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Research Paper

Role of Teacher in 21st Century to Build Mathematical Resilience among Secondary School Learners

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ABSTRACT

The main focus of this study is to explore different strategies a teacher can use to build mathematical resilience among 21st century learners. Mathematical resilience is an application of well-known construct of resilience in a specific subject called mathematics. It is a crucial skill that enables students to persist in their mathematical learning despite challenges. Teachers play a significant role in the development of an individual. The strategies teachers employ in the mathematics classroom significantly impact students' resilience. This study explores the strategies that mathematics teacher can employ to build mathematical resilience among learners and list out various tools that help in developing mathematical abilities of learner. A qualitative research design was employed in this study, and data was obtained via documentary review. Findings suggest that teachers who emphasize growth mindset, positive reinforcement, real-world applications, and student collaboration significantly enhance students' ability to overcome mathematical challenges. Recommendations include professional development, curriculum modifications, for integrating resilience-building practices in classrooms.

Keywords: *Mathematical Resilience, Teachers, Strategies, Resilience-Building, Positive Reinforcement*

Mathematics is an essential tool for understanding our surrounding world. It provides a universal language for describing and understanding patterns, relationships, and quantities. Importance of mathematics has been globally acknowledged. The first education policy of the 21st century, National Education Policy 2020 (NEP 2020) calls attention to importance of mathematics in the context of emerging global technologies and industries. It advocates for developing mathematics and computational thinking to ensure India's leadership in emerging fields like artificial intelligence, machine learning, and data science. Emphasises on prioritizing development of mathematical thinking throughout the school years.

Despite being so important, Mathematics is often regarded as a difficult subject. It elicits fear and anxiety among learner to the extent that they start avoiding even discussions and conversations regarding mathematics. This negative perception is exacerbated by a prevalent

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stereotype threat, that everyone cannot learn mathematics. It is only for the few intelligent ones. This leads to students internalizing the belief that mathematics is inherently challenging subject and they can't learn it.

When students find mathematics difficult, it adversely affects their emotional connection to the subject, manifesting as reduced interest, perseverance, and self-belief, as well as increased boredom (Gafoor & Kurukkan, 2015).

The concept of mathematical resilience is of considerable importance, particularly for students who have endured unfavourable mathematical experiences that have elicited feelings of anger and perceptions of failure, as it facilitates their recovery and continued engagement (Johnston-Wilder & Lee, 2010).

Mathematical Resilience

Resilience is the ability to adapt to challenging life experiences through mental, emotional, and behavioral flexibility and adjustment to the demands of both internal and external environments. And mathematical resilience is the application of well know construct of resilience to the study of mathematics. Resilience required in learning mathematics is called mathematical resilience. Mathematical resilience refers to a student's ability to persist in learning mathematics despite challenges, setbacks, or negative experiences. It encompasses a positive attitude toward mathematics, a growth mindset, and the capacity to manage anxiety and frustration in problem-solving (Johnston-Wilder & Lee, 2010). Students with high mathematical resilience are more likely to engage actively in learning, overcome difficulties, and develop a deeper understanding of mathematical concepts. As described by Jhonston-Wilder *et, al.* there are four correlated factors of mathematical resilience: 1) Value: The belief that mathematics is a valuable subject, not only for academic achievement but also for understanding the world around us, 2) Struggle: The acknowledgment that encountering difficulties in mathematics is an inherent part of the learning journey, even gifted learners have to struggle, 3) Growth: The belief that mathematical knowledge is malleable and continuously developing. They can develop it with perseverance and focused efforts. 4) Resilience: respond positively and keep learning, even when faced with setbacks or difficult problems.

As identified by Thornton and Statton (2015) there are 5 key aspects of mathematical resilience: embracing a growth mindset by learning from errors, practicing metacognition through reflection, demonstrating adaptability by exploring new approaches, valuing interpersonal learning by asking questions, and exhibiting a sense of purpose by seeking meaning in mathematical tasks." Johnston-Wilder, S., & Lee, C. (2010) identify mathematically resilient behaviour as having growth mind set, integrating with mathematic community, understanding the importance of inquiry and exploration, actively learn and readily engage in mutual support, and recognize their strengths and limitations, and actively pursue strategies to overcome their weaknesses.

It appears that mathematically resilient students are those who have growth mindset, understands the value of mathematics in classroom as well as outside the classroom, persistent in their hard work when faced with challenges, shows curiosity and inquiries about new things, are self-aware, self-directed and collaborative.

Teachers play a crucial role in addressing the challenges students face in learning mathematics. Mathematics teachers guide students toward a deeper understanding and

appreciation of mathematical concepts, functioning as both educators and mentors. Beyond simply imparting information, a teacher inspires and empowers students to become active learners. They provide individualized instruction, stimulate intellectual curiosity, and cultivate a positive learning environment that fosters both academic and personal growth. Teachers are pivotal in shaping student's mathematical experiences, significantly influences their engagement, perceptions, attitude towards the subject (Akinsola & Olowojaiye, 2008). Oszwa (2022) highlights that a teacher's approach, attitude, and teaching methods can significantly impact students' emotional relationship with mathematics, either fostering anxiety or building resilience. Lack of counselling and motivation to students on part of teacher affects the mathematics learning of students (Acharya, 2017). Teachers share the responsibility for establishing and nurturing a learning environment that fosters resilience.
The strategies teachers employ in the mathematics classroom significantly impact student's resilience, some instructional approaches empower students to overcome obstacles, while others contribute to a decline in their ability to cope with mathematical difficulties. This paper is an attempt to identify different strategies a teacher can integrate into their pedagogy that foster mathematical resilience in students.

Objective

To explore strategies that teachers can use to develop mathematical resilience in students.

REVIEW OF RELATED LITERATURE

Akinsola, M.K. & Olowojaiye, F.B. (2008) examines how senior secondary students' attitudes about mathematics are affected by two teaching strategies: study question-based instruction (SQBIS) and behavioural objective-based instruction (BOBIS). The main conclusions show that BOBIS and SQBIS are both useful techniques for promoting good attitudes, and there is no clear difference in their effectiveness. The results point out the important role of creative instructional approaches in shifting student attitudes and improving engagement in mathematics learning. These results support a change from conventional teaching approaches towards more innovative and structured teaching strategies that are essential for fostering resilience in addition to enhancing student performance.

Johnston-Wilder, S., & Lee, C. (2010) in the paper "Developing Mathematical Resilience" investigates methods to improve student's perceptions of learning mathematics. The researchers conducted an action research project within a school, implementing collaborative learning strategies and involving non-specialist staff as "math coaches." This approach effectively alleviated anxiety and increased student engagement and performance. The results reveal the significance of a supportive school environment in fostering resilience, suggesting that empowered learners have a greater likelihood of succeeding in mathematics. Ultimately, this research offers valuable insights and practical strategies for educators aimed at nurturing resilience in students, leading to enhanced mathematical outcomes.

Thornton et al. (2012) emphasizes the importance of culturally responsive teaching to improve the mathematical learning of Aboriginal students. The study explores the theoretical approaches to mathematics education that teachers have created within school settings, specifically focusing on how "mathematisation"- process of interpreting or expressing real-world situations in mathematical terms and "contextualisation"- connecting mathematical concepts to real-world situations and applications can be used to design better mathematics

learning experiences for Indigenous students. And suggested that this focus can foster greater mathematical resilience among Aboriginal students.

Johnston-Wilder et al. (2013) articulate the concept of mathematical resilience, emphasizing it as a necessary stance that helps students navigate challenges and overcome anxiety associated with mathematics. The study describes a pilot course designed to train coaches who support mathematical resilience, underlining the significance of personal experience and emotional management in coaching. The course is structured to enhance both personal resilience and the effective use of coaching skills. It gives useful ideas to help both students and teachers build confidence in math. It suggests creating a safe and friendly place where everyone can work together. This can help students feel more comfortable and enjoy learning math.

Johnston-Wilder et al. (2016) in the study "Developing Teaching for Mathematical Resilience in Further Education" focuses on enhancing teacher's abilities to foster mathematical resilience in their students. Through a one-day training course, educators gained insights into the emotional barriers students face in mathematics and learned effective strategies to create a supportive and positive learning environment. The findings suggest that with increased awareness and coaching skills, teachers can shift their own mindsets and help students overcome anxiety, ultimately transforming their experiences with mathematics from fear to resilience.

Ariyanto et al. (2017) investigates the effectiveness of Problem Based learning (PBL) in enhancing resilience among 183 prospective math teachers at Universitas PGRI Semarang. Through pre-test and post-test assessments, the research demonstrates a significant improvement in student's mathematical resilience after engaging in problem-based learning, emphasizing the potential of this approach to prepare future educators to effectively navigate challenges in mathematics education. The findings suggest that incorporating problem-based learning into teacher training programs can cultivate necessary adaptive attitudes in prospective teachers.

M Hafiz et al. (2017) examines the mathematical resilience of junior high school students in Jakarta taught through two different instructional models: Problem Based Learning (PBL) and Guided Discovery Learning (GDL). Results indicated that students in the PBL group showed significantly higher levels of mathematical resilience compared to those in the GDL group.

Hutauruk et al. (2019) examined the effectiveness of a Problem Based Learning Model with a Metacognitive approach (PBLM) in enhancing students' mathematical resilience. The study revealed no significant differences in resilience outcomes between students taught with PBLM and those using traditional methods, irrespective of prior mathematical knowledge. The results suggest that PBLM does not significantly improve mathematical resilience compared to conventional learning.

Ariyanto, L et al. (2019) investigates the impact of Problem based Learning (PBL) on the mathematical resilience of prospective math teachers. Findings indicate that PBL leads to improvements in mathematical resilience compared to Conventional Learning (CL), particularly among students with high prior knowledge mathematical abilities (PKMA). Overall, the research suggests that PBL has a positive effect on enhancing

mathematical resilience, particularly for those who may initially struggle with mathematical concepts.

Khumalo, V. L et al. (2022) explores the difficulties faced by disadvantaged South African learners in mathematics. It stresses the importance of supportive school environments that foster resilience. The study identifies important themes such as "foreground" and "growth strategies" that reveal illuminate the contextual factors that affect learning and the approaches learners adopt to manage academic difficulties. The study ultimately advocates for the adoption of self-regulated learning strategies and emphasizes the need to tackle socio-economic issues to enhance mathematical resilience and improve student outcomes in difficult educational environments.

Oszwa, U. (2022) conducted study that explores the concept of mathematical resilience, identify math anxiety as a significant barrier to student performance. The study presents an ecological model that highlights the roles of students, parents, and teachers in fostering resilience. Key findings indicate that resilience can be developed through positive parental modeling, supportive teacher attitudes, and student-driven strategies like adopting a growth mindset and viewing challenges as growth opportunities. The researcher advocates for integrating mathematical resilience into educational practices to reduce anxiety and improve student achievement, calling for educators to implement resilience-building strategies.

Hamidy, A., & Wibowo, A. (2023) reveals that teacher's Technological Pedagogical Content Knowledge (TPACK) significantly influences student's math resilience, particularly emphasizing the roles of Pedagogical Knowledge and Technological Pedagogical Content Knowledge.

Secadron Jr, A. C., and Tan, D. A. (2023) examines the effectiveness of e-modules developed using the Process-Oriented Guided Inquiry Learning (POGIL) approach to enhance the mathematical resilience and critical thinking skills of Grade 10 students. The result showed that incorporating e-modules with collaborative learning techniques can significantly enhance students' mathematical resilience and critical thinking skills.

Assya, L. A. et.al (2025) revealed that use of Augmented reality (AR)-based contextual teaching and learning (CTL) models can significantly improves the mathematical reasoning abilities and mathematical resilience of junior high school students.

Review of literature affirms that teacher's instructional strategies play a crucial role in developing student's mathematical resilience. Different approaches, such as structured instruction, collaborative and supportive learning, and culturally responsive practices, have been shown to reduce anxiety and foster persistence. Problem-Based Learning emerges as a particularly effective method, though findings vary when combined with metacognition. While new methods such as technology-based teaching demonstrate potential to enhance resilience and critical thinking, parental support, socio-economic context, and student mindset also play important roles in fostering resilience. However, research remains fragmented, highlighting the need to clearly list these strategies and understand how teachers implement them in practice.

Strategies That Teachers Can Use to Develop Mathematical Resilience in Students:

1. **Employing growth mindset approaches:** Learners who adopted the theory of growth mindset and believes that mathematical abilities can be develop shows high achievement rates (Yeager and Dweck, 2021). Teachers should emphasise on the learning process of the students and praise students for their hard work, strategies, and persistence instead of focusing on their innate talent. Teacher can create a classroom environment where mistakes are to be looked upon as natural part of learning and an opportunity to grow instead of as a failure. Teacher should encourage students to analyse their mistakes, identify what went wrong, and explore alternative strategies to solve problems. Share stories of successful individuals who overcame challenges and learned from their mistakes. Each Teacher should seriously consider the psychological wellbeing of their learners and works in direction to improve growth mindset of learners, that will consequently lead to development of mathematical resilience among learners.
2. **Integrating problem-based learning approach (pbl):** The Problem Based Learning (PBL) approach is a student centered pedagogy which encourages active learning by using problems as a starting point, pushing students to figure things out for themselves rather than just being told the answers by the teacher. Instead of rote memorization, PBL encourages students to explore, investigate, and collaborate to find solutions. By actively engaging with challenging problems and putting in the effort to find solutions, students develop a deeper understanding of the importance of perseverance, resilience, and the empowering feeling of overcoming difficulties through their own hard work. Teachers can use various techniques like Group projects, Case studies, Simulations, Peer tutoring, Think-pair-share activities, Jigsaw activities to integrate Problem Based Learning Approach that boost their problem-solving skills. When students work in pair this may boost their self-confidence to face mathematical challenges ultimately build their resilience in mathematics.
3. **Implementing Effective Use of Technology**: Teachers can effectively leverage digital tools to support student engagement and reinforce mathematical resilience in several ways. Teachers can use simulations, such as geometric transformations or probability experiments, to make abstract concepts more concrete and engaging. Teachers can use various AI tools to enhance mathematical abilities of learners.

   Some AI tools are listed here that helps in developing mathematical abilities of learners

- **GeoGebra:** is a powerful dynamic mathematics software for exploring and understanding mathematics geometry, algebra, spreadsheets, graphing, statistics and calculus, intended for learners of all levels of education from primary school to university level. It fosters a dynamic learning environment that encourages experimentation and discovery.
- **Grid Algebra:** is a visual and structured approach to learning algebra, designed to support students in transitioning from arithmetic to abstract algebraic thinking. Developed as an educational tool, it uses a grid-based framework where numbers, operations, and variables are placed systematically, enabling learners to see patterns, relationships, and structures in algebraic expressions. Grid Algebra is most suitable for secondary school students in the early stages of learning algebra. Grid Algebra uses visual and kinaesthetic representations to support number work and introduce algebra in a more intuitive way. It helps learners transition from arithmetic to algebra by linking concepts such as order of operations, solving equations, and simplifying expressions to grid imagery.

- **Julius AI:** is an AI assistant designed for statistical analysis, data science, and computations. This tool provides a diverse set of analytical functions, extending beyond basic tasks to encompass complex procedures such as regression, time series, cluster, Principal Component, and sentiment analysis.
- **Mathspace:** is a smart and interactive math learning tool that helps students of levels from elementary school to high school. It gives step-by-step guidance, instant feedback, and personalized learning to make math easier to understand. It boosts student confidence and problem-solving skills.
- **Mathway:** is an AI-powered math solver that helps students and teachers solve a wide range of mathematical problems, from basic arithmetic to advanced calculus and linear algebra. It is a valuable resource for learning mathematics as it provides step by step solutions, homework assistance accessible to all students.
- **Photomath:** is an educational technology mobile app, owned by Google that help students of all level from elementary through college to develop a deeper understanding of math concepts through the smart use of technology.
- **Symbolab:** is a math problem-solving app that assists users in finding solutions for various math problems, ranging from basic arithmetic to advanced topics like differential equations. It is an intuitive tool that helps students improve mathematical skills and build confidence.
- **Tinkerplots:** is an educational data analysis software program originally created by Clifford Konold and Craig Miller at the University of Massachusetts. It enables students to create colourful graphs and other visual representations from data sets, enhancing their understanding of numbers, probability, and graphing. It allows learners to construct their own data tables, which can then be explored and analysed in multiple ways, fostering deeper engagement with data and statistical concepts. It can be used by students in middle school through to university students.
- **Wolfram alpha:** is a powerful computational knowledge engine that can be used by student in high school or college. It provides detailed, step-by-step solutions and visualizations. Teachers can use Wolfram Alpha by generating visual aids, creating homework, checking answers, and speeding up lesson planning, making math instruction more efficient and engaging.

  Online quizzes and assessments help teachers track progress and offer immediate feedback, focusing not just on correct answers but on effort. By leveraging these tools effectively, teachers can foster a supportive learning environment that encourages curiosity and deeper mathematical understanding. Ultimately, technology serves as a valuable aid in building mathematical resilience, but its effectiveness depends on thoughtful and strategic use to enhance, rather than replace, critical thinking and deep learning.

4. **Providing Teacher Support and Encouragement**: Students when face with mathematics problem, did not get proper support and help might develop negative emotions like anxiety regarding the subject which hampers the mathematical learning of the individual. Teachers should prioritize establishing strong teacher-student relationships through open communication, acknowledge student's minimum to minimum effort regardless of result, and celebrate small wins to boost confidence and motivation. By providing positive reinforcement and scaffolded instruction, teachers empower students to build resilience. By consistently implementing these strategies, teachers can play a vital role in helping students develop the resilience they need to navigate challenges and excel in learning mathematics.

FINDINGS AND DISCUSSION

Every teacher has a part to play in ensuring the learning environment is one where students can thrive despite difficulties. The main objective of the study was to explore strategies that teachers can use to develop mathematical resilience in students.

Firstly, teacher can deliberately implement strategies that nurture a growth mindset among students. A growth mindset is the belief that your abilities and intelligence can be developed through dedication, hard work, and learning from mistakes. This perspective is fundamental to developing resilience, the ability to bounce back from adversity. Growth mindset interventions significantly impact students' resilience (Mohamoud, 2024; Rasyid et al., 2023). Whether through their own belief or through instruction, when students understand that their intellectual abilities can be improved, they typically achieve more during tough school periods and are more likely to complete challenging math (Yeager et al., 2012). When growth mindset interventions are applied by teacher throughout the curriculum this can help to build mathematical resilience in students.

Secondly, teachers can employ problem-based learning approach in mathematics classroom. Problem based learning approach is a learning approach in which students gained knowledge by working on problem rather than by only listening to lectures of teachers. In problem-based learning approach students are provided with open ended problems and allowed to work in groups, search for materials, solve problems. Based on principle of independent and self-directed learning, it helps in development of critical thinking skills, problem-solving and analytical abilities, and communication skills in student. By teaching mathematics through problem-solving strategies, teachers significantly contribute to building students' confidence, regulating their emotional responses to math anxiety, fostering resilience, guiding the effective use of resources, and correcting misconceptions or errors in reasoning (Braich & Mgombelo, 2010). Problem based learning can significantly enhances the mathematical resilience (Ariyanto et al., 2017; Hafiz et al., 2017; Ariyanto et al., 2019). Suryanti and Supeni (2019) suggested that Problem based learning courses significantly contribute to the enhancement of diverse soft skills, including self-awareness, adaptability, critical thinking, and leadership. However, Hutauruk *et al* 2019 found that there is no difference in achievement of mathematical resilience among students taught with problem based learning and conventional learning.

Thirdly, Teachers can integrate and utilise different ICT tool in their teaching learning process. They should be well verse in knowledge about different AI tool for mathematics learning and should equips their learners about them. with the advancement of technology, many ICT tools for teaching learning mathematics has been developed so far. Findings of various studies has confirmed that use of different ICT tools in teaching learning of mathematics has significantly contributed in development of mathematical resilience among learners. Technological Pedagogical Content Knowledge (TPACK) of teacher can have a significant impact on mathematical resilience of students (Hamidy & Wibowo, 2023). Lugalia, et. al (2015) revealed that the introduction and use of ICT, specifically Grid Algebra software, positively impacted students' learning experiences in mathematics, particularly in developing mathematical resilience. Mota et al. (2013) reported that use of the *Thinkplots* software in group fosters students' persistence, supporting mathematical resilience.

Finally, A teacher should acknowledge the importance of positive interpersonal relationships with their students and tries to maintain a good positive relationship with their students. The

strong teacher-student relationships play a crucial role in fostering students' resilience (Johnson, 2008; Alon et al,2025). Evidence from the researches indicates that supportive interactions, encouragement, and positive engagement from teachers can help students persevere through challenges.

CONCLUSION

Mathematical resilience is essential for students to develop confidence, perseverance, and a deep understanding of mathematics. It equips students to persevere in learning, Students with high mathematical resilience are more likely to engage actively in learning, overcome difficulties, and develop a deeper understanding of mathematical concepts. Teachers should be aware of student's affective beliefs and inter relations of those in learning mathematics so as to employ more effective strategies in teaching and to improve student's mathematics learning by reducing their negative beliefs. Teachers can cultivate this by fostering growth mindsets, collaborative learning, and thoughtful technology integration, enhancing confidence and persistence in mathematics. Teachers should be aware of use different AI tool and can employ these tools in order to improve the mathematical abilities of learners. This can ultimately help students overcome anxiety and embrace challenges, ultimately improving mathematical learning outcomes. For this teacher education programs should incorporate in curriculum for professional development opportunities to equip teachers with varied resilience-building strategies. schools should create a comprehensive and effective program that promotes mathematical resilience through mentorship and resource allocation and empowers students to succeed in mathematics. Teachers should be provided with both Preservice and Inservice opportunities with professional development that enable them to foster mathematical resilience among their students.

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