiatry*, *10*(1), 12. https://doi.org/10.1038/s41398-020-0711-3
63. Malanchini, M., Rimfeld, K., Shakeshaft, N. G., Rodic, M., Schofield, K., Selzam, S., ... & Kovas, Y. (2017). The genetic and environmental aetiology of spatial, mathematics and general anxiety. *Scientific reports*, *7*(1), 42218. https://doi.org/10.1038/srep42218
64. Maass, K., Geiger, V., Ariza, M. R., & Goos, M. (2019). The role of mathematics in interdisciplinary STEM education. *Zdm*, *51*, 869-884. https://doi.org/10.1007/s11858-019-01100-5
65. Morán-Soto, G., & González-Peña, O. I. (2022). Mathematics Anxiety and Self-Efficacy of Mexican Engineering Students: Is There Gender Gap?. *Education Sciences*, *12*(6), 391. https://doi.org/10.3390/educsci12060391
66. Morris, T. H. (2019). Self-directed learning: A fundamental competence in a rapidly changing world. *International Review of Education*, *65*(4), 633-653. https://doi.org/10.1007/s11159-019-09793-2
67. Moustafa, A. A., Al-Emadi, A. A., & Megreya, A. M. (2021). The need to develop an individualized intervention for mathematics anxiety. *Frontiers in psychology*, *12*, 723289. https://doi.org/10.3389/fpsyg.2021.723289
68. Mehmet, C., & Hulya, S. (2021). Factors That Cause Students to Develop Math Anxiety and Strategies to Diminish. *Cypriot Journal of Educational Sciences*, *16*(4), 1356-1367. https://orcid.org/0000-0001-8288-445X
69. OECD. (2015). *The ABC of Gender Equality in Education*. Paris: OECD Publishing. http://dx.doi.org/10.1787/9789264229945-en.
70. OECD. (2013). PISA 2012 Results: Ready to Learn (Volume III): Students' Engagement, Drive and Self-Beliefs. Paris: OECD Publishing. http://dx.doi.org/10.1787/9789264201170
71. Paechter, M., Macher, D., Martskvishvili, K., Wimmer, S., & Papousek, I. (2017). Mathematics anxiety and statistics anxiety. Shared but also unshared components and antagonistic contributions to performance in statistics. *Frontiers in psychology*, *8*, 1196. https://doi.org/10.3389/fpsyg.2017.01196
72. Passolunghi, M. C., De Vita, C., & Pellizzoni, S. (2020). Math anxiety and math achievement: The effects of emotional

and math strategy training. *Developmental science*, *23*(6), e12964. https://doi.org/10.1111/desc.12964

73. Passolunghi, M. C., Caviola, S., De Agostini, R., Perin C., Mammarella, I. C. (2016). Mathematics Anxiety, Working Memory, and Mathematics Performance in Secondary-School Children. *Front. Psychol*., 7 (42), 1 – 8. https://10.3389/fpsyg.2016.00042
74. Petronzi, D., Staples, P., Sheffield, D., & Hunt, T. (2019). Acquisition, development and maintenance of maths anxiety in young children. In *Mathematics Anxiety* (pp. 77-102). Routledge. https://10.4324/9780429199981-5
75. Peng, P., & Kievit, R. A. (2020). The development of academic achievement and cognitive abilities: A bidirectional perspective. *Child Development Perspectives*, *14*(1), 15-20. https://doi.org/10.1111/cdep.12352
76. Pizzie, R. G., & Kraemer, D. J. (2021). The association between emotion regulation, physiological arousal, and performance in math anxiety. *Frontiers in psychology*, *12*, 639448. https://doi.org/10.3389/fpsyg.2021.639448
77. Pizzie, R. G., & Kraemer, D. J. M. (2017). Avoiding math on a rapid timescale: Emotional responsivity and anxious attention in math anxiety. *Brain and Cognition, 118,* 100–107. https://doi.org/10.1016/j.bandc.2017.08.004
78. Posner, M. I., & Rothbart, M. K. (2007). Research on attention networks as a model for the integration of psychological science. Annual Review of Psychology, 58, 1–23. https://doi.org/10.1146/annurev.psych.58.110405.085516
79. Ramirez, G., Shaw, S. T., & Maloney, E. A. (2018). Math anxiety: Past research, promising interventions, and a new interpretation framework. *Educational psychologist*, 53(3), 145-164. https://doi.org/10.1080/00461520.2018.1447384
80. Rodriguez-Planas, N., & Nollenberger, N. (2018). Let the girls learn! It is not only about math … it's about gender social norms. *Economics of Education Review, 62*, 230–252. https://10.1016/j.econedurev.2017.11.006
81. Rozgonjuk, D., Kraav, T., Mikkor, K., Orav-Puurand, K., & Täht, K. (2020). Mathematics anxiety among STEM and social sciences students: the roles of mathematics self-efficacy, and deep and surface approach to learning. International Journal of STEM Education, 7(1), 1-11. https://doi.org/10.1186/s40594-020-00246-z
82. Samuel, T. S., Buttet, S., & Warner, J. (2023). "I Can Math, Too!": Reducing Math Anxiety in STEM-Related Courses Using a Combined Mindfulness and Growth Mindset Approach (MAGMA) in the Classroom. *Community College Journal of Research and Practice*, *47* (10), 613 - 626. https://doi.org/10.1080/10668926.2022.2050843
83. Shafiq, M., Ajmal, S., & Amin, R. (2020). Effectiveness of Cognitive Behavioral Group Therapy in Reducing Math Anxiety in Adolescents. *Clinical and Counselling Psychology Review*, *2*(2). https://doi.org/10.32350/ccpr.22.04
84. Sharma, S., & Sarkar, P. (2020). Efficiency of Blended Learning in reduction of Anxiety: with special reference to High School Students. *International Journal of Grid and Distributed Computing*, *13*(1), 277-285. http://surl.li/sxklr
85. Stiles, W., Barkham, M., Mellor-Clark, J., & Connell, J. (2008). Effectiveness of cognitive-behavioural, person-centred, and psychodynamic therapies in UK primary-care routine practice: Replication in a larger sample. *Psychological Medicine*, *38*(5), 677-688. https://10.1017/S0033291707001511
86. Smetackova, I. (2015). Gender stereotypes, performance and identification with math. *Procedia-Social and Behavioral Sciences*, *190*, 211-219. https://doi.org/10.1016/j.sbspro.2015.04.937
87. Szczygieł, M., & Pieronkiewicz, B. (2022). Exploring the nature of math anxiety in young children: Intensity, prevalence, reasons. *Mathematical Thinking and Learning*, 24(3), 248-266. https://doi.org/10.1080/10986065.2021.1882363
88. Taylor, B. A. (2004). *The influence of classroom environment on high school students' mathematics anxiety and*

attitudes (Doctoral dissertation, Curtin University).
89. Tang, Y. P., & Huang, S. J. (2019). Self-paced active learning: Query the right thing at the right time. In *Proceedings of the AAAI conference on artificial intelligence* (Vol. 33, No. 01, pp. 5117-5124). https://doi.org/10.1609/aaai.v33i01.33015117
90. Vanbinst, K., Bellon, E., & Dowker, A. (2020). Mathematics anxiety: an intergenerational approach. *Frontiers in Psychology*, *11*, 1648. https://doi.org/10.3389/fpsyg.2020.01648
91. Vos, H., Marinova, M., De Leon, S. C., Sasanguie, D., & Reynvoet, B. (2023). Gender differences in young adults' mathematical performance: Examining the contribution of working memory, math anxiety and gender-related stereotypes. *Learning and Individual Differences*, *102*, 102255. https://doi.org/10.1016/j.lindif.2022.102255
92. Wang, Z., Borriello, G. A., Oh, W., Lukowski, S., & Malanchini, M. (2021). Co-development of math anxiety, math self-concept, and math value in adolescence: The roles of parents and math teachers. *Contemporary Educational Psychology*, *67*, 102016. https://doi.org/10.1016/j.cedpsych.2021.102016
93. Wang, Z., Hart, S. A., Kovas, Y., Lukowski, S., Soden, B., Thompson, L. A., ... & Petrill, S. A. (2014). Who is afraid of math? Two sources of genetic variance for mathematical anxiety. *Journal of child psychology and psychiatry*, *55*(9), 1056-1064. https://doi.org/10.1111/jcpp.12224
94. Xhaferi, B., & Xhaferi, G. (2020). Online learning benefits and challenges during the COVID 19-pandemic-students' perspective from SEEU. *Seeu Review*, *15*(1), 86-103. https://doi.org/10.2478/seeur-2020-0006
95. Zanabazar, A., Deleg, A., & Ravdan, M. (2023). A study of factors causing math anxiety among undergraduate students. International Journal of Innovative Research and Scientific Studies, 6(3), 578-585. https://doi.org/10.53894/ijirss.v6i3.1609
96. Zettle, R. D. (2003). Acceptance and commitment therapy (ACT) vs. systematic desensitization in treatment of mathematics anxiety. *The psychological record*, *53*, 197-215. https://doi.org/10.1007/BF03395440
97. Živković, M., Pellizzoni, S., Mammarella, I. C., & Passolunghi, M. C. (2023). The relationship between math anxiety and arithmetic reasoning: The mediating role of working memory and self-competence. *Current Psychology*, 42(17), 14506-14516. https://doi.org/10.1007/s12144-022-02765-0

How to cite this article: Georgios Tsirimokos, Eleni Lekka, Georgios Pilafas, Penelope Louka. 'Math is not for me'. investigating mathematics anxiety in secondary and higher education: a critical discussion of current practices and future recommendations. *International Journal of Science & Healthcare Research*. 2024; 9(2): 237-249. DOI: *10.52403/ijshr.20240234*

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