

Neuroscience Meets EdTech: Combating Mathematics Anxiety

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ABSTRACT

Mathematics anxiety continues to be a pervasive issue in education, contributing to decreased self-confidence, reduced motivation, and lower academic performance among students. This paper explores an integrated pedagogical framework that combines the Brain-Based Teaching Approach (BBTA) with technology-enhanced learning as a strategic intervention to mitigate these challenges. Drawing on neuroscience principles, BBTA emphasizes creating a supportive emotional climate, sustaining learner engagement through meaningful tasks, and promoting active processing of knowledge. Evidence from previous studies demonstrates that BBTA, when supported by technology, leads to a measurable reduction in mathematics anxiety, significant improvement in motivation, and enhanced achievement across varying levels of task difficulty. This paper outlines the theoretical basis for the integrated model, discusses its application in the mathematics classroom, and explores its scalability to other disciplines. This paper concludes with recommendations for the potential of BBTA with technology integration as a sustainable, research-informed strategy for fostering both cognitive development and emotional well-being in mathematics education.

Keywords: Brain-Based Teaching Approach, Mathematics Anxiety, Mathematics Achievement, Technology Tool,

INTRODUCTION

Mathematics is a foundational subject essential for academic and professional success. However, many students struggle with mathematics anxiety which is a negative emotional response that disrupts cognitive processing and inhibits learning. Mathematics anxiety, characterized by feelings of tension, apprehension, and fear when confronted with mathematical tasks, has been widely recognized as a persistent obstacle to student success (Mohd et al., 2024). Students who experience mathematics anxiety often avoid problem-solving, show reduced self-confidence, and perform below their potential. Beyond the academic implications, such anxiety also affects students' broader emotional well-being, leading to long-term disengagement with STEM fields. Addressing this issue requires more than traditional drill-and-practice methods; it calls for teaching strategies that attend to both the cognitive and emotional aspects of learning.

Students who believe in their abilities and see value in the subject are more likely to persevere and achieve success. In this context, the combination of neuroscience-informed pedagogy and modern educational technology presents a promising approach to enhance engagement, alleviate anxiety, and promote lasting learning outcomes (Sahni et al., 2025). Students who feel more motivated and confident in their math skills tend to perform better in school. Advances in neuroscience and educational psychology have provided new insights into how the brain learns most effectively. The Brain-Based Teaching Approach (BBTA) uses these insights by creating learning environments that promote relaxed alertness, coordinated immersion, and active processing (Amjad et al., 2023). By combining BBTA with digital tools like mobile learning platforms, multimedia

resources, and adaptive technologies, math lessons can become more dynamic, engaging, and supportive. These ideas help create a new approach to teaching mathematics that enables students to reach their full potential today.

LITERATURE REVIEW

1. Motivation, Self-Efficacy and Mathematics Learning

Motivation and self-efficacy are essential for students' engagement and success in mathematics. Self-efficacy refers to one's belief in their ability to perform specific tasks, which encourages persistence when facing complex problems, boosts cognitive resourcefulness, and directly impacts performance outcomes. Recent studies have emphasized this connection: a meta-analysis of 21 studies found a positive correlation between self-efficacy and mathematical creativity. In the Malaysian higher education context, mathematics self-efficacy has been shown to influence intrinsic motivation significantly, one of the strongest predictors of engagement (Amjad et al., 2023). Mastery experiences, vicarious experiences, and social persuasion shape self-efficacy. It is the most powerful predictor of achievement, although vicarious experiences sometimes had adverse effects.

Longitudinal studies also demonstrate that self-efficacy varies in relation to task difficulty. At the tertiary level, self-efficacy mediates the relationship between prior mathematics knowledge and performance, accounting for approximately 30% of the variability in performance. Together, these findings confirm that self-efficacy is both a predictor and a result of effective mathematics learning, boosting motivation, resilience, and achievement. Research indicates that mathematics anxiety can significantly impair working memory, restrict problem-solving ability, and create a cycle of avoidance and underachievement. The emotional strain of anxiety often prevents students from fully engaging in lessons, lowering their performance regardless of their ability. Bandura's self-efficacy theory, as outlined in Schwarzer (2024), suggests that belief in one's abilities is a key factor in motivation and achievement. Success in previous math experiences reinforces confidence, while seeing peers succeed can foster social motivation. Motivation is also connected to persistence, resilience, and academic success (Yaftian & Barghamadi, 2022).

2. Technology-Enhances Learning in Mathematics

Digital tools, from mobile applications to interactive multimedia, have transformed traditional classrooms into dynamic, student-centered environments. Technology encourages active learning, higher-order thinking, and personalized instruction, leading to increased motivation and engagement. BBTA is based on neuroscience principles, aligning instructional strategies with how the brain naturally processes and retains information. Key principles include: 1) Relaxed Alertness which creates a safe, supportive environment to reduce anxiety, 2) Orchestrated Immersion which offers challenging yet achievable tasks that sustain engagement, and 3) Active Processing which promotes students to interact with and apply knowledge for better retention. When combined with technology, BBTA can develop an ideal learning ecosystem that addresses both cognitive and emotional aspects of learning (Saleh & Subramniam, 2019).

Technology integration in mathematics education has transformed traditional teaching into dynamic, multi-sensory, and student-centered experiences. Multimedia learning environments help reduce mathematics anxiety by making abstract concepts feel more concrete (Yaftian & Barghamadi, 2022). Game-based learning platforms enhance performance and foster positive experiences, although their short-term effects may be limited (Subramaniam & Saleh, 2024). Conversational agents provide personalized support and feedback, which help decrease anxiety by creating a safe and interactive dialogue. Virtual Reality (VR) enables clear visualization of abstract ideas, lowering anxiety and boosting motivation (Pahmi et al., 2025). Artificial Intelligence (AI) tools are increasingly used to tailor mathematics instruction (Tang, 2025). Overall, technology-enhanced strategies offer the benefit of providing immediate, supportive, and adaptable learning experiences. Their effectiveness is maximized when combined with neuroscience-informed pedagogies such as BBTA.

3. Brain-Based Teaching Approaches and Neuroscience Foundation

Brain-Based Teaching Approaches (BBTA) apply neuroscience principles to align instruction with how the brain

naturally learns. Central to BBTA are relaxed alertness, orchestrated immersion, and active processing (Saleh & Subramniam, 2019). Empirical studies have shown that implementing brain-based activities, such as imagery, role-playing, and brainstorming, enhances students' intrinsic motivation and self-efficacy in mathematics (Mohd et al., 2022). When BBTA is withdrawn, gains diminish, confirming its direct effect on learning outcomes. Neuroscience research also supports the potential of BBTA. Gentle electrical brain stimulation has been shown to improve math performance in adults with initially low achievement (Amjad et al., 2022). While not directly instructional, this underscores the brain's adaptability. BBTA emphasizes creating learning environments that feel safe, engage multiple senses, and promote reflection, which helps reduce mathematics anxiety. When combined with technology, BBTA can enhance both cognitive and emotional engagement in the learning process.

DISCUSSION

1. Addressing Mathematics Anxiety through BBTA and Technology

Mathematics anxiety often causes students to avoid math, feel less confident, and struggle academically. Azizan et al. (2022) found that using BBTA with technology can help reduce anxiety for pre-university students. BBTA's focus on relaxed alertness helps by creating a safe and supportive classroom environment. Technology enhances this by providing students with interactive tasks and demonstrating that making mistakes is a natural part of the learning process. In the experimental group, students engaged with a set of digital tools designed to align with BBTA principles. GeoGebra, Desmos and Cabri 3D were employed to visualize mathematical concepts dynamically, supporting relaxed alertness by reducing abstraction-related stress. A gamified quiz platform such as Kahoot! and Quizizz promoted orchestrated immersion by presenting mathematical challenges in a competitive yet enjoyable environment that sustained engagement. Meanwhile, a Roblox platform was embedded in the learning management system which enhanced student interaction and made learning more fun within their peers, directly fostering active processing as students reflected on their mistakes and consolidated understanding at their own pace.

By mapping these tools to BBTA principles, the intervention leveraged both neuroscience and digital pedagogy in complementary ways. When these elements are combined, mathematics lessons become safer spaces for students, allowing them to focus on solving problems rather than feeling anxious (Mohd et al., 2024). In their study with technical students, anxiety levels decreased, while motivation and performance improved. These results support other research that emphasizes the importance of addressing both emotional well-being and cognitive skills (Schoenfeld, 2016). BBTA helps create supportive environments, and technology provides interactive, low-pressure ways to learn.

2. Enhancing Motivation, Self-Efficacy and Achievement

Motivation and self-efficacy are essential for success in mathematics. Research shows that learners with higher motivation and self-efficacy tend to stick with their efforts longer and achieve better results (Christensen & Osgood, 2024). This study confirms these findings, revealing that the experimental group experienced less anxiety and exhibited greater motivation and achievement. BBTA's principles of orchestrated immersion and active processing foster intrinsic motivation by engaging students in meaningful and challenging activities. Technology supports these outcomes by providing adaptive pathways and immediate feedback, allowing students to progress at their own pace (Tang, 2025).

Social influence is also key, as digital environments enable students to observe their peers' progress and gain vicarious reinforcement, thereby boosting their self-efficacy. These motivational dynamics underscore BBTA's dual influence on both the emotional and cognitive sides of learning, especially in technology-rich settings. Students who feel capable and motivated tend to be more persistent and achieve more. BBTA and Technology enhances these effects by customizing instruction, offering immediate feedback, and reducing the fear of failure. Innovations like VR and conversational AI further expand BBTA principles into scalable digital environments (Pahmi et al., 2025).

3. Challenges, Policy Alignment and Future Direction

Integrating BBTA with technology holds promise, but challenges remain. Scalability and equity are key issues, particularly in schools with limited resources, where tools like VR or AI may not always be available. To address scalability and equity concerns, schools with limited budgets can utilize open-source or free tools that align with BBTA principles. GeoGebra, for instance, is a freely available software that supports visual-spatial learning and reduces cognitive load (Osypova & Tatochenko, 2021). Platforms like Kahoot! and Quizizz provide free versions suitable for gamified orchestration of lessons. Even basic features of Google Classroom or Moodle can be adapted to facilitate *Active Processing* through reflective quizzes and collaborative tasks (Antipuesto & Tan, 2023). By advocating cost-effective alternatives, the integrated BBTA-technology model becomes viable across a wider range of educational settings or even in low-resource educational contexts.

Other than that, educators also require proper training to utilize neuroscience-based teaching methods in conjunction with new technology effectively. To fully realize the benefits of this model, ongoing professional development is crucial. Educators need training in neuroscience-based teaching methods and technical skills. Supportive policies are also vital to ensure resources reach all types of schools. Despite these challenges, BBTA, along with its technology, aligns well with national STEM goals and global efforts toward digital transformation. In Malaysia, this approach aligns with the country's focus on enhancing STEM education and staying abreast of global digital trends. By integrating neuroscience-based teaching with technology, the model aims to boost both student achievement and well-being in today's classrooms.

4. Implication for Practice

BBTA and technology collaborate to help students overcome both emotional and cognitive challenges in learning mathematics. This approach provides educators with tools to tailor lessons using adaptive technology, support students' well-being, and create classrooms where students remain motivated and curious. BBTA can also be turned into educators training modules, digital tools for schools and tutoring centers, and flexible resources for different subjects and grade levels. This approach aligns with national STEM education priorities and meets the need for innovative hybrid learning solutions. Technology tools, such as multimedia, gamification, and adaptive learning systems, can enhance engagement, tailor instruction, and provide timely feedback.

For educators, beyond adopting BBTA and technology generally, a deliberate design of mastery experiences is essential. This could involve structuring lessons with gradually increasing problem difficulty to ensure early successes that build confidence. Technology platforms can track progress and celebrate milestones, reinforcing mastery and confidence. To cultivate positive vicarious experiences, educators may use collaborative features of digital tools to showcase peer problem-solving strategies, normalizing mistakes as learning opportunities and highlighting diverse approaches to success. Such deliberate design strengthens students' self-efficacy in their mathematical abilities, thereby enhancing motivation and achievement.

Policymakers should support scalable implementations by investing in infrastructure, funding educator training, and encouraging schools to adopt innovative pedagogical frameworks. The evidence from this study can inform policy decisions on integrating neuroscience and technology into curriculum design. Future research should explore AI-driven personalization, virtual reality for abstract learning, and comparative studies across cultural contexts. Researchers can also examine the role of socio-emotional factors such as resilience and well-being in mathematics learning outcomes.

Figure 1 illustrates how the Brain-Based Teaching Approach (BBTA) integrates with technology-enhanced strategies to create emotionally safe, interactive, and cognitively stimulating environments.

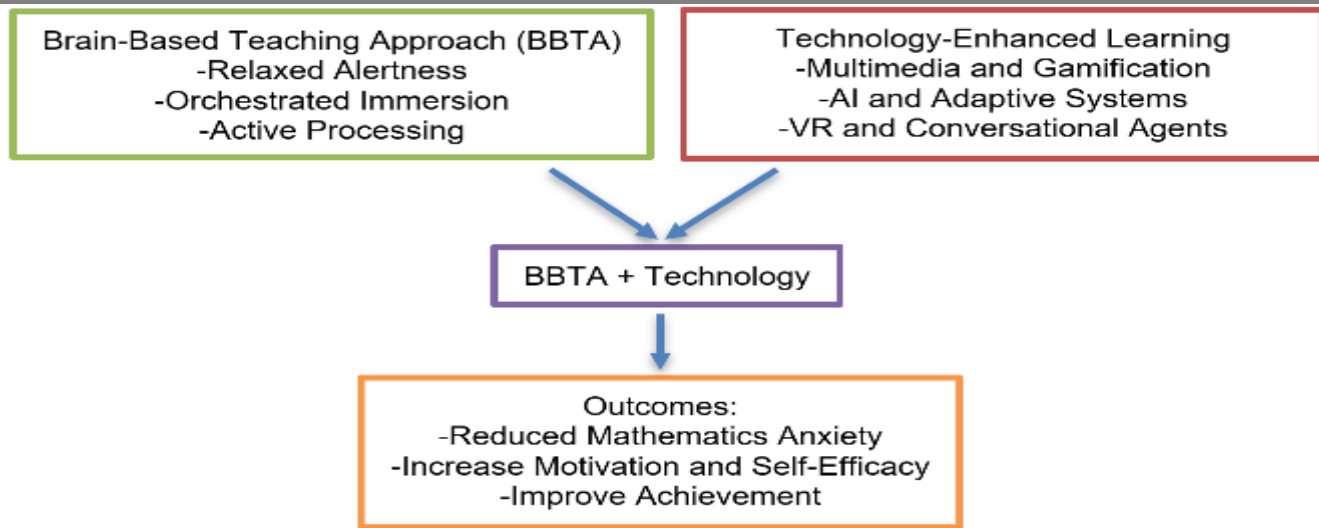


Figure 1 Integration of BBTA and Technology in Mathematics Learning

Table 1 Description of the table

Aspect	Description
Study Design	Quasi-experimental study with control and experimental groups.
Target Participants	pre-diploma students (aged 18–19 years) divide into: - Experimental group - Control group
Intervention	- Experimental group received BBTA with technology-enhanced lessons (2 weeks, 5 hours/week). - Control group received conventional teaching.
Instruments	- Pre- and post-tests on mathematics topics (easy, medium, hard levels). - Questionnaires on motivation and anxiety (before and after intervention).
Key Findings	- Significant reduction in mathematics anxiety (from high to moderate levels). - Increase in student motivation. - Improvement in mathematics achievement across difficulty levels. - Strong correlation between motivation and performance.

CONCLUSION

The integration of brain-based teaching principles with technology-enhanced learning presents a transformative approach to mathematics education. By addressing emotional barriers such as anxiety and enhancing cognitive engagement through interactive tools, the BBTA model promotes increased motivation, confidence, and achievement. The findings from this study support its wider application across various disciplines and educational settings. With proper training, technological integration, and institutional support, BBTA can reshape learning experiences, empower students, and contribute to long-term educational success. By adopting open-source or cost-effective technologies and embedding them within a neuroscience-based framework, educators can transform mathematics classrooms into spaces of confidence, curiosity, and achievement. This integrated approach not only prepares students for success in mathematics but also contributes to the broader global agenda of innovative and inclusive education in the 21st century.

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