

# A Modular Teaching Program to Alleviate Math Anxiety in Primary Education

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**Abstract:** Mathematics anxiety is a pervasive issue that undermines students' academic performance, self-confidence, and engagement with mathematics. Recognizing its adverse effects, six partner countries collaborated under an Erasmus Plus project to investigate the root causes of mathematics anxiety and design an innovative intervention. Using a mixed-methods approach, surveys and interviews were conducted in five partner countries to identify key factors contributing to mathematics anxiety in primary school students. Based on these findings, a modular teaching program integrating robotics applications was developed to alleviate anxiety and promote positive engagement with mathematics. This article provides an in-depth overview of the study's methodology, findings, and the modular teaching program, emphasizing its potential for transformative change in mathematics education.

**Keywords:** Math anxiety, robotics in education, innovation in education.

## I. INTRODUCTION

Mathematics serves as a cornerstone of education, fostering critical thinking, logical reasoning, and problem-solving skills essential for personal and professional development. However, for many students, mathematics is associated with anxiety, frustration, and avoidance. Mathematics anxiety, characterized by feelings of tension, fear, or apprehension when engaging with mathematical tasks, presents a significant barrier to learning. This phenomenon not only impacts students' academic performance but also limits their aspirations in mathematics-intensive fields such as science, technology, engineering, and mathematics (STEM).

Addressing mathematics anxiety is particularly critical in primary education, where foundational attitudes and skills are established. Negative experiences with mathematics during these formative years can lead to long-term disengagement and underachievement. Recognizing this, an Erasmus Plus project brought together six partner countries to develop a comprehensive approach to mitigate mathematics anxiety among primary school students. The study aimed to:

1. Investigate the root causes of mathematics anxiety through surveys and interviews with students, teachers, and parents.
2. Develop a modular teaching program incorporating robotics applications to provide an engaging, hands-on approach to learning mathematics.
3. Assess the potential of this program to enhance students' confidence, enjoyment, and proficiency in mathematics.

## II. LITERATURE REVIEW

### A. Understanding Mathematics Anxiety

Mathematics anxiety is a multifaceted phenomenon influenced by a combination of cognitive, emotional, and environmental factors. It manifests as a debilitating fear or discomfort that interferes with mathematical problem-

solving and academic performance. This condition can significantly impair an individual's ability to engage with mathematical tasks, often leading to avoidance behaviours and a negative feedback loop that perpetuates the anxiety.

Mathematics anxiety often impairs working memory, a critical cognitive resource for processing and manipulating numerical information. This cognitive interference disrupts a student's ability to focus, strategize, and solve problems efficiently. Importantly, mathematics anxiety is not limited to underachieving students; high-performing individuals may also experience anxiety due to perfectionism, societal expectations, or the pressures of high-stakes testing environments.

Cognitive contributors to mathematics anxiety include negative self-perceptions, limited problem-solving strategies, and difficulty connecting abstract concepts to real-world applications. For example, students who internalize the belief that they are inherently "not good at math" may disengage from learning opportunities, further reinforcing their struggles. Emotional factors such as fear of failure, low self-efficacy, and the lingering effects of prior negative experiences with mathematics also exacerbate anxiety. These emotional barriers create a sense of helplessness and reduce motivation, making it challenging for students to persevere through mathematical difficulties [1].

Environmental influences play a critical role in shaping students' attitudes toward mathematics. Unsupportive teaching methods, such as overly rigid instruction or lack of differentiated learning opportunities, can alienate students and hinder their engagement. High-pressure academic settings, where performance is prioritized over mastery, often amplify anxiety levels. Additionally, a lack of access to engaging learning resources, such as manipulatives or interactive tools, limits students' ability to explore mathematical concepts in a hands-on, meaningful way. Collectively, these factors underscore the complexity of mathematics anxiety and the need for targeted interventions that address its root causes.

#### B. Addressing Mathematics Anxiety in Primary Schools

Addressing mathematics anxiety requires a comprehensive, multifaceted approach that integrates cognitive, emotional, and environmental strategies. Primary school represents an opportune stage for intervention, as students are more receptive to new learning experiences and emotional resilience can be cultivated early in their educational journey.

#### C. Cognitive Interventions

Cognitive strategies aimed at reducing mathematics anxiety focus on reshaping students' perceptions of their abilities and enhancing their problem-solving skills. Explicit instruction in problem-solving techniques, such as breaking down complex problems into manageable steps, can build students' confidence and competence. Encouraging students to approach mathematical challenges with a growth mindset—the belief that abilities can be developed through effort and persistence—is particularly effective. Teachers can foster this mindset by celebrating effort and progress rather than solely emphasizing correct answers [2].

#### D. Emotional Interventions

Emotional strategies target the affective dimensions of mathematics anxiety. Social-emotional learning (SEL) programs, which emphasize self-awareness, emotional regulation, and interpersonal skills, are highly effective in creating a supportive classroom environment. For example, mindfulness practices and stress-reduction techniques can help students manage the physiological responses associated with anxiety, such as increased heart rate and tension.

Teacher-student relationships also play a pivotal role in addressing emotional barriers to learning. Educators who demonstrate empathy, patience, and a genuine belief in their students' potential can significantly reduce anxiety levels. Furthermore, creating a classroom culture that values mistakes as learning opportunities encourages risk-taking and resilience, both of which are essential for overcoming mathematics anxiety [3].

#### E. Environmental Interventions

Environmental interventions focus on creating a supportive and engaging learning environment. Innovative teaching practices, particularly those involving technology, have shown great promise in reducing mathematics anxiety. Interactive tools such as educational games, virtual simulations, and robotics applications offer students a hands-on and enjoyable way to explore mathematical concepts. These approaches align with constructivist learning theories, which emphasize active participation, exploration, and discovery.

For example, robotics-based learning engages students in programming and problem-solving activities that make abstract mathematical concepts tangible and relatable. By integrating mathematics into interdisciplinary projects, such as designing and coding a robot to navigate a maze, students develop a deeper understanding of mathematical principles while simultaneously building confidence in their abilities [4].

#### F. Teacher Training and Parental Involvement

Teacher training is a cornerstone of effective interventions for mathematics anxiety. Educators equipped with a repertoire of strategies to address anxiety can create positive and inclusive learning environments. Professional development programs that focus on differentiated instruction, formative assessment techniques, and the use of manipulatives and digital tools are particularly beneficial.

Parental involvement is another critical factor in addressing mathematics anxiety. Parents who model positive attitudes toward mathematics and provide support at home can significantly influence their children's confidence and attitudes. Simple activities, such as playing math-based games or discussing real-world applications of mathematical concepts, help demystify the subject and foster a more positive outlook [5].

#### G. Collaborative Approaches

Collaboration among teachers, parents, and students is essential for addressing mathematics anxiety effectively. Regular communication between educators and families ensures that interventions are consistent and tailored to individual needs. Additionally, involving students in goal-setting and self-assessment fosters a sense of ownership over their learning journey, empowering them to overcome challenges and build resilience.

Addressing mathematics anxiety in primary schools requires a holistic approach that considers cognitive, emotional, and environmental factors. By implementing targeted interventions, such as cognitive restructuring, SEL programs, innovative teaching practices, and robust teacher training, educators can create a supportive learning environment that empowers students to succeed in mathematics. Parental involvement and collaborative efforts further enhance the effectiveness of these strategies, ensuring that students develop the skills and confidence needed to thrive in their mathematical endeavours [6].

### **III. WHY ROBOTICS ARE IMPORTANT TO RELEASE MATH ANXIETY?**

#### A. The Importance of Using Robotics in Education to Alleviate Math Anxiety

Mathematics is often perceived as a daunting subject by many students, and one of the most significant barriers to learning math is the anxiety that some learners experience. This phenomenon, commonly known as math anxiety, can have long-lasting effects on a student's academic performance and overall attitude toward mathematics. Recent studies and educational trends have introduced innovative solutions to tackle this issue, with the use of robotics being one of the most promising methods. Robotics, with its hands-on and interactive nature, offers an engaging platform for learning that has the potential to reduce math anxiety and foster a positive learning experience. In this paper, we will explore how the integration of robotics in education can help alleviate math anxiety, focusing on its educational benefits, the way it redefines student-teacher interactions, and how it nurtures a deeper understanding of mathematical concepts [7].

#### B. The Nature of Math Anxiety and Its Impact on Students

Math anxiety is a psychological phenomenon where individuals experience intense fear, nervousness, or worry when engaging with mathematical tasks. This anxiety can manifest in various forms, from physical symptoms like sweating or nausea to cognitive symptoms like negative self-talk and a lack of confidence in one's mathematical abilities. Math anxiety often stems from negative past experiences with math, a fear of failure, or the pressure to perform well in exams. As a result, students with math anxiety tend to avoid math-related tasks, have difficulty retaining information, and often underperform in assessments [8].

The impact of math anxiety is significant. It creates a negative cycle where students' fears about mathematics prevent them from engaging fully with the subject, which, in turn, reinforces their anxiety. This cycle can continue throughout their academic careers, hindering their overall academic success and affecting their future opportunities in fields that require mathematical understanding, such as engineering, science, and technology.

**C. Robotics as a Tool for Reducing Math Anxiety**

Robotics provides a dynamic and engaging way for students to interact with math concepts. The hands-on nature of robotics allows students to physically manipulate objects, providing an active learning environment that can make abstract mathematical ideas more concrete and understandable. By combining elements of mathematics, engineering, and technology, robotics can offer students a multifaceted learning experience that bridges the gap between theory and practice.

The key to alleviating math anxiety with robotics lies in its ability to create a non-threatening and supportive environment. In traditional math instruction, students are often passive recipients of information, which can make learning feel impersonal and intimidating. In contrast, robotics encourages students to be active participants in their learning process. When students are tasked with programming and controlling robots, they engage with mathematical concepts like geometry, measurement, and algebra in a practical, real-world context. This active engagement helps to reduce the fear and anxiety that often accompany abstract mathematical problems [9].

**D. Engaging Students through Robotics**

Robotics in education transforms the learning experience by introducing an element of play and creativity. When students work with robots, they are not just solving math problems—they are building and creating something tangible. This process fosters a sense of accomplishment and boosts confidence, both of which are crucial for overcoming math anxiety. Additionally, robotics often requires collaboration, which helps students feel less isolated in their learning journey. Working together on a robotics project allows students to share ideas, solve problems collectively, and provide mutual support, all of which contribute to a positive learning atmosphere.

By incorporating robotics into the curriculum, educators can create an engaging and motivating learning environment. For example, students might be tasked with programming a robot to navigate a maze, which requires them to apply mathematical concepts like angles, coordinates, and problem-solving strategies. This real-world application of math helps students see the relevance of what they are learning and makes math feel less abstract and more connected to their everyday lives [10].

**E. Robotics as a Medium for Understanding Abstract Mathematical Concepts**

Mathematics, by its nature, involves abstract concepts that can be difficult for students to grasp. Many students struggle to see the practical application of mathematical principles, which can lead to frustration and, ultimately, math anxiety. Robotics offers a solution to this problem by providing a context in which students can see these abstract concepts come to life.

For instance, geometry concepts like angles, symmetry, and shapes can be taught through the design and programming of robots. By calculating angles to program a robot to turn in a specific direction or using geometry to design a robot's path, students can directly apply what they learn in the classroom to real-world problems. Similarly, algebraic thinking can be introduced through programming languages, which require students to use variables, equations, and logic to control the robot's behaviour. This hands-on approach helps students make connections between abstract mathematical concepts and tangible outcomes, which significantly reduces the intimidation factor associated with math [11].

Furthermore, robotics introduces an element of trial and error that is often absent in traditional math instruction. In robotics, failure is not seen as a setback but as a natural part of the learning process. Students learn to troubleshoot problems, test hypotheses, and adjust their approach based on the feedback from the robot. This iterative process helps students build resilience, improves their problem-solving skills, and reduces the fear of making mistakes—an important aspect of overcoming math anxiety.

**F. Fostering Collaboration and Reducing Isolation**

Math anxiety can often stem from feelings of isolation, as students who struggle with math may feel they are alone in their difficulties. In traditional classroom settings, these students may hesitate to ask questions or seek help, fearing judgment or embarrassment. Robotics, however, fosters collaboration and teamwork, which can help break down these barriers.



When students work in groups on robotics projects, they have the opportunity to share their knowledge, ask questions, and support one another. This collaborative environment creates a sense of community, where students can work together to solve problems and celebrate their successes. By participating in group activities, students with math anxiety can feel less isolated and more supported in their learning. Additionally, the social aspect of robotics helps to normalize struggles and encourages students to view mistakes as learning opportunities rather than failures [12].

In group settings, students may also take on different roles, such as programmer, designer, or tester. This division of labor allows each student to contribute their strengths to the project, creating a sense of shared responsibility and accomplishment. As a result, students can develop a more positive attitude toward math and see it as a collaborative and enjoyable process rather than a solitary and intimidating task.

#### G. Enhancing Teacher-Student Interactions

Robotics also has the potential to enhance the teacher-student relationship. Traditional math instruction can sometimes be rigid and formulaic, with little room for personalized attention or creativity. In contrast, robotics provides an opportunity for teachers to interact with students in a more dynamic and individualized way. Teachers can guide students through the process of building and programming robots, offering real-time feedback and support as students work on their projects [13].

This individualized support helps students build confidence and reinforces the idea that learning math is not a solitary endeavour but a collaborative process between teacher and student. Teachers can also use robotics as a tool for formative assessment, observing how students approach problems, solve challenges, and apply mathematical concepts in real-time. This approach allows for more personalized and constructive feedback, which is essential for reducing math anxiety and helping students build a deeper understanding of the subject [14].

The use of robotics in education offers a powerful and innovative approach to addressing math anxiety. By providing an engaging, hands-on learning experience, robotics helps students connect abstract mathematical concepts to real-world applications, fostering a deeper understanding of math. Robotics also promotes collaboration, creativity, and problem-solving, all of which contribute to reducing the fear and isolation often associated with math anxiety. As educators continue to explore new ways to engage students and make learning more accessible, robotics presents a promising avenue for creating a positive and supportive environment where students can overcome their math anxiety and develop a love for learning mathematics.

Incorporating robotics into the curriculum is not just about teaching students how to build robots—it's about transforming the way they engage with mathematics and helping them see the subject as a dynamic and rewarding field of study.

## IV. METHODOLOGY

#### A. Data Collection

The study employed a mixed-methods approach to gather comprehensive insights into the causes of mathematics anxiety. Surveys were administered to primary school students, teachers, and parents in five partner countries. These surveys aimed to identify common themes and patterns related to students' experiences with mathematics. Additionally, semi-structured interviews were conducted to explore participants' perspectives in greater depth, providing nuanced understanding of the cognitive, emotional, and environmental factors contributing to mathematics anxiety. Based on surveys and interviews, a modular curriculum was developed for teachers and pre-service teachers.

#### B. Development of the Modular Teaching Program

Grounded in a methodological framework of scientific rigor, this study aimed to derive authentic and evidence-based insights from pre-service teachers and educators regarding the efficacy of using robotic applications in mathematics teaching. Data collection was conducted through a carefully designed online survey created using Google Forms to ensure accessibility and ease of participation. The survey was structured into two distinct sections: the first section gathered demographic information, specifically participants' gender and professional status, while the second section delved deeply into participants' perceptions and attitudes toward the integration of robotics in mathematics education.

The second section featured a comprehensive 17-item questionnaire designed on a 5-Point Likert Scale, where participants were asked to indicate their level of agreement, ranging from "1. Strongly Disagree" to "5. Totally Agree". This quantitative approach allowed for the systematic collection of data from a robust sample of over 150 participants, ensuring statistical reliability and representativeness.

In addition to the survey, qualitative data were gathered through in-depth interviews conducted with 15 education professionals. These interviews featured open-ended questions aimed at obtaining detailed and nuanced insights into two critical areas: mathematics anxiety and the potential of robotic applications to address this issue in primary school settings. By combining quantitative survey data with qualitative interview responses, the study employed a mixed-methods approach, providing a comprehensive and multidimensional understanding of the challenges and opportunities associated with the use of robotics in mathematics education.

This rigorous methodological design ensured the collection of both broad trends and deep, context-specific reflections, enriching the study's findings and reinforcing its contributions to the field of mathematics education.

Drawing on the data collected, the project team designed a modular teaching program tailored to address the identified needs. The program integrates robotics applications as a central component, leveraging their potential to create engaging and interactive learning experiences. Each module focuses on specific mathematical concepts and incorporates hands-on activities that encourage collaboration, problem-solving, and creativity.

## **V. RESULTS AND DISCUSSION**

### **A. Key Findings from Surveys and Interviews and Curriculum Development**

The data revealed several common factors contributing to mathematics anxiety among primary school students:

- Negative experiences: Prior struggles with mathematics created a fear of failure and aversion to the subject.
- Low self-confidence: Students doubted their ability to succeed in mathematics, often attributing difficulties to inherent inability.
- High-pressure environments: Competitive academic settings and unrealistic expectations intensified students' anxiety.
- Lack of engagement: Traditional teaching methods failed to capture students' interest or make mathematics relatable.

The project consortium developed ten comprehensive modules based on rigorous qualitative and quantitative research conducted across the partner countries. Each module is meticulously designed to support educators in addressing mathematics anxiety through innovative teaching approaches. Specifically, the modules incorporate clearly defined learning outcomes, effective teaching methods and techniques, engaging learning-teaching activities, reliable assessment tools, and a strong theoretical background to ensure both practicality and academic rigor.

The modular curriculum has been made publicly available on the project's official website, [www.rbtsinmath.eu](http://www.rbtsinmath.eu). Teachers, pre-service teachers, and educators can easily access and download these resources free of charge, enabling widespread implementation in various educational settings. The project aims to empower educators with tools and strategies to alleviate mathematics anxiety and foster positive student engagement with mathematics.

Below is a brief description of the modules developed under this initiative:

#### **Module 1: Learning Theories**

This module introduces key learning theories that underpin effective teaching practices, including behaviorism, constructivism, and cognitive approaches. Educators will explore how these theories shape teaching strategies and influence students' learning experiences, providing a strong foundation for instructional planning.

#### **Module 2: Maths Anxiety**

Math anxiety is a significant barrier to student success in mathematics. This module examines its causes, symptoms, and impact on learning. Educators will learn strategies to identify and address math anxiety, fostering a supportive environment that builds student confidence and encourages positive attitudes toward math.

**Module 3: The History of Robotics Applications in Education**

Robotics has evolved significantly as a learning tool over time. This module explores the historical milestones and development of robotics in education, highlighting key innovations and their role in enhancing student engagement, problem-solving, and hands-on learning experiences.

**Module 4: Learning Math as A Game**

Gamifying math lessons transforms the way students approach learning by making it interactive and enjoyable. This module focuses on strategies for turning mathematical concepts into games, fostering motivation, deeper understanding, and a positive math-learning experience for primary school students.

**Module 5: The Use of Robotics in Mathematics Education in Primary Schools**

Robotics offers innovative opportunities to teach math concepts through hands-on activities and real-world applications. This module discusses how robotics can be integrated into primary school math education to develop critical thinking, logic, and problem-solving skills in young learners.

**Module 6: Flipped Learning and Its Practices in Primary Schools**

Flipped learning redefines traditional teaching by moving instruction outside the classroom and creating space for active, student-centered learning. This module introduces the flipped classroom model and showcases effective practices to implement it in primary school mathematics education.

**Module 7: Teaching Flipped Learning and Its Practices in Higher Education Institutions**

This module explores the role of flipped learning in higher education, focusing on its theoretical background, benefits, and implementation practices. Educators will learn how to design and deliver flipped learning experiences to prepare future teachers for innovative classroom approaches.

**Module 8: How to Use Robotics to Teach Mathematics in Primary Schools**

Integrating robotics into math lessons helps make abstract concepts tangible and engaging. This module provides educators with practical techniques and examples for using robotics to teach mathematics in primary schools, fostering creativity and computational thinking.

**Module 9: Development of Computational Thinking**

Computational thinking is a problem-solving process that involves decomposition, pattern recognition, and logical reasoning. This module highlights its importance in mathematics education and offers strategies and activities to help students develop computational thinking skills through engaging tasks.

**Module 10: Coding and Robotics to Improve Math Learning**

Coding and robotics offer innovative pathways for improving math learning by connecting digital literacy with mathematical reasoning. This module explores practical methods to integrate coding and robotics into math lessons, enabling students to develop problem-solving, creativity, and analytical skills (rbtsinmath).

**VI. CONCLUSION AND IMPLEMENTATIONS**

The integration of these ten modules represents a significant advancement in mathematics education, addressing both long-standing and emerging challenges while embracing innovative solutions. Together, the modules provide a comprehensive framework that equips educators with the theoretical knowledge, practical strategies, and technological tools needed to foster student success, engagement, and confidence in mathematics.

Beginning with Module 1, the exploration of learning theories offers educators a foundational understanding of how students learn, enabling the design of effective and adaptable instructional strategies. By combining behaviorist, constructivist, and cognitive perspectives, teachers are better prepared to meet the diverse needs of their learners.

This theoretical groundwork becomes essential as educators confront the pervasive issue of math anxiety in Module 2, which highlights the emotional and psychological barriers to mathematical achievement. By identifying the causes and symptoms of math anxiety and offering targeted interventions, educators can create inclusive, supportive learning environments that empower students to engage with mathematics positively.

The role of robotics in education, introduced in Module 3, provides a historical context for understanding how technology has transformed teaching and learning. Robotics emerges as a powerful tool for improving engagement, fostering hands-on learning, and encouraging problem-solving skills—core themes that are further developed across subsequent modules. Module 4, for instance, underscores the importance of gamification as an approach to make mathematics interactive and enjoyable, cultivating student motivation and reinforcing conceptual understanding through play-based strategies.

The application of robotics in mathematics education is explored in-depth in Module 5, where hands-on, real-world activities are presented as a means to teach mathematical concepts while simultaneously developing critical thinking and logical reasoning skills. These practices align seamlessly with Module 6, which introduces flipped learning in primary schools—a pedagogical approach that moves beyond traditional instruction by prioritizing active, student-centered learning. Similarly, Module 7 extends this discussion into higher education, demonstrating the transformative potential of flipped learning for preparing future educators to implement innovative teaching methods in their classrooms.

In Module 8, robotics is revisited with a focus on its practical application in teaching mathematics in primary schools. The integration of robotics not only makes abstract concepts more accessible but also encourages creativity and computational thinking among young learners. This naturally leads to Module 9, which emphasizes the development of computational thinking—a critical skill in today’s digital age. Through decomposition, pattern recognition, and logical reasoning, students acquire a systematic approach to problem-solving that strengthens their mathematical understanding.

Finally, Module 10 bridges mathematics, coding, and robotics, presenting a forward-thinking approach to improving math learning. By connecting digital literacy with mathematical reasoning, students are equipped with essential 21st-century skills, including creativity, problem-solving, and analytical thinking. This module reinforces the importance of interdisciplinary learning, ensuring that students are prepared to navigate the challenges of an increasingly technological world.

In conclusion, the collective impact of these modules lies in their ability to address critical aspects of mathematics education—emotional, cognitive, and technological—while fostering a supportive, engaging, and innovative learning environment. By blending theoretical insights with practical applications, the modules empower educators to overcome challenges such as math anxiety, improve instructional methods, and embrace technology as a means to enhance learning outcomes. This holistic approach not only transforms how mathematics is taught and learned but also ensures that students develop the confidence, skills, and mindset needed for lifelong success in mathematics and beyond.

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