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RESEARCH ARTICLE

Changing mindsets of previously non-mathematics and science enthusiasts: Factors leading to shift of behaviors towards math and science

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ABSTRACT

Understanding the concept of mindset shift in education is essential as it offers important perspectives on how individuals' beliefs and attitudes toward learning transform, affecting their motivation, involvement, and overall academic success. This study examined the experiences of college students who had previously experienced apprehension toward science and mathematics. The research aimed to understand the factors that influenced their attitudes toward these subjects and the mechanisms that facilitated a shift in their mindset. College students (n=16) were purposively sampled to participate in one-on-one interviews. Several factors contributed to these shifts, including teacher encouragement, the application of real-world concepts, and positive reinforcement. These elements helped shift students' perceptions of these subjects, developing motivation for learning and engagement. The study also emphasized the importance of social interactions, guidance, and support from teachers and peers in facilitating mindset changes. As students transitioned from a fixed mindset to a growth mindset, they were more willing to embrace challenges, view mistakes as opportunities for learning, and persist in problem-solving tasks. This mindset shift helped them sustain their academic journey, as they became more open to deal with challenges, seek guidance when necessary, and persist through difficulties. Understanding how such shifts influence students' resilience in the face of academic challenges could also contribute to the development of targeted interventions that enhance learning outcomes and build a lifelong love for learning.

Keywords: growth mindset; learning anxiety; mindset shift; support

1. Introduction

Psychological factors significantly influence individuals' attitudes and performance in academic

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disciplines such as mathematics and science. A key factor is stereotype threat, which refers to the apprehension of confirming negative stereotypes associated with one's social group. Zhao et al.[1] observed that stereotype threat had a pronounced impact on academic persistence among students with low psychological disengagement but was less impactful on those who were psychologically disengaged from academics. Stereotype threat theory, as explained by Owens[2], suggests that minority students underperform due to the pressures arising from negative stereotypes about their racial group. This phenomenon can deeply affect learners, particularly those belonging to groups perceived as less competent in these subjects, creating mental barriers that hinder effort and engagement. Consequently, such threats perpetuate a cycle of underachievement in math and science fields of study.

The concept of reciprocal determinism offers another perspective for understanding the dynamics of students' experiences in mathematics and science. According to this theory, behavior, personal factors (such as beliefs and attitudes), and environmental elements (like social influences and educational opportunities) are interdependent and mutually influential[3]. Schiavo et al.[4] and Liu et al.[5] emphasized the reciprocal relationship between mathematics self-efficacy and mathematics achievement. The interaction of these interconnected components, such as teaching methods and classroom environments, plays a crucial role in transforming students' mindsets toward these subjects. For instance, educators who inspire curiosity and demonstrate real-world applications of mathematical and scientific concepts often cultivate positive attitudes and greater motivation among students[6].

Anxiety and stress are also critical psychological factors that affect students' engagement with math and science. High levels of anxiety are known to negatively correlate with academic achievement, leading to poorer performance in these areas[7,8]. Due to the cognitive and emotional demands of these disciplines, excessive anxiety can harm learning outcomes and performance. Sumeera et al.[9] observed that anxiety hinders students from achieving satisfactory examination results, creating a negative feedback loop that reinforces their reluctance to engage with mathematical and scientific concepts. Students grappling with such anxiety often develop negative thought patterns about their self-efficacy. For instance, they may lack confidence in their abilities to handle mathematical problems, which can further exacerbate feelings of inadequacy during problem-solving tasks[10,11].

These three psychological factors—stereotype threat, reciprocal determinism, and anxiety and stress—interconnect to provide a comprehensive understanding of students' challenges and motivations in mathematics and science education. By addressing these issues, educators and academic institutions can implement strategies that alleviate negative experiences while fostering an inclusive and engaging learning environment. Such efforts can reshape the perspectives of previously disengaged learners, enabling them to recognize the value and relevance of these essential disciplines.

2. Literature review

Teachers and peers play a significant role in shaping students' perceptions of intelligence, whether it is fixed or can be developed. With a fixed mindset, students may perceive mathematics as inherently difficult due to the complexity of tasks, believe that low achievement equates to a lack of ability in the subject, and lose motivation following failure. This mindset can lead to the belief that prolonged effort in mathematics is futile[12]. However, mathematics provides essential skills for understanding the world through modeling both abstract and practical problems[13]. Despite its importance, the subject often faces criticism for discontinuities across curricula at various educational levels, resulting in gaps in student learning[14].

One significant barrier to achievement in mathematics and science is stereotype threat, defined as the fear of confirming negative stereotypes about one's social group. This fear triggers a series of attentional, cognitive, emotional, and motivational responses that can hinder academic performance and engagement[15,16]. Many students internalize societal stereotypes, such as the notion that math and science are "too hard," particularly for certain genders or abilities, which fosters self-doubt and reduces effort[17]. These negative perceptions reinforce cycles of underachievement[18]. Addressing these issues through inclusive environments that challenge stereotypes and promote belonging can help students overcome these mental barriers and cultivate confidence and capability.

The concept of reciprocal determinism underscores the interplay between personal factors, behavior, and environmental influences in academic settings. According to Bandura's theory, academic achievement and self-efficacy are mutually reinforcing[19,20]. This dynamic is evident in how teaching styles, classroom environments, and individual attitudes shape students' engagement with math and science. For instance, rigid teaching methods may perpetuate negative beliefs about these subjects, while supportive and interactive approaches foster curiosity and motivation[21]. Tailored instructional strategies that nurture a positive feedback loop can enhance students' interest, persistence, and achievement in these fields.

Anxiety and stress are also critical factors influencing students' performance and attitudes toward math and science. Classroom experiences often evoke emotions like anxiety, which negatively impacts performance and persistence[22]. Many students fear failure and feel overwhelmed by the pressure to excel, leading them to avoid these subjects and perpetuating cycles of negative experiences[23]. High stress levels undermine confidence and problem-solving abilities, making these subjects seem more intimidating. Stress can stem from various sources, including personal challenges, academic demands, or home environments[24]. Strategies such as gradual exposure to challenging material, collaborative learning, and consistent positive reinforcement can help reduce anxiety, build resilience, and foster a more confident approach to these disciplines. Additionally, fear conditioning is recognized as a model for understanding anxiety disorders, including social anxiety and panic disorders[25,26].

These psychological factors—stereotype threat, reciprocal determinism, and anxiety—are deeply interconnected and collectively influence students' perceptions and engagement with mathematics and science. The findings emphasize the need to address these barriers to break cycles of disengagement. Inclusive teaching practices, coupled with stress management tools and supportive environments, can empower students to develop positive mindsets. Inclusive classrooms, which accommodate diverse learning styles and backgrounds, provide opportunities to create equitable learning environments that foster belonging and adaptability[27]. Ultimately, integrating psychology-informed strategies has the potential to drive meaningful and lasting improvements in students' attitudes and achievements in mathematics and science.

3. Objectives

This paper explored how exposure to science and mathematics influences the shift in mindset among students who are not initially enthusiastic about these subjects. Below are the specific objectives addressed in this study.

1. Determine prior mindsets of non-math and non-science enthusiast learners before finally taking math/science programs.
2. Determine the process of mindset shift from being non-enthusiasts to becoming enthusiasts of math and science.

4. Methods

4.1. Research design

This study employed a qualitative research design to investigate the factors contributing to a shift in mindset among individuals who were previously disengaged from math and science. A qualitative approach was selected to explore participants' subjective experiences, providing a comprehensive understanding of the complex processes underlying attitude change, which are challenging to measure quantitatively. Specifically, an exploratory research design[28], was utilized to examine the experiences of these participants. Exploratory research is particularly valuable for investigating underexplored phenomena and generating new insights[29]. Through this approach, the study sought to gain an in-depth understanding of participants' experiences, attitudes, and perceptions regarding their engagement with mathematics and science. Semi-structured interviews were selected as the primary data collection method, as they facilitated the elicitation of detailed narratives, allowing for the identification of recurring themes and patterns.

4.2. Population and sampling

The study involved 16 college students from the Philippines who had previously exhibited disinterest or aversion toward mathematics and science but later experienced a significant shift in their attitudes and behaviors toward these disciplines. To ensure the inclusion of participants with relevant experience, a purposive sampling technique was employed. This method is widely used in qualitative research as it allows researchers to deliberately select individuals who can provide rich, meaningful, and contextually relevant data[30]. With strong focus on participants who have undergone a discernible change in perspective, purposive sampling enhances the depth and reliability of the study findings while minimizing the risk of irrelevant or superficial data[31]. **Table 1** presents the summary of information collected from the interviewed participants. Previous attitude describes participants' perceptions toward math and science subjects prior to enrolment in their current course.

Table 1. Summary information of 16 selected participants.

Name	Sex	Age	Course	Previous Attitude Toward Math/Science
Alex	M	19	Biology	Found science concepts overwhelming.
Bea	F	20	Chemistry	Struggled with complex formulas.
Carlo	M	21	Mathematics	Believed math was too abstract.
Dana	F	18	Physics	Felt physics was too difficult.
Ethan	M	22	Computer Science	Thought math was irrelevant.
Fiona	F	23	Environmental Science	Feared science experiments.
Greg	M	20	Engineering	Avoided math due to anxiety.
Hazel	F	19	Biotechnology	Struggled with memorizing terms.
Ivan	M	21	Statistics	Saw statistics as confusing.
Jessa	F	24	Marine Biology	Disliked science's technical jargon.
Kyle	M	18	Applied Mathematics	Found equations intimidating.
Liana	F	22	Pharmacy	Had difficulty with chemical reactions.
Mark	M	23	Computer Science	Thought of math as complicated subject to learn.
Nina	F	20	Biology	Found anatomy overwhelming.
Owen	M	21	Mechanical Engineering	Struggled with problem-solving in math.
Paula	F	19	Agricultural Science	Believed science was not practical.

4.3. Instrumentation

The semi-structured interview guide served as the primary data collection instrument, designed to elicit detailed accounts of respondents' mindset transformations. The guide consisted of open-ended questions that encouraged participants to discuss their previous attitudes, the factors contributing to their shift, and the processes involved in transitioning from disengagement to enthusiasm. This format ensured consistency across interviews while allowing respondents the freedom to elaborate on their experiences, which helps in capturing specific ideas and reflections. **Table 2** presents the final interview guide developed to elicit the responses from participants.

Table 2. Final interview guide.

Objectives	Interview questions
Determine prior mindsets of non-math and non-science enthusiast learners before finally taking math/science programs.	1. Being a non-math or non-science enthusiast before, why do you think we have learners who have negative mindsets towards math and science? Explain further. 2. What causes for students to increase their low interests to math and science? Enumerate and explain the causes. 3. What are some factors that can change the mindsets of non-math and science enthusiasts towards taking courses in science and math? Explain further.
Determine the process of mindset shift from being non-enthusiasts to becoming enthusiasts of math and science.	1. What specific reasons started your mindset shift towards liking math and science from being a non-enthusiasts? Explain further. 2. Is it possible that towards liking math and science, you still experience reasons to dislike them? What are these reasons? Elaborate more. 3. How should academe help learners to appreciate mathematics and science education? Explain.

4.4. Data collection

The data gathering process involved conducting semi-structured interviews with the 40 selected respondents. These interviews were conducted either face-to-face or virtually, depending on the participants' availability and preference. Prior to their participation, respondents were thoroughly informed about the objectives, procedures, and the voluntary nature of their involvement. Each participant provided written informed consent. Confidentiality and anonymity were maintained by assigning unique codes to participants instead of using their real names, ensuring their identities remained protected. The data collected was securely stored and used exclusively for research purposes. As emphasized by Beurskens et al[32], responsible management of research data was paramount within the academic community. Participants were also assured of their right to withdraw from the study at any stage. With their consent, the sessions were audio-recorded to ensure the accuracy of the data. Transcription of the recordings was carried out verbatim, allowing for a thorough and detailed analysis. Adherence to this ensured that the data collected was credible and reflective of the participants' true experiences and perspectives.

4.5. Data analysis

The collected data was analyzed using reflexive thematic analysis, a widely recognized approach for interpreting qualitative data. Reflexive thematic analysis allows for a flexible and accessible framework to identify and analyze themes within a dataset[33,34]. The analysis process was conducted in distinct stages: familiarization with the data, coding to identify key concepts, categorizing codes into themes, and refining these themes to represent the participants' experiences accurately. This method facilitated a structured yet adaptable approach to uncover psychological, environmental, and motivational factors that contributed to the observed mindset shifts.

5. Results

Objective 1: Determine prior mindsets of non-math and non-science enthusiast students before finally taking math/science programs.

Thematic analysis revealed three major prior mindsets that non-math and non-science enthusiast students: (1) it is *frustrating,* (2) it is *impractical*, and (3) it is *rigid*.

Participants commonly described their initial experiences with mathematics and science as overwhelming and discouraging. Many felt that their inability to understand complex concepts led to persistent self-doubt and a reluctance to engage further. The repeated cycle of failure reinforced the belief that they were inherently incapable of succeeding in these subjects.

Some expressed a preference for subjects such as literature, history, and the arts, which they perceived as more directly connected to personal development and real-world understanding. In contrast, mathematics and science appeared abstract, consisting of formulas and theories that seemed disconnected from practical applications. The lack of perceived utility contributed to a loss of motivation, making it difficult for them to invest effort in learning these subjects.

Participants recalled their learning experiences in mathematics and science as rigid and uninspiring. Instruction often focused on memorization and procedural tasks rather than fostering conceptual understanding or critical thinking. Theoretical explanations lacked real-world context, making the subjects feel mechanical and monotonous. As a result, students struggled to develop a meaningful connection to the material, reinforcing their disinterest and disengagement.

Theme 1: Frustrating

Participants recalled experiencing intense frustration when they struggled to understand mathematical or scientific concepts. The challenge in understanding these subjects led to a growing mental barrier, making it increasingly difficult for them to engage with the material. For example, a student who repeatedly failed to understand algebraic equations might have felt discouraged to the point of avoiding math altogether, believing that they would never succeed.

> "I remember feeling overwhelmed and frustrated when I couldn't understand certain concepts, and this sense of failure started to build a mental block."

Each unsuccessful attempt to solve a problem reinforced the idea that they lacked the ability to succeed. Over time, instead of trying to improve, they resigned themselves to the belief that mathematics and science were simply beyond their capabilities.

> "This cycle of frustration made me dread these subjects, and over time, I just accepted that I wasn't good at them."

Some noted that this negative experience caused them to feel self-doubt. When they encountered a challenging problem, their initial frustration often escalated into questioning their own intelligence and abilities causing disinterest.

> "Whenever I faced a difficult problem or couldn't understand a topic, I felt really frustrated, and that frustration would snowball into self-doubt."

Instead of viewing difficulties as obstacles that could be overcome with practice, they began to define themselves as inherently incapable of excelling in mathematics or science. Participants developed the belief that mathematics and science were inherently difficult subjects that only a select few could master.

> "Maybe I'm just not the type of person who's good at this."
>
> "Every time I couldn't solve a problem or understand a topic, it reinforced the idea that math and science were 'too hard' for me."
>
> "I began to believe I was incapable, and that belief only made me more resistant to trying."

Some participants expressed that despite their efforts, they saw little to no improvement in their performance, which led to a sense of hopelessness. This lack of progress discouraged them from investing more time and effort into learning.

> "I just felt like there was no point in putting in the extra work, because no matter how hard I tried, the results didn't change much."

The participants' belief in their incapacity to succeed in mathematics and science stemmed from repeated struggles with understanding key concepts, leading to feelings of frustration and failure. These ongoing challenges reinforced their self-doubt and, over time, fossilized the belief that these subjects were too difficult for them to master, causing them to disengage and abandon further efforts.

Theme 2: Impracticality

Participants felt that mathematics and science had no relevance to their daily lives or future aspirations, leading them to question the value of learning these subjects. For example, a student might have thought that learning advanced algebra or physics was unnecessary because they didn't see how it could help them in their personal or professional goals, especially if they were pursuing a career in the humanities or arts.

> "I just didn't see the point of math or science in my life."
>
> "For a long time, I couldn't see how math or science applied to my life or my goals."

Some with interests in subjects such as literature, history, or the arts often felt disconnected from mathematics and science. They saw little relevance in learning complex formulas or conducting scientific experiments, viewing these subjects as distant from their passions and future careers.

> "I was more interested in subjects like literature, history, or even the arts, and I just couldn't relate to why I needed to learn advanced formulas or conduct experiments."

Participants could easily see the value in subjects they were passionate about, such as literature or history, because they believed these areas contributed to their personal growth and understanding of the world. However, mathematics and science seemed abstract and disconnected from their life experiences. For example, a student might have found it meaningful to learn about the lives of authors or historical figures, but struggled to see how learning trigonometric identities or chemical reactions contributed to their personal or professional development.

> "In those subjects, I could understand why learning about different authors or historical events mattered to my personal growth and understanding of the world. But with math and science, it felt like I was just memorizing equations or formulas that didn't seem to have any real-world application for someone with my interests."

They expressed that when they could not understand the practical benefits of mathematics or science, it was difficult to stay engaged or motivated to study. If they saw no connection between the subjects and their future goals, they were less likely to put in the effort needed to succeed.

> "If I couldn't understand how it was going to benefit me, it made it hard to stay motivated."

Without understanding the purpose or practical applications of math and science, participants saw these subjects as irrelevant and unnecessary. The lack of clear real-world connections made it hard for them to see the value in learning these subjects.

> "I didn't see the *why* behind math and science, which led me to view them as abstract and unnecessary subjects."

Participants' belief in the impracticality of mathematics and science stemmed from their inability to connect these subjects to their personal interests and career aspirations. Their focus on subjects they found more relevant, such as literature or history, reinforced the idea that math and science lacked real-world application in their lives.

Theme 3: Rigidity

Rigidity highlighted the participants' frustrations with the conventional approach to teaching mathematics and science, which they perceived as overly structured and disconnected from the real world. This rigidity in teaching methods was often a significant barrier to engagement, making the subjects feel monotonous and irrelevant to their everyday experiences.

A student recalled feeling disinterested in a science class because the teacher strictly adhered to a textbook without incorporating any interactive or relatable examples, leaving the student feeling disconnected from the material. The lack of dynamic, interactive teaching methods likely contributed to their belief that math and science were dry, uninteresting, and inaccessible.

> "A big part of why I didn't enjoy math and science growing up was because of how they were taught."

> "The whole process felt very mechanical and dry, without any excitement or connection to the world outside the classroom."

There could be a sense of disconnect between the activities in the classroom and their purpose. A participant might have experienced this while learning how to solve algebraic equations or memorize the periodic table of elements, but without understanding why such knowledge was important.

> "The lessons were often too theoretical or rigid, with no real connection to real-world applications."

> "I remember feeling like we were just memorizing facts or equations without ever exploring how they could be interesting or exciting."

For example, when a student is taught to follow a specific process for solving quadratic equations, but the teacher does not explain the practical significance of these equations in real-life situations (e.g., calculating areas, designing structures, or predicting trends), the lesson feels like a mechanical task rather than a meaningful exploration.

> "The lessons often felt like we were just going through the motions, memorizing facts or following steps without understanding why we were doing them."

The lack of engagement likely contributed to their belief that math and science were dry, abstract, and not applicable to their personal or professional aspirations. When students are not given the opportunity to see how their studies apply outside of the classroom, they are less likely to appreciate the significance of what they are learning. This disconnect may have fueled the perception that these subjects were rigid and unworthy of their time and effort.

Objective 2: Determine the process of mindset shift from being non-enthusiasts to becoming interested of math and science.

After pursuing math- and science-related programs in college, there was a notable shift in their perceptions about the subjects. In higher education, participants were often introduced to a more applied and interdisciplinary approach, which allowed them to see the real-world relevance of math and science.

Thematic analysis revealed three major mechanisms in aiding students' positive mindset regarding mathematics and science: (1) *teaching approach,* (2) *elicit application* of concepts, and (3) development of *growth mindset*.

Teachers who encouraged critical thinking and inquiry, rather than focusing solely on memorization, helped students appreciate the learning process. They began to view these subjects not as a collection of facts to memorize but as puzzles to solve, which made learning more exciting. This shift in approach emphasized creative problem-solving and logical thinking, rather than merely finding the right answers.

Students found that learning became more meaningful when they could clearly see how math and science applied to real-world situations. Exposure to practical applications, such as how physics relates to technology or how chemistry is involved in everyday products like medicine, food, and cosmetics, increased their interest in these subjects. This helped students see the value of math and science beyond theoretical concepts.

Lastly, students who believed that intelligence could be developed through effort and practice began to manage challenges differently. Instead of viewing struggles in math and science as a sign of inadequacy, they recognized that persistence and learning from mistakes were essential components of the learning process. Teachers who emphasized the importance of perseverance and provided positive reinforcement helped students build their confidence.

Theme 1: Teaching Approach

Participants described how their perceptions of math and science transformed when teachers encouraged them to ask questions and think critically about the material. This shift in teaching style made a profound impact on their mindset, as it made the subjects feel less like rigid fields of knowledge and more like dynamic processes to explore. For example, a student recalled how, when they were encouraged to probe deeper into the concepts they were learning, their understanding expanded beyond just rote memorization.

> "When teachers encouraged me to ask questions or think critically about the material, it shifted my mindset."

Instead of focusing solely on memorizing formulas or facts, which many students often found tedious, they began to appreciate the process of inquiry. This meant that rather than simply recalling the steps in solving an equation or repeating scientific principles, they engaged in a deeper understanding of why those principles worked.

> "Instead of feeling like I was just memorizing facts or equations, I started to appreciate the process of inquiry."

Students also mentioned that when math and science lessons focused on problem-solving and critical thinking rather than just memorization, the subjects became more engaging. For instance, some participants noted that approaching a problem as a puzzle or challenge, rather than a test of ability, added an element of excitement to the learning process. The idea that math and science were problems to be solved with logic and creativity made these subjects feel like exciting challenges to conquer, rather than dry academic tasks.

> "If math and science lessons focus more on how to think critically and problem-solve rather than simply memorize formulas, it can make the subject feel more like a puzzle or challenge, which can be exciting."

Some participants highlighted how teachers helped them recognize that math and science were not just about finding the *right* answer, but about learning how to approach problems with creativity and a logical mindset. This broader perspective helped students see the value in making mistakes or taking different paths to a solution, as each step was part of the process of discovering and learning.

> "They showed us that math and science weren't just about finding the *right* answer they were about learning how to approach problems creatively and with a logical mindset."

Essentially, mindset shift occurred when teachers encouraged students to ask questions and think critically about the material, which helped them view math and science as dynamic processes rather than rigid subjects. This approach allowed students to engage with the material more deeply, appreciating the process of inquiry and problem-solving rather than just memorizing formulas and facts.

Theme 2: Explicit Application

Participants shared how their perceptions of math and science improved when they began to see the real-world applications of these subjects. Initially, many students felt detached from math and science because they could not understand how these subjects would benefit their daily lives or future aspirations. However, when they were shown how these subjects were practically used in various fields, they began to feel a deeper connection to them.

> "When I started to see how math and science were used in the real world, it sparked more interest."

Once they understood how math and science were integral parts of real-world systems, their interest grew. For example, a student who once thought algebra was an abstract task might have become intrigued upon realizing how it helped in engineering designs or architectural planning. Realizing that these concepts were not just isolated in textbooks, but rather tools to understand and solve everyday problems, made them more engaging.

> "If math and science lessons can show how these concepts apply in fields that students care about, they become more engaging and meaningful."

> "I think math would be much more interesting if professors connected it to things that matter in everyday life, like budgeting, engineering, or even game theory."

Many students reported that when math and science were connected to their personal interests or fields of study, the lessons felt more relevant and engaging. For instance, a student pursuing a career in healthcare might have found chemistry much more fascinating when they learned about how it applies to medicine or drug formulations. The practical application made the subjects feel less like abstract concepts and more like essential knowledge that directly contributed to their future careers.

> "…learning about how physics applies to technology or how chemistry is used in everyday products like medicine, food, or even cosmetics helped me see the value of these subjects."

Before seeing the real-world applications, students often struggled to connect with abstract concepts like equations. A student might have found it difficult to engage with algebraic equations, as they seemed irrelevant to their personal goals. However, once students understood that these equations could be used to solve practical problems—like calculating interest rates on loans or optimizing business strategies—they could better appreciate the importance of learning such abstract concepts.

> "It's hard to care about abstract equations when I don't see how they're going to help me in my career or personal life."

The shift in mindset occurred when students were introduced to real-world applications of math and science, helping them understand the practical value these subjects offered. This connection to their personal interests or future career goals made the concepts more relevant and engaging, encouraging them to see math and science as tools for solving everyday problems rather than abstract, isolated knowledge.

Theme 3: Growth Mindset

Many students reported that their perception of math and science significantly changed when they began to embrace the concept of a growth mindset. Prior to this shift, they often believed that their abilities in these subjects were fixed, leading to frustration and a sense of helplessness when they struggled. The growth mindset, however, emphasizes that intelligence is not static and that through dedication and effort, anyone can improve. This realization led them to approach their learning in a more positive and open-minded way.

> "One thing that helped me change my attitude toward math and science was adopting a growth mindset."

> "When I learned that intelligence in these subjects is not fixed and that with effort and practice, anyone can improve, I started to approach the material differently."

Shifting from a fixed mindset (believing that their abilities in math were predetermined) to a growth mindset (believing that they could improve with effort), students changed their self-perception. For example, a student who struggled with algebra may have previously thought, "I'll never get this," but after adopting a growth mindset, they started to think, "If I keep practicing and seek help when needed, I can improve." This new perspective helped them approach challenges with more patience and persistence, leading to a more positive and proactive attitude toward learning.

> "I stopped thinking of myself as *bad at math* and started thinking of myself as someone who could improve with effort."

> "But once I adopted a growth mindset, I realized that struggling with a topic wasn't a sign of weakness it was a normal part of the learning process."

One major driving factor of enthusiasm among students were their teachers. Teachers who focused on the importance of persistence and viewed mistakes as learning opportunities created an environment where students felt encouraged to try again, even when the material seemed overwhelming.

For instance, when a teacher praised a student's effort and acknowledged their attempts to understand a difficult topic, rather than focusing solely on the right answer, the student was more likely to stay motivated and keep pushing through challenging material. This positive reinforcement made students feel supported in their learning journey and helped them develop the resilience needed to overcome obstacles.

> "Teachers who emphasized the importance of perseverance and learning from mistakes helped me develop this mindset. This shift helped me stay motivated even when the material seemed difficult."

Positive reinforcement from teachers was crucial in helping students build confidence in their abilities. Acknowledging even small achievements, such as solving a challenging equation or demonstrating an improved understanding of a scientific concept, made students feel that their progress was being recognized.

> "When teachers gave positive reinforcement and acknowledged even small successes, it built my confidence."

The mindset shift occurred when students began to understand that their abilities in math and science could improve with effort and practice, rather than being fixed traits. The encouragement and positive reinforcement from teachers who emphasized perseverance and viewed mistakes as part of the learning process further motivated students to persist, leading them to develop a more resilient and growth-oriented approach to these subjects.

6. Discussion

Examining mindset shifts is important as it reveals how individuals adapt and change their thinking processes, influencing their learning experiences and overall development. Understanding these shifts can help teachers design more effective teaching strategies that build resilience, critical thinking, and problem-solving skills. This paper observed several mechanisms for mindset shifts among students, including the role of teacher encouragement, real-world applications of academic concepts, and the impact of positive reinforcement in shaping attitudes toward learning.

Numerous studies have highlighted that negative emotions such as rejection, frustration, and avoidance significantly hinder students' engagement with science and mathematics, which generally affect their academic outcomes[35,36]. Prior research in both primary[36] and secondary education[37,38] has documented a self-perpetuating cycle in which students encounter mathematical difficulties, leading to heightened anxiety, diminished motivation, and lower performance. This cycle reinforces negative self-perceptions, causing disengagement from the subject. Given this dynamic, it becomes imperative to examine students' perceptions to disrupt this cycle and cultivate a more constructive learning environment.

In this regard, the current study extends the discourse by investigating mindset shifts as a mechanism to alter students' attitudes toward mathematics. Research indicates that having positive beliefs and expectations about the subject can significantly enhance students' motivation and engagement, as cognitive and affective factors are deeply interconnected[39].

For example, the findings of this study revealed that students who initially perceived mathematics as a rigid and difficult subject experienced a mindset shift when they were encouraged to ask questions and engage in critical thinking. One participant shared that prior to this shift, they believed they were inherently "bad at math," which led to frustration and avoidance. However, when their teacher emphasized the process of problem-solving rather than just obtaining the correct answer, they began to see mathematics as a logical and creative challenge rather than an insurmountable obstacle. This change in perspective not only reduced their anxiety but also increased their willingness to engage with the subject, demonstrating how cognitive and affective factors interact to shape learning experiences.

The findings of this study align with Zone of Proximal Development (ZPD) from Vygotsky[40], as students' mindset shifts were strongly influenced by social interactions, guidance, and support from teachers and peers. The study revealed that students who initially struggled with mathematics and science exhibited greater motivation and engagement when they received structured guidance that progressively allowed them to take ownership of their learning. This supports Laurillard[41] explaining that motivation is inherent when control over learning is gradually transferred from an expert (teacher or peer) to the learner, building a sense of efficacy.

One driving factor for mindset shift could be the existence of positive reinforcement, as gradual changes in perceptions require conditioning. As Eremie and Doueyi-Fiderikumo[42] assert, timely encouragement serves as a powerful tool for behavior management, influencing students' willingness to engage with mathematical concepts. Similarly, this study revealed that students who received positive reinforcement from their teachers—such as verbal praise, acknowledgment of effort, or encouragement—experienced a shift in mindset, leading to greater persistence and motivation in learning.

Fundamentally, Dweck and Molden[43] believed that positive mindset can be linked to the development of growth mindset among students. Notably, students who transitioned from a fixed to a growth mindset often credited their shift to the supportive learning environment created by their teachers. For example, when teachers emphasized effort over innate ability, framed mistakes as learning opportunities, and provided constructive feedback, students began to view challenges as part of the learning process rather than as indicators of their limitations. When teachers deliberately dismantling the fear of failure and normalizing struggle as part of intellectual growth, teachers create an environment where students actively seek feedback, take risks in problem-solving, and adapt their understanding through meaningful academic interactions. This not only improves immediate learning outcomes but also build long-term academic persistence, as students internalize the belief that consistent effort leads to improvement.

7. Conclusion

This study explored mindset shifts as a mechanism for altering students' attitudes toward mathematics and science learning. The findings revealed several key observations: students who initially viewed mathematics as a rigid and challenging subject experienced a transformation when encouraged to engage in critical thinking and problem-solving. This shift was facilitated by a supportive learning environment, characterized by teacher encouragement, positive reinforcement, and real-world applications of academic concepts. In addition, the study highlighted the importance of social interactions, wherein structured guidance from teachers and peers significantly enhanced students' motivation and engagement. These factors demonstrated how cognitive and affective elements interact to building a growth mindset, which generally improve students' overall academic engagement and reducing anxiety.

However, this study had some limitations that warrant further consideration. First, the research focused on a limited sample of students and was conducted in a specific educational context, which may affect the generalizability of the findings. Future studies could address this limitation by including a more diverse range of students across various educational levels and contexts. Also, while the study explored the role of teachers in facilitating mindset shifts, it would be beneficial to investigate the influence of peer interactions and self-directed learning on mindset development. Future research could also develop longitudinal studies to assess the long-term impact of mindset shifts on students' academic persistence and performance in mathematics.

Conflict of interest

The authors declare no conflict of interest.

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