

Fostering Mathematical Mindsets: A Modern Consolidated Systematic Review and Qualitative Synthesis of Research Literature

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Article Info	Abstract
Article History Received: 30 April 2025 Accepted: 6 December 2025	The concept of mathematical mindsets, based on Carol Dweck's theory of fixed and growth mindsets, has significant implications for mathematics education. This systematic review and qualitative synthesis aim to analyze existing research on fostering mathematical mindsets to provide insights into their development and impact on educational outcomes. Methodologically, the study follows the PRISMA guidelines, for conducting a comprehensive systematic review of the research literature across major academic databases to identify relevant studies. Data extraction and thematic synthesis were performed using qualitative data analysis software MAXQDA 24 to ensure consistency and comprehensiveness. Key findings highlight that growth mindsets in mathematics encourage students to embrace challenges, view failures as learning opportunities, and persist in their efforts, leading to improved academic performance and reduced math anxiety. The study identifies effective interventions, such as mindset workshops, teacher professional development, and parental involvement strategies, that have shown positive outcomes in fostering growth mindsets. Additionally, sociocultural factors, teacher beliefs, and classroom practices significantly influence the development of mathematical mindsets. The main contributions of this review include identifying gaps in the current research and suggesting areas for future exploration, such as the long-term effects of mindset interventions and their applicability across diverse educational contexts. The study concludes that cultivating mathematical mindsets holds the potential to enhance students' engagement and success in mathematics. However, the review also acknowledges limitations related to the variability in intervention designs and contextual factors, emphasizing the need for further research to optimize strategies for fostering growth mindsets in mathematics education.
Keywords Mathematical mindsets Dweck's Theory Mindset interventions Mathematics education Teacher beliefs Classroom strategies Parental involvement Peer influence Sociocultural factors Professional development Supportive classroom environment Mindfulness practices Resistance to change Academic success Motivation Self-efficacy	

Introduction

The concept of mathematical mindsets has gained substantial attention in the field of education in recent years. As proposed by psychologist Carol Dweck, mindsets refer to individuals' beliefs about the nature of intelligence and abilities (Dweck, 2006). Dweck's research distinguishes between two primary mindsets: fixed and growth mindsets. A fixed mindset entails the belief that intelligence and abilities are fixed traits that individuals possess from birth, and they cannot be significantly altered through effort or learning. In contrast, a growth mindset

involves believing that intelligence and abilities are not fixed but developed through dedication, perseverance, and effective learning strategies.

In mathematics education, the impact of mindsets on students' academic performance, attitudes, and behaviors has become a subject of considerable interest. A growing body of research indicates that students' mathematical mindsets significantly influence their engagement, learning outcomes, and long-term success in the subject. Studies have shown that students with growth mindsets are more likely to embrace challenges, view them as opportunities to learn, persist in the face of setbacks, and demonstrate higher levels of effort and resilience (Blackwell et al., 2007). They are also more receptive to feedback and more inclined to adopt effective learning strategies, leading to improvements in their mathematical skills and understanding (Good et al., 2003).

On the other hand, students with fixed mindsets avoid challenging tasks to protect their self-perceived intelligence, shy away from academic risks, and are more prone to feelings of helplessness and disengagement when encountering difficulties (Yeager & Dweck, 2012). This leads to a downward spiral in which their performance plateaus or declines over time. Given the significance of mathematics education in preparing students for future academic and professional pursuits, understanding and cultivating growth mindsets has become a critical objective for educators and policymakers. Educators aim to promote a positive learning environment that nurtures students' confidence, resilience, and motivation in mathematics by identifying effective strategies to foster growth mindsets among students.

This literature review aims to comprehensively analyze existing research on cultivating mathematical mindsets. By examining the factors influencing the development of mathematical mindsets and reviewing the effectiveness of interventions and strategies, this review seeks to contribute valuable insights to mathematics education.

Significance of Cultivating Mathematical Mindsets

Cultivating mathematical mindsets holds immense significance in education, particularly in mathematics instruction. Extensive research has demonstrated that students' mindsets are crucial in shaping their attitudes, behaviors, and academic performance in mathematics (Dweck, 2006). Understanding and promoting growth mindsets in this domain has several positive implications for students' learning experiences and long-term success.

- *Academic Achievement:* Students with growth mindsets are more likely to embrace challenges and view them as opportunities for learning and growth. As a result, they tend to put in more effort and persist in their endeavors, leading to improved academic achievement in mathematics (Blackwell et al., 2007). On the other hand, students with fixed mindsets shy away from challenges, potentially limiting their opportunities to develop critical problem-solving skills and mathematical proficiency.
- *Motivation and Engagement:* Emphasizing a growth mindset enhances students' motivation and engagement in mathematics. When students believe their efforts and strategies lead to improvement, they are more likely to remain motivated and actively participate in mathematical tasks and discussions.

(Good et al., 2003). This sustained engagement contributes to a positive learning environment and supports students in developing a deeper understanding of mathematical concepts.

- *Resilience and Perseverance*: Mathematical mindsets influence students' response to setbacks and failure. Those with growth mindsets tend to demonstrate greater resilience and perseverance, viewing challenges and mistakes as a natural part of the learning process (Yeager & Dweck, 2012). This resilience fosters a willingness to learn from errors and continue to seek solutions, which is essential for sustained progress in mathematics.
- *Reducing Math Anxiety*: Cultivating growth mindsets helps alleviate math anxiety among students. Students with fixed mindsets experience heightened anxiety when faced with challenging math tasks, fearing that their performance reflects an inherent lack of intelligence. In contrast, growth mindset interventions have been shown to reduce math anxiety, allowing students to approach mathematics with greater confidence and composure (Ramirez et al., 2013).
- *Closing Achievement Gaps*: Mathematical mindsets also play a role in addressing achievement gaps among students. By promoting growth mindsets and creating an inclusive learning environment, educators help close the gap between high- and low-achieving students, empowering all learners to reach their full mathematical potential.

In conclusion, cultivating mathematical mindsets has the potential to foster a positive and supportive learning environment, promote academic achievement, enhance student motivation and engagement, build resilience, reduce math anxiety, and address achievement gaps. By integrating growth mindset principles into mathematics education, educators empower students to develop a growth-oriented outlook, unlocking their full potential in pursuing mathematical knowledge and understanding.

Research Questions

This exploration of mathematical mindsets in education is guided by several critical research questions. These questions aim to understand the dynamics of mindset development, the effectiveness of interventions, and the contextual factors influencing students' attitudes toward mathematics. Key research questions in this study include:

- What are the defining characteristics of growth and fixed mindsets in mathematics?
- How do various factors such as teacher beliefs, parental involvement, and sociocultural influences impact the development of mathematical mindsets?
- What interventions have proven effective in cultivating growth mindsets in mathematics, and what are their outcomes across different educational levels?
- What challenges and obstacles hinder the development of growth mindsets in mathematics, and how can they be addressed?

Theoretical Framework

The theoretical framework for understanding and cultivating mathematical mindsets is heavily based on the

work of Carol S. Dweck, whose theory of mindsets was introduced in her book "Mindset: The New Psychology of Success" (2006). Dweck's theory distinguishes between two primary mindsets: fixed and growth. In a fixed mindset, individuals believe their intelligence and abilities are static traits, inherent from birth and unchangeable. This belief leads to avoidance of challenges and a perception of failures as limitations of their capabilities. Conversely, those with a growth mindset see intelligence and abilities as malleable, developed through effort, perseverance, and effective learning strategies. They embrace challenges as opportunities for growth and view setbacks as part of the learning process, leading to increased effort and resource-seeking behavior.

Applying Dweck's theory to mathematics education highlights the significant impact of students' mindsets on their engagement, motivation, and performance. Emphasizing a growth mindset in mathematics classrooms empowers students to adopt a positive learning approach, embrace challenges, and develop a deeper understanding of mathematical concepts. Additionally, insights from related psychological theories, such as Bandura's self-efficacy theory, which stresses belief in one's capability to succeed (Bandura, 1997), and social cognitive theory, which emphasizes learning through observation and modeling (Bandura, 1986), further enrich the framework. These theories help explain how teacher and peer behaviors influence students' mindset development. Integrating these perspectives allows educators and researchers to design effective interventions promoting growth mindsets in mathematics education.

Growth Mindset vs. Fixed Mindset

The concepts of growth mindset and fixed mindset, as proposed by Carol S. Dweck (2006), form the foundation for understanding individuals' beliefs about their abilities and intelligence, profoundly impacting academic performance and personal development. In a growth mindset, individuals believe intelligence and abilities are developed through effort and effective learning strategies. They view challenges as learning opportunities and persist through setbacks, maintaining a positive attitude toward learning (Blackwell et al., 2007). In contrast, those with a fixed mindset see intelligence and abilities as fixed traits, leading them to avoid challenges to protect their perceived intelligence and competence. In mathematics education, a growth mindset encourages students to tackle complex problems confidently and view mistakes as integral to learning, fostering a love of learning and intrinsic motivation. Conversely, a fixed mindset leads to avoidance of challenging tasks and a reluctance to seek help, limiting students' opportunities to develop their mathematical skills.

Dweck's Theory of Mindset and Its Application to Mathematics

Carol S. Dweck's theory of mindset, outlined in her book "Mindset: The New Psychology of Success" (2006), offers a framework for understanding the profound impact of individuals' beliefs about their intelligence on their behavior and achievements. A growth mindset, wherein intelligence is seen as improvable through effort and learning, leads to resilience, persistence, and motivation to seek challenges. In contrast, a fixed mindset views intelligence as static, resulting in avoidance of challenges to protect one's self-image.

Applying Dweck's theory to mathematics education reveals that students' beliefs significantly influence their academic performance and attitudes toward the subject. Students with a growth mindset see challenges as opportunities for learning, engage with complex problems, and persist in finding solutions. They are receptive to feedback and view mistakes as valuable learning experiences, leading to deeper conceptual understanding (Blackwell et al., 2007). Conversely, students with a fixed mindset avoid challenging tasks and fear mistakes, hindering their engagement and growth in mathematics. Educators and policymakers use Dweck's theory to foster a growth-oriented learning environment, emphasizing the malleability of mathematical abilities to empower students to embrace challenges and develop a positive attitude toward learning mathematics.

Related Psychological Theories and Models

In addition to Dweck's mindset theory, other psychological theories provide insights into factors influencing mindset development and academic performance, particularly in mathematics education. Bandura's self-efficacy theory highlights the importance of believing in one's capabilities to succeed, influencing motivation, effort, and persistence (Bandura, 1977). Social cognitive theory emphasizes learning through observation and modeling, suggesting that students' mindsets are shaped by observing their teachers and peers (Bandura, 1986). Attribution theory examines how individuals explain their successes and failures, with attributions to effort and strategies fostering a growth mindset (Weiner, 1985). Mindfulness theory and practices, which involve present-moment awareness and non-judgmental acceptance, have shown promise in promoting a growth mindset and reducing negative behaviors related to a fixed mindset (Schonert-Reichl et al., 2015). Integrating these theories provides a comprehensive understanding of the psychological mechanisms behind mindset development and helps design effective interventions to promote growth mindsets in mathematics education.

Methodology

This study employs a systematic review and qualitative synthesis to examine the existing literature on fostering mathematical mindsets. Following the PRISMA guidelines, the methodology involves a rigorous and transparent process to ensure the inclusion of relevant and high-quality studies.

Database Search and Selection Criteria

The literature search was conducted using six major databases: JSTOR, Google Scholar, ERIC, PsycINFO, Web of Science, and Scopus. The search strategy involved keywords related to mathematical mindsets, growth mindset, fixed mindset, mathematics education, mindset interventions, and student motivation. The initial search yielded 150 records. Additionally, 10 records were identified through other sources such as references from key articles and expert recommendations, resulting in a total of 160 records.

Screening Process

After removing duplicates, 140 unique records remained. These records were screened based on their titles and

abstracts to assess their relevance to the study's focus on mathematical mindsets and educational outcomes. This screening process led to the exclusion of 70 records that did not meet the inclusion criteria.

Eligibility Assessment

The full texts of the remaining 70 articles were then assessed for eligibility. Articles were excluded if they were not peer-reviewed (10 articles), did not focus on mathematics education (5 articles), or were not available in English (5 articles). This left 50 articles that met all the inclusion criteria and were included in the qualitative synthesis.

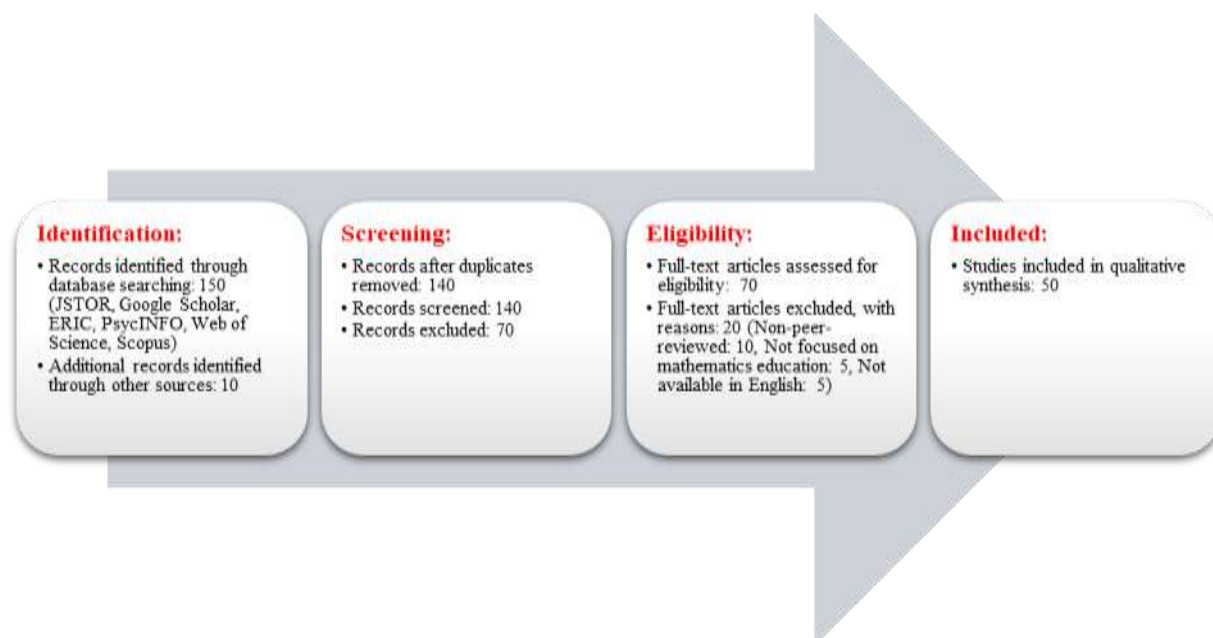


Figure 1. PRISMA Flow Diagram Summary

Data Extraction

Data extraction was performed using MAXQDA 24, a qualitative data analysis software. The extracted data included information on study design, sample characteristics, intervention details, outcomes, and findings related to mathematical mindsets. Key variables were systematically recorded to ensure consistency and comprehensiveness in capturing relevant data from each study.

Data Analysis

The data analysis involved coding the extracted data using MAXQDA 24. An initial coding scheme was developed based on the research questions and the theoretical framework of the study. This scheme included categories such as types of mindsets, interventions used, educational outcomes, and factors influencing mindset development.

- **Open Coding:** Each article was read thoroughly, and relevant sections were coded according to the predefined categories. New codes were created as necessary to capture emerging themes and patterns.

- **Axial Coding:** The codes were then grouped into broader categories to identify relationships and connections between different concepts. This stage involved refining the coding scheme and organizing the data into meaningful clusters.
- **Selective Coding:** The final stage of coding involved integrating and synthesizing the categories to construct a coherent narrative that addressed the research questions. Key themes and insights were identified, and representative quotes from the studies were selected to illustrate these themes.

Synthesis of Results

The synthesis of results was conducted by organizing the coded data into thematic areas that reflected the major findings of the included studies. Thematic analysis allowed for the identification of common patterns, differences, and unique insights across the studies.

- **Thematic Analysis:** This process involved examining the data within each theme to understand the underlying factors influencing mathematical mindsets and the effectiveness of various interventions. Themes were refined and adjusted as more studies were analyzed to ensure a comprehensive representation of the findings.
- **Narrative Synthesis:** The findings were then synthesized into a narrative that highlights the key themes and patterns. This narrative includes discussions on the characteristics of growth and fixed mindsets, the impact of different interventions, and the contextual factors that influence mindset development in mathematics education.

By adhering to the PRISMA guidelines and employing a systematic approach, this study ensures a comprehensive and robust review of the literature on fostering mathematical mindsets. The use of MAXQDA 24 facilitates a detailed and organized analysis of qualitative data, allowing for a thorough synthesis of the findings and the development of a nuanced understanding of the factors influencing mathematical mindsets and the effectiveness of interventions.

Findings

The qualitative analysis and thematic synthesis yielded several important results which will be presented and discussed in the subsequent sections. Table 1 shows the main themes, sub-themes, citations and number of citations supporting each of these themes and sub-themes.

Table 1. The Main Themes, Sub-themes, Citations and Number of Citations that Emerged from the Qualitative Analysis and Thematic Synthesis

Main Theme	Sub-theme	Citations	Number of Citations
Mathematical Mindsets	Defining Mathematical	Dweck (2006); Blackwell et al.	3
	Mindsets	(2007); Boaler et al. (2018)	
	Characteristics of a	Dweck (2006); Blackwell et al.	3

Main Theme	Sub-theme	Citations	Number of Citations
	Growth Mindset	(2007); Boaler et al. (2018)	4
	Identifying Fixed Mindset Tendencies	Dweck (2006); Yeager & Dweck (2012); Blackwell et al. (2007); Ramirez et al. (2013)	
	Differentiation Between Mindset and Skillset	Dweck (2006); Boaler et al. (2018)	
			2
Factors in Play	Influencing Mathematical Mindsets	Hill et al. (2008); Maloney et al. (2015); Pomerance et al. (2016); Robinson-Cimpian et al. (2014); Sisk et al. (2018); Yeager et al. (2019)	6
	Role of Teachers and Teaching Practices	Boaler & Dweck (2016); Hill et al. (2008); Dweck (2006); Tomlinson (2017); Yeager et al. (2019)	5
	Teacher Beliefs and Attitudes	Boaler & Dweck (2016); Hill et al. (2008); Rattan et al. (2012)	3
	Effective Classroom Strategies	Boaler & Dweck (2016); Dweck (2006); Hill et al. (2008); Tomlinson (2017)	4
	Parental Involvement and Support	Maloney et al. (2015); Hill et al. (2008); Boaler & Dweck (2016)	3
	Peer Influence and Classroom Dynamics	Boaler & Dweck (2016); Yeager et al. (2019); Hill et al. (2008); Robinson-Cimpian et al. (2014); Tomlinson (2017); Sisk et al. (2018); Maloney et al. (2015)	7
	Sociocultural Factors and Stereotypes	Robinson-Cimpian et al. (2014); Boaler & Dweck (2016); Yeager et al. (2019); Tomlinson (2017)	4
	Impact of Past Experiences and Success/Failure Feedback	Dweck (2006); Boaler & Dweck (2016); Raudenbush et al. (2018); Yeager et al. (2019)	4
Mindset Interventions	Interventions to Cultivate Mathematical Mindsets	Boaler & Dweck (2016); Yeager et al. (2019); Paunesku et al. (2015)	3
	Mindset-Focused	Dweck (2006); Yeager et al.	5

Main Theme	Sub-theme	Citations	Number of Citations
	Professional Development for Teachers	(2019); Boaler & Dweck (2016); Hill et al. (2008); Rattan et al. (2012)	
	Creating a Supportive Classroom Environment	Dweck (2006); Boaler & Dweck (2016); Hill et al. (2008); Tomlinson (2017)	4
	Incorporating Growth Mindset Language and Feedback	Dweck (2006); Boaler & Dweck (2016); Hill et al. (2008)	3
	Parental and Community Involvement Strategies	Yeager et al. (2019); Hill et al. (2008); Boaler & Dweck (2016); Tomlinson (2017)	4
	Leveraging Technology for Mindset Interventions	Yeager et al. (2019); Hill et al. (2008); Boaler & Dweck (2016)	3
	Incorporating Mindfulness Practices in Mathematics Education	Alessandro et al. (2022); Lee & Jang (2021); Lutzenberger et al. (2015); Seligman et al. (2005)	4
	Outcomes and Effectiveness of Mindset Interventions	Yeager et al. (2019); Blackwell et al. (2007); Paunesku et al. (2015); Dweck (2006); Raudenbush et al. (2018)	5
	Variations across Different Age Groups and Educational Levels	Good et al. (2003); Mangels et al. (2019); Levy & Dweck (1999); Blackwell et al. (2007); Harackiewicz et al. (2014); Paunesku et al. (2015); Hulleman & Harackiewicz (2014); Rattan et al. (2012)	8
	Challenges and Obstacles		
Challenges and Obstacles	Common Challenges and Obstacles	Mueller & Dweck (1998); Gunderson et al. (2012); Maloney & Beilock (2012); Boaler & Dweck (2016); Rattan et al. (2012); Aparicio et al. (2019)	6
	Identifying Common Barriers to Mindset Development	Dweck (2006); Boaler & Dweck (2016); Maloney & Beilock (2012); Gunderson et al. (2012);	6

Main Theme	Sub-theme	Citations	Number of Citations
		Mueller & Dweck (1998); Rattan et al. (2012)	
	Addressing Resistance to Change	Rattan et al. (2012); Mueller & Dweck (1998); Boaler & Dweck (2016); Paunesku et al. (2015); Blackwell et al. (2007); Yeager & Dweck (2012)	6
	Potential Unintended Consequences of Mindset Interventions	Yeager & Dweck (2012); Sisk et al. (2018); Aparicio et al. (2019); Haimovitz & Dweck (2017); Boaler & Dweck (2016); Hammer (2020)	6

Results

Main Theme 1. Mathematical Mindsets

Sub-theme: Defining Mathematical Mindsets

Mathematical mindsets refer to individuals' beliefs, attitudes, and perceptions regarding their mathematical abilities and the nature of mathematics as a subject. These mindsets are rooted in the broader framework of mindset theory, as proposed by Dweck (2006), and play a significant role in shaping students' engagement, motivation, and performance in mathematics.

- *Growth Mindset in Mathematics:* A growth mindset in mathematics entails believing that mathematical abilities and skills are developed and improved through effort, effective learning strategies, and perseverance. Students with a growth mindset view mathematics as a subject that offers opportunities for learning and growth. They embrace challenges and are more likely to approach complex mathematical problems confidently and naturally (Blackwell et al., 2007). Mistakes and setbacks are considered essential aspects of the learning process, encouraging students to seek help and persist in enhancing their mathematical proficiency.
- *Fixed Mindset in Mathematics:* Conversely, a fixed mindset in mathematics is characterized by the belief that mathematical abilities are fixed traits inherent from birth and cannot be significantly altered through effort or learning. Students with a fixed mindset perceive mathematics as a subject that requires innate talent, and they avoid challenging mathematical tasks to protect their self-perceived intelligence (Dweck, 2006). Fear of failure and making mistakes hinder their willingness to engage in rigorous mathematical exploration and limit their growth potential in the subject.
- *Mindset Continuum:* It is important to note that mathematical mindsets exist on a continuum rather than as strict dichotomies. While some students predominantly exhibit a growth mindset, others display a mix of growth and fixed mindset tendencies depending on the context or the specific mathematical task. The continuum reflects the dynamic nature of mindset beliefs and their potential to change over time with intervention and support (Boaler et al., 2018).

Sub-theme: Characteristics of a Growth Mindset in Mathematics

A growth mindset in mathematics is characterized by specific attitudes, beliefs, and behaviors that promote a positive and constructive approach to learning and problem-solving. These characteristics are rooted in Carol S. Dweck's theory of mindset (2006) and have been extensively studied in the context of mathematics education.

- *Embracing Challenges:* Students with a growth mindset in mathematics view challenges as opportunities for learning and growth. They are not afraid to tackle complex mathematical problems and are willing to invest the effort required to overcome difficulties (Blackwell et al., 2007).
- *Persistence in the Face of Setbacks:* Individuals with a growth mindset exhibit resilience and perseverance when encountering obstacles or making mistakes in mathematics. They understand that errors are a natural part of the learning process and use setbacks as opportunities to learn and improve (Dweck, 2006).
- *Effort and Strategy:* Students with a growth mindset believe effort and effective learning strategies contribute to their mathematical success. They understand that their abilities are developed through dedicated practice and by employing different problem-solving approaches (Boaler et al., 2018).
- *Seeking Help and Feedback:* Individuals with a growth mindset in mathematics are open to seeking help from teachers, peers, or educational resources. They value feedback to enhance their understanding and skills (Blackwell et al., 2007).
- *Viewing Mistakes as Learning Opportunities:* Rather than viewing mistakes as signs of failure or inadequacy, students with a growth mindset see them as valuable learning experiences. They analyze their errors to identify areas of improvement and adjust their approach accordingly (Dweck, 2006).
- *Developing a Love of Learning:* Students with a growth mindset tend to have a positive attitude towards mathematics, fostering genuine curiosity and interest in the subject. They view mathematical exploration as enjoyable and meaningful (Boaler et al., 2018).
- *Effort over Talent:* Individuals with a growth mindset prioritize effort and improvement over inherent talent or natural ability. They believe continuous effort and dedication lead to substantial progress in mathematics (Blackwell et al., 2007).
- *Seeing Math as a Journey:* A growth mindset in mathematics recognizes that mathematical learning is a lifelong journey. Students understand that their mathematical abilities continue to evolve and develop over time, encouraging a long-term perspective on learning (Boaler et al., 2018).

Sub-theme: Identifying Fixed Mindset Tendencies and Their Impact

Fixed mindset tendencies in mathematics are characterized by specific attitudes, beliefs, and behaviors that reflect a belief in the immutability of one's mathematical abilities and a resistance to challenges.

- *Identifying Fixed Mindset Tendencies:* Identifying these tendencies is crucial for educators and policymakers to understand how fixed mindsets influence students' academic performance and overall learning experiences in mathematics.
 - *Avoidance of Challenges:* Students with fixed mindset tendencies in mathematics avoid challenging mathematical tasks or shy away from exploring complex problems. They prefer

tasks that align with their perceived abilities, as taking on challenging tasks might threaten their self-concept (Dweck, 2006).

- *Fear of Failure*: Individuals with fixed mindset tendencies often fear failure in mathematics, as they associate unsuccessful outcomes with a lack of inherent intelligence or mathematical aptitude. This fear leads to a reluctance to take risks and a preference for safe, low-risk tasks (Yeager & Dweck, 2012).
- *Limited Resilience*: Students with fixed mindset tendencies display limited resilience when faced with mathematical difficulties or mistakes. Rather than viewing setbacks as opportunities for learning, they become discouraged and disheartened by challenges (Blackwell et al., 2007).
- *Seeking Validation*: Individuals with fixed mindset tendencies seek constant validation of their mathematical abilities from teachers, peers, or parents. They prioritize performance over the learning process and seek external approval to maintain their self-perceived intelligence (Yeager & Dweck, 2012).
- *Avoiding Effort*: Students with fixed mindset tendencies be inclined to avoid putting in significant effort in mathematics, believing that their abilities are predetermined and cannot be significantly improved through practice or study (Dweck, 2006).
- *Negative Self-Talk*: Individuals with fixed mindset tendencies engage in negative self-talk and harbor self-doubts about their mathematical abilities. This negative self-talk further reinforces their belief in limited capacity and hinders their motivation to engage in rigorous mathematical exploration (Yeager & Dweck, 2012).
- *Impact of Fixed Mindset Tendencies*: Fixed mindset tendencies harm students' academic performance and overall learning experiences in mathematics. Students with fixed mindsets struggle to reach their full potential in the subject due to their reluctance to take on challenges and limited resilience in the face of difficulties. This leads to stagnant academic progress and a lack of motivation to develop their mathematical skills further (Blackwell et al., 2007). Additionally, fixed mindset tendencies contribute to math anxiety, as students perceive challenging math tasks as threatening their self-concept. This anxiety further hinders their ability to concentrate, learn, and perform effectively in mathematics (Ramirez et al., 2013).

Sub-theme: Differentiation Between Mindset and Skillset

Mindset and skillset are distinct but interconnected factors that influence an individual's success and performance in various domains, including academics. Understanding the differences between these concepts is essential for educators and learners to navigate the learning process and achieve optimal outcomes effectively.

- *Mindset*: Mindset refers to an individual's beliefs, attitudes, and perceptions about their abilities, intelligence, and potential for growth. It encompasses how one views one's traits, whether one believes these traits are fixed and unchangeable (fixed mindset) or malleable and improvable through effort and learning (growth mindset) (Dweck, 2006). Mindset significantly impacts an individual's approach to challenges and failures. Those with a growth mindset tend to embrace challenges, see them as

opportunities for learning, and persist in the face of setbacks. In contrast, individuals with a fixed mindset avoid challenges, fear failure, and limit their willingness to engage in tasks that challenge their perceived abilities.

- *Skillset:* Skillset, on the other hand, refers to the specific competencies, knowledge, and abilities an individual possesses in a particular domain. It encompasses the practical skills and expertise one has developed through learning, training, and experience. Skillset is objective and is measured and demonstrated through performance and achievements. In academics, a student's skill set in mathematics, for example, includes proficiency in arithmetic, problem-solving, understanding geometric concepts, and applying mathematical principles to real-world scenarios.
- *Relationship between Mindset and Skillset:* Mindset and skillset are interrelated and influence each other. A growth mindset motivates individuals to develop and enhance their skills by believing in their capacity for improvement and embracing learning opportunities. Individuals with a growth mindset are more likely to invest effort, seek resources, persist in their learning endeavors, and develop robust skill sets (Boaler et al., 2018). Conversely, skillsets also influence mindset. Experiencing success and competence in a particular domain reinforces a growth mindset, as individuals see tangible evidence of their ability to improve and excel through their developed skills.

Main Theme 2. Factors in Play

Sub-theme: Influencing Mathematical Mindsets

Mathematical mindsets are shaped by a combination of individual, social, and educational factors that play a crucial role in influencing students' beliefs, attitudes, and perceptions about their mathematical abilities and growth potential. Understanding these factors is essential for educators and policymakers to create a supportive learning environment that fosters positive mathematical mindsets.

- *Teacher Beliefs and Practices:* Teachers' beliefs about mathematics and teaching practices significantly impact students' mindsets. When teachers demonstrate a growth mindset, emphasize the importance of effort, and provide opportunities for challenging tasks, students are more likely to adopt similar growth-oriented beliefs (Hill et al., 2008). Conversely, teachers who unintentionally convey fixed mindset messages or use ability-based grouping inadvertently reinforce fixed mindset tendencies in students.
- *Parental Attitudes and Support:* Parents' attitudes towards mathematics and their support for their children's learning influence students' mindset development. Parents who value and show enthusiasm for mathematics, offer encouragement, and focus on effort rather than innate ability promote growth mindsets in their children (Maloney et al., 2015).
- *Peer Influence and Classroom Culture:* Peer interactions and the overall classroom culture play a vital role in shaping students' mindset beliefs. A positive and collaborative classroom environment that celebrates effort supports risk-taking and encourages the sharing of ideas to foster growth mindsets (Pomerance et al., 2016). Conversely, a competitive or judgmental classroom culture reinforces fixed mindset tendencies.
- *Sociocultural Factors:* Sociocultural factors, such as cultural norms and societal expectations, influence

students' mindset beliefs about mathematics. Stereotypes related to gender, race, and socioeconomic status affect how students perceive their mathematical abilities and opportunities, potentially impacting their mindset development (Robinson-Cimpian et al., 2014).

- *Feedback and Assessment Practices:* The nature of feedback and assessment provided to students shape their mindset beliefs. Constructive feedback that focuses on effort, progress, and specific strategies for improvement encourages growth mindsets (Sisk et al., 2018). In contrast, feedback that emphasizes fixed traits or uses comparative evaluations reinforces fixed mindset tendencies.
- *Past Experiences and Academic History:* Students' experiences and academic history in mathematics influence their mindset development. Repeated experiences of success or failure create a cumulative effect on mindset beliefs. Negative experiences, such as receiving low grades or feeling inadequately supported, contribute to fixed mindset tendencies (Dweck, 2006).
- *Mindfulness and Mindset Interventions:* Mindfulness practices and targeted mindset interventions positively impact students' beliefs. Mindfulness activities that cultivate present-moment awareness and non-judgmental acceptance reduce anxiety and promote growth mindset beliefs (Schonert-Reichl et al., 2015). Mindset interventions that explicitly teach the malleability of abilities and the power of effort improve students' mindset beliefs and academic performance (Yeager et al., 2019).

Sub-theme: Role of Teachers and Teaching Practices

Teachers play a crucial role in shaping students' mathematical mindsets and influencing their beliefs, attitudes, and perceptions about their abilities in mathematics. The teaching practices employed by educators either foster a growth mindset or inadvertently reinforce fixed mindset tendencies among students.

- *Demonstrating a Growth Mindset:* Teachers who model a growth mindset themselves profoundly impact their students. When educators openly embrace challenges, value effort, and view mistakes as opportunities for learning, students are more likely to adopt similar growth-oriented beliefs (Boaler & Dweck, 2016). By demonstrating a growth mindset, teachers provide a positive example that encourages students to approach mathematics with confidence and a willingness to learn from setbacks.
- *Providing a Supportive Learning Environment:* Creating a supportive and nurturing learning environment is crucial for promoting a growth mindset in mathematics. Teachers foster a sense of psychological safety, where students feel comfortable taking risks and asking questions without fear of judgment (Hill et al., 2008). A supportive classroom culture allows students to see challenges as opportunities for growth, which leads to increased engagement and motivation in mathematics.
- *Emphasizing Effort and Learning Process:* Teachers encourage growth mindsets by focusing on the process of learning rather than solely on outcomes. Emphasizing effort, persistence, and effective learning strategies over innate talent helps students develop a belief in their ability to improve through dedicated practice (Dweck, 2006). Providing specific feedback highlighting the progress made and the strategies used reinforces a growth mindset.
- *Differentiation and Individualization:* Teachers address students' diverse needs and abilities through differentiation and individualization. Tailoring instruction to meet students where they are academically helps avoid fixed mindset messages associated with ability-based grouping (Tomlinson,

2017). Students who experience success and growth through personalized instruction are more likely to develop a positive mathematical mindset.

- *Promoting Collaboration and Discussion:* Encouraging collaborative learning and classroom discussions positively impacts students' mathematical mindsets. Opportunities for students to engage in mathematical discourse and share different problem-solving approaches broaden their perspectives and increase their confidence in their mathematical abilities (Boaler & Dweck, 2016).
- *Mindset Interventions:* Teachers incorporate targeted mindset interventions into their teaching practices to explicitly teach the concept of growth mindset and its potential impact on learning outcomes (Yeager et al., 2019). These interventions involve discussions, activities, and reflections that challenge fixed mindset beliefs and encourage adopting growth-oriented thinking.

Sub-theme: Teacher Beliefs and Attitudes

Teachers' beliefs and attitudes about mathematics and their students' abilities significantly influence students' mathematical mindsets and overall academic performance. These beliefs shape instructional practices and classroom culture, playing a crucial role in fostering either growth mindsets or inadvertently reinforcing fixed mindset tendencies among students.

- *Beliefs About Mathematics:* Teachers' beliefs about the nature of mathematics impact how they approach teaching the subject. If teachers view mathematics as a rigid, fixed discipline with predetermined abilities, they unintentionally convey fixed mindset messages to their students (Boaler & Dweck, 2016). On the other hand, teachers who see mathematics as a dynamic and evolving field, open to exploration and growth, are more likely to promote a growth mindset among their students.
- *Beliefs About Students' Abilities:* Teachers' beliefs about their students' mathematical abilities also influence their instructional decisions. When teachers hold high expectations for all students and believe in their capacity for improvement, students are more likely to develop a positive mathematical mindset (Hill et al., 2008). Conversely, low expectations or the belief that certain students have limited mathematical potential inadvertently reinforce fixed mindset tendencies in those students.
- *Attitudes Towards Mathematics:* Teachers' attitudes towards mathematics impact the enthusiasm and passion they bring to the subject. Educators who demonstrate enthusiasm and enjoyment for mathematics inspire students and create a positive learning environment (Boaler & Dweck, 2016). Conversely, a teacher with a negative attitude toward mathematics inadvertently conveys a sense of apprehension or disinterest, potentially influencing students' mindset development.
- *Growth Mindset Among Teachers:* Teachers with a growth mindset are powerful role models for their students. Educators with growth mindsets are more likely to value effort, embrace challenges, and view failures as learning opportunities (Hill et al., 2008). Their belief in the malleability of abilities encourages students to adopt similar growth-oriented thinking.
- *Reflective Practice:* Teachers' reflective practices and self-awareness about their mindset beliefs are essential. By reflecting on their attitudes and beliefs, educators identify potential fixed mindset tendencies and take intentional steps to promote a growth mindset culture in their classrooms (Boaler & Dweck, 2016).

Sub-theme: Effective Classroom Strategies

Practical classroom strategies play a significant role in promoting positive mathematical mindsets and creating a growth-oriented learning environment. Educators foster a growth mindset culture in the mathematics classroom by implementing instructional practices that support the effort, encourage exploration, and value students' diverse abilities.

- *Emphasizing Effort and Process:* Teachers emphasize the importance of effort and the learning process in mathematics. By praising students' hard work, perseverance, and problem-solving strategies, educators reinforce the idea that success is not solely determined by innate ability but is a result of dedicated practice and improvement (Dweck, 2006).
- *Providing Opportunities for Challenges:* Offering challenging mathematical tasks and open-ended problems stimulates students' curiosity and promotes a growth mindset. When students are encouraged to grapple with complex problems, they develop problem-solving skills, resilience, and a belief in their ability to tackle complex concepts (Boaler & Dweck, 2016).
- *Fostering Collaborative Learning:* Encouraging collaborative learning experiences allows students to engage in mathematical discourse and learn from one another. Working in groups helps students build confidence, gain new perspectives, and develop a growth mindset through shared problem-solving experiences (Hill et al., 2008).
- *Providing Specific Feedback:* Offering specific and constructive feedback on students' mathematical work enhances their growth mindset beliefs. The feedback that focuses on the process of learning acknowledges progress and guides improvement, reinforces the idea that abilities are developed through effort and practice (Boaler & Dweck, 2016).
- *Embracing Mistakes and Learning from Failures:* It is crucial to create a classroom culture where mistakes are viewed as opportunities for learning. Teachers should model a positive attitude toward errors and guide students in analyzing their mistakes to identify areas for improvement (Dweck, 2006).
- *Incorporating Real-World Applications:* Connecting mathematics to real-world applications enhances students' motivation and relevance. Demonstrating how mathematical concepts are used in everyday contexts helps students understand the practicality and value of mathematics, fostering a growth mindset (Boaler & Dweck, 2016).
- *Differentiation and Individualization:* Adopting differentiation strategies to meet student's diverse needs and abilities ensures that all learners experience success and growth. Tailoring instruction to individual learning styles and providing opportunities for extension or additional support promotes a positive mathematical mindset (Tomlinson, 2017).

Sub-theme: Parental Involvement and Support

Parental involvement and support are essential in shaping students' mathematical mindsets and academic success. When parents actively engage in their children's mathematical learning, demonstrate positive attitudes towards mathematics, and encourage, students are more likely to develop a growth mindset and approach the subject confidently and enthusiastically.

- *Demonstrating Positive Attitudes:* Parents' attitudes towards mathematics influence how their children perceive the subject. When parents express positive attitudes and enthusiasm for mathematics, their children tend to view it as an enjoyable and valuable domain (Maloney et al., 2015). On the other hand, parents who convey negative attitudes or express mathematics anxiety inadvertently pass on fixed mindset beliefs to their children.
- *Valuing Effort and Resilience:* Parents play a crucial role in fostering a growth mindset by valuing effort, persistence, and resilience in their children's mathematical endeavors. Rather than solely focusing on grades or outcomes, praising hard work and progress reinforces the belief that abilities are developed through dedication and learning (Hill et al., 2008).
- *Providing Learning Support:* Home learning support positively impacts students' mathematical mindsets. Engaging in math activities, such as solving puzzles, playing math games, or discussing real-world math applications, enhances children's understanding and motivation (Maloney et al., 2015).
- *Encouraging Curiosity and Exploration:* Encouraging curiosity and exploration in mathematics helps children develop a positive attitude towards problem-solving and mathematical inquiry. Parents engage their children in open-ended discussions, encourage questions, and celebrate the process of discovery and learning (Boaler & Dweck, 2016).
- *Modeling a Growth Mindset:* Parents model a growth mindset by openly discussing their learning experiences and efforts to overcome challenges. Sharing personal growth and resilience stories inspires children to adopt a similar growth-oriented perspective (Hill et al., 2008).
- *Creating a Supportive Learning Environment:* Creating a supportive learning environment at home involves providing resources and opportunities for mathematical exploration. Parents ensure access to appropriate math materials, books, and educational resources that align with their children's interests and abilities (Maloney et al., 2015).
- *Communication with Teachers:* Collaboration between parents and teachers is essential for supporting students' mathematical mindsets. Regular communication allows parents to stay informed about their children's progress, discuss areas for growth, and align efforts to promote a growth mindset at home and in the classroom (Boaler & Dweck, 2016).

Sub-theme: Peer Influence and Classroom Dynamics

Peer influence and the overall classroom dynamics play a significant role in shaping students' mathematical mindsets and attitudes toward learning. Positive interactions with peers and a supportive classroom environment foster a growth mindset, while negative dynamics inadvertently reinforce fixed mindset beliefs among students.

- *Collaborative Learning and Supportive Atmosphere:* Encouraging collaborative learning and fostering a supportive atmosphere in the classroom positively influence students' mathematical mindsets. When students work together, share ideas, and support one another, they gain confidence in their problem-solving abilities and become more open to taking intellectual risks (Boaler & Dweck, 2016). A collaborative environment promotes the idea that learning is a collective effort and everyone benefits from each other's insights.
- *Promoting a Growth Mindset Culture:* The classroom dynamics, shaped by teachers and peers,

influence students' mindset beliefs. Teachers explicitly promote a growth mindset by reinforcing that intelligence and mathematical abilities are developed through effort and dedication (Yeager et al., 2019). Peers with growth mindset tendencies also influence others to adopt similar beliefs through positive social reinforcement (Hill et al., 2008).

- *Addressing Stereotypes and Bias:* Stereotypes and biases related to gender, race, or socioeconomic status impact students' mathematical mindsets. Negative stereotypes make students doubt their abilities or conform to societal expectations, reinforcing fixed mindset tendencies (Robinson-Cimpian et al., 2014). Teachers and peers work together to challenge and debunk such stereotypes to create an inclusive and empowering learning environment.
- *Grouping Strategies and Mixed-Ability Settings:* Classroom grouping strategies influence peer dynamics and mindset development. Flexible grouping that mixes students of different abilities is beneficial, allowing students to learn from one another and appreciate diverse perspectives (Tomlinson, 2017). In contrast, fixed ability grouping perpetuates fixed mindset beliefs if students are labeled based on perceived abilities.
- *Peer Feedback and Encouragement:* Peer feedback and encouragement profoundly impact students' mindset beliefs. Constructive feedback on effort, progress, and learning reinforces a growth mindset (Sisk et al., 2018). Peers who provide positive reinforcement for taking on challenges and making mistakes as part of the learning process contribute to a growth-oriented classroom culture.
- *Addressing Math Anxiety:* Math anxiety spreads through peer interactions, negatively impacting students' mindset beliefs and confidence in their mathematical abilities (Maloney et al., 2015). Addressing math anxiety through supportive peer interactions, mindfulness techniques, and a growth mindset approach alleviates its impact on students' mindset development.

Sub-theme: Sociocultural Factors and Stereotypes

Sociocultural factors and stereotypes significantly influence students' mathematical mindsets and academic performance. These factors encompass cultural norms, societal expectations, and stereotypes related to gender, race, and socioeconomic status. Understanding and addressing these influences are essential for creating an inclusive and empowering learning environment that fosters positive mathematical mindsets.

- *Gender Stereotypes:* Gender stereotypes that associate mathematics with the male ability or disfavor females impact girls' mindset, beliefs, and performance in the subject. Negative stereotypes make girls doubt their mathematical abilities or internalize the belief that they are less capable of mathematics than their male peers (Robinson-Cimpian et al., 2014). Teachers and peers work to challenge gender biases and promote an equitable learning environment.
- *Racial and Ethnic Stereotypes:* Racial and ethnic stereotypes influence students' mathematical mindsets and academic achievement. Stereotypes suggesting that certain racial or ethnic groups are inherently better or worse at mathematics affect students' beliefs about their abilities (Robinson-Cimpian et al., 2014). Culturally responsive teaching and curriculum help combat these stereotypes and create an inclusive learning environment.
- *Socioeconomic Status:* Socioeconomic status impacts students' access to educational resources and

opportunities, influencing their mindset development. Students from disadvantaged backgrounds face additional challenges and barriers that affect their mindset beliefs (Maloney et al., 2015). By addressing disparities in access and support, educators promote equitable opportunities for all students.

- *Culturally Relevant Mathematics*: Integrating culturally relevant mathematics into the curriculum fosters a sense of belonging and relevance for students from diverse backgrounds. Connecting mathematical concepts and students' cultural experiences enhances engagement and mindset development (Boaler & Dweck, 2016).
- *Growth Mindset as a Counterforce*: Promoting a growth mindset serves as a counterforce to negative sociocultural factors and stereotypes. By explicitly teaching the concept of a growth mindset and emphasizing the potential for improvement through effort and learning, educators empower students to challenge limiting beliefs (Yeager et al., 2019).
- *Inclusive Pedagogies*: Inclusive pedagogies that recognize and value students' diverse backgrounds and abilities create a welcoming and supportive learning environment. Differentiated instruction, incorporating multiple perspectives, and creating opportunities for student voice contribute to a positive mathematical mindset culture (Tomlinson, 2017).

Sub-theme: Impact of Past Experiences and Success/Failure Feedback

Students' past experiences and feedback, particularly regarding success and failure in mathematics, significantly influence their mindset development. Positive experiences and constructive feedback foster a growth mindset, while negative experiences and feedback contribute to fixed mindset tendencies.

- *Cumulative Effect of Past Experiences*: Students' past experiences in mathematics have a cumulative effect on their mindset development. Repeated successes or failures shape students' beliefs about their abilities and potential for growth (Dweck, 2006). Positive experiences, such as receiving praise for effort and improvement, reinforce a growth mindset, while negative experiences, like struggling without appropriate support, lead to fixed mindset beliefs.
- *Influence of Success Feedback*: Feedback that focuses solely on praising innate ability or intelligence inadvertently promotes fixed mindset beliefs. When students are praised for being "smart" rather than for their effort or specific strategies, they develop the notion that their abilities are fixed and cannot be improved (Dweck, 2006). In contrast, feedback that acknowledges effort and the use of effective strategies reinforces the belief in the malleability of abilities and encourages a growth mindset.
- *Impact of Failure Feedback*: How failure is framed and the feedback provided after a setback significantly impact students' mindset beliefs. When failure is seen as a natural part of the learning process, and students are encouraged to learn from their mistakes, it fosters resilience and a belief in the power of effort (Boaler & Dweck, 2016). On the other hand, failure feedback that emphasizes personal inadequacy or inability reinforces fixed mindset tendencies.
- *Growth Mindset Interventions*: Mindset interventions that explicitly teach the concept of growth mindset and its potential impact on learning effectively counter the adverse effects of past experiences and feedback. These interventions help students understand that abilities are developed through effort and learning, leading to positive mindset shifts (Yeager et al., 2019).

- *Importance of Supportive Learning Environment:* A supportive learning environment at home and in the classroom is essential in mitigating the impact of past experiences and feedback. When students receive encouragement, targeted feedback, and appropriate support, they are more likely to maintain a growth mindset even in the face of challenges (Boaler & Dweck, 2016).

Main Theme 3. Mindset Interventions

Sub-theme: Interventions to Cultivate Mathematical Mindsets

Efforts to cultivate positive mathematical mindsets in students have led to the development of various interventions that target mindset beliefs and attitudes toward mathematics. These interventions aim to promote a growth mindset, challenge fixed mindset tendencies, and empower students to embrace challenges and persevere in their mathematical learning journey.

- *Mindset Workshops and Curriculum Integration:* Mindset workshops and curriculum integration explicitly teach students growth mindset concepts and strategies. These interventions help students understand the malleability of abilities and the importance of effort and effective learning strategies in achieving success (Boaler & Dweck, 2016). By incorporating growth mindset principles into the mathematics curriculum, educators reinforce the belief that intelligence and mathematical abilities are developed through dedication and practice.
- *Writing Prompts and Reflection Activities:* Engaging students in writing prompts and reflection activities related to their mathematical experiences fosters self-awareness and mindset development. Students are encouraged to analyze their beliefs about their abilities and identify any fixed mindset tendencies (Yeager et al., 2019). Reflecting on their growth and progress empowers students to embrace a growth-oriented perspective.
- *Feedback Interventions:* Feedback interventions target how teachers provide student feedback regarding their performance. By emphasizing effort, specific progress, and practical problem-solving strategies, educators reinforce the growth mindset belief that abilities are developed through practice and learning (Boaler & Dweck, 2016). This type of feedback helps shift the focus from fixed ability labels to continuous improvement.
- *Teacher Professional Development:* Teacher professional development programs on growth mindset principles and strategies equip educators with tools to cultivate positive mathematical mindsets in their students. When teachers model a growth mindset and incorporate growth-oriented practices in their teaching, they create an environment that supports mindset development (Hill et al., 2008).
- *Parent Engagement and Workshops:* Involving parents in mindset interventions extend the impact beyond the classroom. Parent workshops emphasize the importance of effort, provide growth mindset strategies, and address common mindset misconceptions to empower parents to support their children's development at home (Dweck, 2006).
- *Long-Term Interventions and Follow-up:* Long-term interventions that extend over an extended period have more sustained effects on mindset development. These interventions involve continuously reinforcing growth mindset messages and periodic follow-up activities to monitor students' mindset progress (Yeager et al., 2019).

Sub-theme: Mindset-Focused Professional Development for Teachers

Mindset-focused professional development for teachers is designed to equip educators with the knowledge, strategies, and skills to foster growth mindsets among their students. By enhancing teachers' understanding of mindset principles and providing practical tools for implementation, this form of professional development empowers educators to create a growth mindset culture in the classroom.

- *Mindset Theory and Research:* Mindset-focused professional development begins with an overview of mindset theory and the relevant research. Educators are introduced to the pioneering work of Carol Dweck, who identified the concepts of fixed and growth mindsets (Dweck, 2006). Understanding the neural basis of mindset beliefs and the impact of mindset on academic achievement (Yeager et al., 2019) lays the foundation for teachers to recognize the significance of mindset in the learning process.
- *Identifying Fixed Mindset Tendencies:* Teachers learn to recognize and address fixed mindset tendencies that inadvertently manifest in their instructional practices. Professional development workshops help educators identify areas where they unintentionally reinforce fixed mindset beliefs, such as praising intelligence over effort or using ability-based grouping (Boaler & Dweck, 2016).
- *Promoting a Growth Mindset Language:* Teachers are encouraged to use growth mindset language in student interactions. This involves praising effort, perseverance, and effective learning strategies instead of solely praising innate ability (Dweck, 2006). Educators foster a growth mindset culture in the classroom by using language emphasizing continuous improvement and growth potential.
- *Encouraging Risk-Taking and Resilience:* Mindset-focused professional development highlights the importance of creating a supportive learning environment where students feel safe to take risks and embrace challenges. Teachers are provided with strategies to encourage resilience and a willingness to learn from mistakes (Boaler & Dweck, 2016). Promoting a growth mindset helps students view errors as opportunities for growth rather than as indicators of failure.
- *Emphasizing the Learning Process:* Teachers are guided to emphasize the learning process rather than solely focusing on outcomes. This involves providing specific and constructive feedback that highlights progress and the use of effective strategies (Hill et al., 2008). By valuing the learning process, educators reinforce that success is achieved through dedication and improvement over time.
- *Mindset Interventions in Instruction:* Mindset-focused professional development equips teachers with practical interventions to teach growth mindset principles explicitly. These interventions include mindset workshops, reflection activities, and writing prompts designed to encourage students to analyze their beliefs about intelligence and abilities (Yeager et al., 2019).
- *Collaboration and Continued Support:* Mindset-focused professional development is most effective when it includes opportunities for collaboration and continued support. Teachers share experiences, discuss challenges, and exchange best practices for promoting growth mindsets. Follow-up support helps educators sustain the mindset-focused approach in their classrooms.

Sub-theme: Creating a Supportive Classroom Environment

A supportive classroom environment is essential for cultivating positive mathematical mindsets in students.

When students feel valued, safe, and encouraged to take intellectual risks, they are more likely to develop a growth mindset and approach mathematics confidently and enthusiastically. Creating such an environment involves several key strategies and practices.

- *Fostering a Growth Mindset Culture:* Teachers play a central role in establishing a growth mindset culture in the classroom. They explicitly teach the concept of a growth mindset, emphasizing that intelligence and mathematical abilities are developed through effort and effective learning strategies (Dweck, 2006). By promoting the idea that mistakes are opportunities for learning and encouraging students to embrace challenges, teachers foster a culture that values the process of learning.
- *Valuing Effort and Progress:* In a supportive classroom environment, effort, and progress are celebrated and valued as much as, if not more than, outcomes. Teachers praise students' hard work, perseverance, and problem-solving strategies, reinforcing that success is achieved through dedication and improvement over time (Boaler & Dweck, 2016).
- *Providing a Safe Learning Space:* A safe learning space is essential for fostering positive mathematical mindsets. Teachers create an atmosphere where students feel comfortable sharing ideas, asking questions, and making mistakes without fear of judgment (Hill et al., 2008). When students know their efforts are respected and their contributions are valued, they are more likely to take intellectual risks and engage actively in their learning.
- *Offering Differentiated Instruction:* Recognizing and catering to student's diverse needs and abilities is vital for creating a supportive classroom environment. Differentiated instruction allows teachers to tailor their approach to meet individual students' learning styles and readiness levels (Tomlinson, 2017). Providing opportunities for extension or additional support ensures that all students experience success and growth.
- *Incorporating Collaborative Learning:* Collaborative learning experiences promote a positive classroom environment by encouraging peer interactions and fostering community. Working in groups allows students to share ideas, learn from one another, and develop their problem-solving skills collectively (Hill et al., 2008). Collaborative activities also build students' confidence and create a supportive network for learning.
- *Encouraging Positive Teacher-Student Relationships:* Positive teacher-student relationships are fundamental for a supportive classroom environment. Teachers who genuinely care and are interested in their students' well-being inspire trust and motivation (Boaler & Dweck, 2016). Forming strong connections with students helps them feel valued and contributes to their overall mindset development.
- *Providing Timely and Specific Feedback:* Effective feedback is crucial to a supportive classroom environment. Teachers provide timely and specific feedback that focuses on the learning process and identifies areas for improvement (Hill et al., 2008). Feedback acknowledging progress and effort reinforces the growth mindset belief that abilities are developed through learning and practice.

Sub-theme: Incorporating Growth Mindset Language and Feedback

Incorporating growth mindset language and feedback in the classroom is a powerful way to promote positive mathematical mindsets among students. By using language emphasizing effort, progress, and growth potential,

educators instill in students the belief that they develop their mathematical abilities through dedication and learning.

- *Emphasizing Effort and Process:* Teachers use growth mindset language by praising students' effort and hard work instead of solely focusing on outcomes. For example, instead of saying, "You are so smart," they say, "I appreciate your effort and determination in solving that problem" (Dweck, 2006). By valuing the learning process, educators reinforce that success is achieved through dedication and improvement over time.
- *Celebrating Specific Strategies:* Teachers highlight students' specific strategies and approaches to solving problems when providing feedback. This feedback reinforces that effective strategies and problem-solving skills are learned and improved (Boaler & Dweck, 2016). Acknowledging students' progress in their problem-solving abilities fosters a growth mindset and encourages them to continue refining their skills.
- *Encouraging Risk-Taking:* A language growth mindset encourages students to take intellectual risks and embrace challenges. Teachers create an environment where mistakes are seen as part of the learning process and an opportunity for growth (Dweck, 2006). Students who feel supported in pursuing challenging problems are more likely to develop resilience and a willingness to learn from mistakes.
- *Promoting a Growth Mindset Dialogue:* Teachers engage students in growth mindset discussions and reflections. Asking questions such as, "What strategies did you try? What did you learn from your mistakes? How did you approach this differently next time?" prompts students to think about their learning process (Boaler & Dweck, 2016). Encouraging students to talk about their growth and progress reinforces a growth-oriented mindset.
- *Modeling a Growth Mindset:* Educators model a growth mindset by sharing their learning experiences and challenges. Demonstrating a willingness to take on new tasks, learn from mistakes, and continuously improve sends a powerful message to students about the value of a growth-oriented perspective (Hill et al., 2008).
- *Providing Incremental Feedback:* Feedback that focuses on incremental progress is critical to growth mindset language. Teachers break down complex tasks into smaller steps and provide feedback at each stage of the learning process (Dweck, 2006). Incremental feedback helps students recognize their progress, reinforcing the belief that improvement is achievable through continuous effort.

Sub-theme: Parental and Community Involvement Strategies

Involving parents and the broader community is crucial for reinforcing growth mindset principles and cultivating positive mathematical mindsets in students. Collaborative efforts between schools, families, and communities create a supportive ecosystem that nurtures students' mindset development and academic success.

- *Growth Mindset Workshops for Parents:* Organizing growth mindset workshops for parents help them understand the concept of growth mindset and its impact on their child's learning (Yeager et al., 2019). These workshops provide parents with strategies to promote a growth mindset at home, such as emphasizing effort over innate ability, praising specific strategies, and encouraging a positive attitude

toward challenges (Boaler & Dweck, 2016).

- *Communication of Growth Mindset Messages:* Schools actively communicate growth mindset messages to parents and the community through newsletters, emails, and school events. Schools reinforce the importance of growth mindset beliefs by sharing success stories of students who have overcome challenges through perseverance and effort (Hill et al., 2008).
- *Family Math Nights:* Family math nights allow parents and students to engage in math-related activities together. These events showcase the importance of a growth mindset in mathematics and demonstrate how to support math learning at home. Encouraging positive math experiences within the family setting contributes to students' mindset development (Boaler & Dweck, 2016).
- *Community Partnerships:* Collaborating with local organizations and community partners strengthens the growth mindset culture beyond the school walls. Partnerships with libraries, museums, and businesses offer additional learning opportunities that promote a growth-oriented approach to education (Tomlinson, 2017).
- *Parent-Teacher Collaboration:* Maintaining open and regular communication between teachers and parents is essential for reinforcing growth mindset principles. Teachers share strategies parents use to support their child's learning journey and mindset development at home (Yeager et al., 2019). Collaborating on growth-oriented goals and celebrating students' progress collectively creates a cohesive approach to fostering positive mathematical mindsets.
- *Parent Involvement in Goal Setting:* Including parents in goal-setting empowers them to participate actively in their child's academic development. Collaborative goal setting based on growth mindset principles emphasizes effort, progress, and pursuing challenges as critical components of academic success (Hill et al., 2008).
- *Community Outreach Events:* Engaging the broader community in growth mindset initiatives amplifies the impact of mindset-focused efforts. Schools organize community outreach events, such as math fairs or workshops, to promote the importance of growth mindset beliefs and dispel common misconceptions about math (Boaler & Dweck, 2016).

Sub-theme: Leveraging Technology for Mindset Interventions

Technology offers innovative and effective ways to deliver mindset interventions and cultivate positive mathematical mindsets in students. Educators engage students in interactive activities through various digital tools and platforms, provide personalized feedback, and extend mindset-focused initiatives beyond the traditional classroom setting.

- *Mindset Apps and Games:* Mindset-focused apps and games immerse students in engaging experiences reinforcing growth mindset principles. These interactive tools help students understand the concept of a growth mindset, provide opportunities for reflection, and offer strategies for developing a growth-oriented attitude toward learning (Yeager et al., 2019). Such apps and games are accessed on personal devices, allowing students to reinforce mindset concepts outside school hours.
- *Online Growth Mindset Workshops:* Online growth mindset workshops allow flexibility and scalability. Webinars and virtual workshops reach a wider audience, including parents and educators, and provide

insights into fostering growth mindset beliefs in mathematics (Hill et al., 2008). Interactive online sessions include activities, discussions, and resources to support mindset development.

- *Mindset Reflection Journals:* Digital platforms are excellent tools to create student mindset reflection journals. Through online journals, students document their growth mindset experiences, record progress, and set goals for their mathematical learning journey (Boaler & Dweck, 2016). Teachers provide feedback and encouragement through digital annotations, fostering ongoing mindset development.
- *Online Growth Mindset Assessments:* Digital assessments help educators gauge students' mindset beliefs and measure changes over time. Online surveys and quizzes will be administered to assess students' mindset orientation and identify areas where growth mindset support is needed (Yeager et al., 2019). Analyzing assessment data informs targeted mindset interventions.
- *Growth Mindset Social Media Campaigns:* Social media platforms provide an avenue for sharing growth mindset messages with a broader audience. Schools and educators leverage social media to post motivational content, success stories, and growth mindset tips (Boaler & Dweck, 2016). By harnessing the power of social media, mindset-focused initiatives reach students, parents, and community members.
- *Virtual Growth Mindset Challenges:* Virtual growth mindset challenges encourage students to apply growth mindset principles in real-life scenarios. These challenges involve solving math problems, setting learning goals, and reflecting on progress using digital tools (Hill et al., 2008). Virtual challenges offer a dynamic and interactive approach to mindset development.
- *Growth Mindset E-Learning Modules:* Creating e-learning modules that integrate growth mindset principles into the math curriculum allows students to access mindset-focused content at their own pace. These modules incorporate videos, quizzes, and interactive activities to engage learners (Boaler & Dweck, 2016). E-learning platforms provide opportunities for differentiated instruction based on individual student needs.

Sub-theme: Incorporating Mindfulness Practices in Mathematics Education

Integrating mindfulness practices into mathematics education represents a progressive approach to enhancing students' learning experiences, cognitive skills, emotional well-being, and attitudes toward mathematics. This comprehensive approach addresses the multifaceted challenges students face in mathematics by promoting focus, self-awareness, and a positive mindset, fostering a conducive learning environment for mathematical engagement and comprehension.

- *Mindfulness Practices in Mathematics Education:* Mindfulness practices, characterized by present-focused attention and non-judgmental awareness, have gained traction in educational settings due to their potential to improve cognitive skills, classroom behavior, and emotional regulation (Alessandro et al., 2022; Lee & Jang, 2021). Specifically, in mathematics education, these practices offer a novel pathway to mitigate math anxiety, enhance students' understanding of mathematical concepts, and cultivate a growth mindset toward learning mathematics (Luttenberger et al., 2015). Activities such as mindful counting, problem-solving, visualization, and mindful math games encourage students to

engage in mathematical tasks with calmness, concentration, and creativity (Seligman et al., 2005).

- *Strategies for Incorporating Mindfulness in Mathematics:* Several strategies effectively integrate mindfulness into the mathematics curriculum. Breathing exercises and mindful breaks during lessons significantly reduce students' anxiety and stress related to math, enabling them to approach mathematical challenges with a clear and composed mindset. Mindful visualization and problem-solving exercises promote a more profound comprehension of mathematical concepts and critical thinking by encouraging students to visualize geometric shapes, mentally simulate mathematical processes, and approach problems with a reflective and strategic mindset. Furthermore, mindfulness-based interventions have shown efficacy in reducing math anxiety and improving performance, suggesting their potential as valuable tools in addressing negative attitudes toward mathematics (Luttenberger et al., 2015).
- *Enhancing Mathematical Understanding Through Mindful Reflection:* Mindful reflection and journaling are powerful tools in mathematics education. They allow students to articulate their thoughts, emotions, and experiences related to mathematics in a supportive, nonjudgmental environment. This practice not only aids in developing self-awareness regarding one's mathematical journey and mindset but also facilitates cultivating a positive attitude towards facing challenges and acknowledging progress in mathematics learning.
- *The Role of Mind-Mapping in Mathematics Education:* Complementing mindfulness practices, the application of mind-mapping techniques has been explored to enhance the learning experience in mathematics further. These techniques assist in developing analytical, organizational, collaborative, and creative skills, augmenting students' ability to comprehend and retain mathematical concepts (Luangkrajang, 2022; Murtiningsih et al., 2022). Research indicates that mind mapping supports students in achieving a deeper understanding of topics, enhancing creativity, and improving skills such as reading comprehension and writing, which are valuable in the context of mathematics education (Yunus & Chien, 2016; Muassomah et al., 2022; Wahid & Sudirman, 2023).

Main Theme 4. Outcomes and Effectiveness

Sub-theme: Outcomes of Mindset Interventions

In various studies, mindset interventions to cultivate positive mathematical mindsets have shown promising outcomes. These interventions target students' beliefs about their mathematics abilities and emphasize that intelligence and mathematical skills are developed through effort and practice. The following section provides an overview of the outcomes and effectiveness of mindset interventions in fostering positive mathematical mindsets and improving academic performance in mathematics.

- *Improved Academic Performance:* Several studies, such as Yeager et al. (2019), have demonstrated that growth mindset interventions improve academic performance in mathematics. Students who received mindset-focused interventions showed enhanced achievement, particularly those who had previously struggled academically. The belief in the potential for growth and the value of effort motivates students to engage more deeply in their mathematical studies, leading to higher levels of achievement.
- *Increased Persistence and Effort:* Mindset interventions have been linked to increased students'

persistence and effort when faced with challenging math tasks. By promoting a growth mindset, these interventions encourage students to view challenges as opportunities for learning and improvement. As a result, students are more likely to persist in their efforts and tackle complex mathematical problems with a positive attitude (Blackwell et al., 2007).

- *Reduced Math Anxiety:* Mindset interventions have also been associated with reducing math anxiety among students. When students adopt a growth mindset, they experience less anxiety about making mistakes or being judged based on their performance. The belief that abilities are developed over time helps alleviate the fear of failure and creates a more relaxed learning environment (Paunesku et al., 2015).
- *Positive Attitudes Towards Mathematics:* Interventions that promote growth mindset beliefs contribute to students developing more positive attitudes towards mathematics. By reframing challenges as opportunities for growth, students view math as an engaging and meaningful subject. This shift in mindset leads to increased interest and enjoyment in learning mathematics (Dweck, 2006).
- *Long-Term Impact:* Longitudinal studies, such as the research by Raudenbush et al. (2018), have indicated that mindset interventions have a sustained impact on students' mindset beliefs and academic performance over time. Cultivating positive mathematical mindsets fosters a more enduring motivation to learn and succeed in mathematics.

Sub-theme: Variations across Different Age Groups and Educational Levels

The impact of mindset interventions on students' mathematical attitudes and academic performance varies across age groups and educational levels. While growth mindset principles benefit learners of all ages, the effectiveness of mindset interventions is influenced by developmental factors, cognitive abilities, and the educational context. The following section discusses variations observed in mindset interventions across various age groups and educational levels, drawing insights from relevant studies.

- *Early Childhood Education:* In early childhood education, mindset interventions foster a positive attitude towards learning and academic challenges. Research by Good et al. (2003) explored the effectiveness of growth mindset interventions in preschool settings. The study found that children exposed to mindset-focused messages exhibited more significant effort and enthusiasm in approaching learning tasks. Early exposure to growth mindset principles lays the foundation for a positive mindset toward academics as students progress through their educational journey.
- *Elementary School:* Mindset interventions aim to instill growth-oriented beliefs in mathematics. Studies by Mangels et al. (2019) and Levy and Dweck (1999) revealed that elementary school students who received mindset-focused instruction showed increased motivation, resilience, and effort in mathematics. These interventions are particularly impactful during the early elementary years, as students develop their attitudes and beliefs about their mathematical abilities.
- *Middle School and High School:* Mindset interventions remain relevant in middle and high school settings, where students face increasing academic demands and performance pressures. Research by Blackwell et al. (2007) and Harackiewicz et al. (2014) demonstrated that growth mindset interventions positively influenced academic performance and reduced math anxiety in middle and high school

students. These interventions help students maintain a positive attitude toward mathematics and persevere through academic challenges.

- *College and Higher Education:* In college and higher education, mindset interventions have been shown to impact students' academic achievement and retention. Research by Paunesku et al. (2015) and Hulleman and Harackiewicz (2014) indicated that growth mindset interventions improved college students' course grades and persistence rates. These findings highlight the relevance of mindset interventions in supporting students' success in higher education.
- *Teacher and Faculty Mindset:* The mindset of teachers and faculty members also influences students' mindset development. Studies by Rattan et al. (2012) and Good et al. (2003) found that when instructors held growth mindset beliefs, students demonstrated greater motivation and engagement in their studies. Educators who promote growth mindset principles in their teaching create a more supportive and encouraging learning environment.

Main Theme 5. Challenges and Obstacles

Sub-theme: Common Challenges and Obstacles

While mindset interventions have shown promise in fostering positive mathematical mindsets, several challenges and obstacles hinder their effectiveness. These challenges arise from various factors, including educational practices, societal influences, and individual differences. This section explores key challenges and obstacles in cultivating mathematical mindsets, drawing insights from relevant research.

- *Fixed Mindset Reinforcement:* In educational settings, fixed mindset beliefs are inadvertently reinforced through praise and feedback that focuses on innate talent or intelligence rather than effort and growth. Research by Mueller and Dweck (1998) found that praising students for their intelligence leads to a fixed mindset, as students become more concerned about proving their intelligence rather than embracing challenges. Overcoming fixed mindset reinforcement requires a deliberate shift in educators' language and feedback to emphasize effort and growth.
- *Stereotypes and Sociocultural Influences:* Stereotypes about mathematics, such as the belief that certain groups are naturally better at math than others, create a fixed mindset among students from underrepresented backgrounds. Research by Gunderson et al. (2012) highlighted that societal stereotypes influence students' beliefs about their mathematical abilities. Addressing these stereotypes and promoting a growth mindset for all students is essential for cultivating positive mathematical mindsets.
- *Math Anxiety:* Math anxiety is a common obstacle to developing positive mathematical mindsets. Research by Maloney and Beilock (2012) revealed that math anxiety hinders students' willingness to embrace challenges and persist in problem-solving. Mindset interventions that reduce math anxiety and create a supportive learning environment help students develop a growth mindset toward mathematics.
- *Individual Differences:* Students' differences, such as prior experiences with math and self-perception of mathematical ability, impact their receptiveness to mindset interventions. Students who have experienced repeated failures or negative feedback in mathematics find it more challenging to adopt a growth mindset. Addressing individual differences requires personalized and differentiated approaches

in mindset cultivation (Boaler & Dweck, 2016).

- *Mindset Consistency:* Developing a growth mindset requires consistent reinforcement over time. A single mindset intervention does not lead to sustained changes in students' beliefs. Research by Dweck and Master (2009) emphasized the importance of providing ongoing support and reinforcement for growth mindset beliefs to take root and thrive.
- *Cultural Context:* Mindset interventions must be adapted to fit the cultural context of different educational settings. Cultural variations in beliefs about effort, intelligence, and academic achievement influence the acceptance and effectiveness of mindset interventions (Aparicio et al., 2019).
- *Teacher Mindset:* Teachers' mindset beliefs impact their instructional practices and the classroom climate. Teachers with fixed mindset beliefs unknowingly communicate negative messages about students' potential and inadvertently discourage a growth mindset in their classrooms (Rattan et al., 2012).

Sub-theme: Identifying Common Barriers to Mindset Development

Various common barriers students encounter throughout their educational journey impede the development of a growth mindset in mathematics. Identifying and understanding these barriers is crucial in designing effective interventions to foster positive mathematical mindsets. The following section explores some of the most prevalent barriers to mindset development, drawing insights from research and literature.

- *Fixed Mindset Beliefs:* One of the primary barriers to mindset development is the presence of fixed mindset beliefs, where individuals view intelligence and mathematical ability as fixed traits rather than skills developed through effort. Research by Dweck (2006) has shown that individuals with fixed mindsets are more likely to avoid challenges and give up quickly when faced with difficulties in mathematics.
- *Past Negative Experiences:* Students who have experienced repeated failures or received negative feedback in mathematics develop a negative attitude towards the subject. These negative experiences lead to self-doubt and a belief that they cannot improve, hindering the development of a growth mindset (Boaler & Dweck, 2016).
- *Fear of Failure:* Math anxiety and the fear of making mistakes are significant barriers to mindset development. Students who are anxious about math avoid challenging tasks to protect themselves from potential failure or embarrassment (Maloney & Beilock, 2012).
- *Negative Stereotypes:* Societal stereotypes about math ability create a fixed mindset among certain groups, such as women and minority students, leading them to internalize negative beliefs about their mathematical capabilities (Gunderson et al., 2012). Stereotype threat further inhibits mindset development by undermining students' confidence and motivation.
- *External Praise and Rewards:* Praising students for their innate intelligence or mathematical talent rather than their effort reinforces a fixed mindset (Mueller & Dweck, 1998). Similarly, relying heavily on extrinsic rewards for performance in math discourages students from embracing challenges and developing a growth mindset.
- *Lack of Supportive Learning Environment:* An unsupportive learning environment, where mistakes are

stigmatized, or learning is overly focused on grades, deters students from taking risks and embracing a growth mindset. Creating a supportive and encouraging classroom culture is essential for mindset development (Rattan et al., 2012).

- *Belief in Math as Innate Talent:* The notion that being good at math results from innate talent hinders mindset development. Students who believe math ability is fixed from birth do not see the value of effort to improve (Boaler & Dweck, 2016).

Sub-theme: Addressing Resistance to Change

Resistance to change is a significant barrier to mindset development in mathematics. Students are reluctant to embrace a growth mindset due to various factors, such as fear of failure, negative past experiences, or fixed beliefs about their abilities. Addressing resistance to change requires thoughtful and targeted strategies to help students overcome these barriers. The following section explores practical approaches to address resistance to change and promote the adoption of a growth mindset, drawing insights from research and literature.

- *Promote a Safe and Supportive Learning Environment:* Creating a safe and supportive learning environment is essential for addressing resistance to change. Teachers establish a classroom culture where mistakes are seen as opportunities for learning, and students feel comfortable taking risks and embracing challenges. Research by Rattan et al. (2012) highlighted the importance of instructor support in fostering a growth mindset in students.
- *Emphasize Effort and Process:* Encourage students to focus on effort and the learning process rather than solely on the outcomes. Teachers provide specific feedback highlighting the effort students put into their work and their problem-solving strategies. Research by Mueller and Dweck (1998) indicated that praising students for their effort instead of their intelligence fosters a growth mindset.
- *Teach the Science of Brain Plasticity:* Educate students about brain plasticity and how the brain grows and changes with effort and practice. Understanding that intelligence is not fixed but is developed over time helps students shift from a fixed mindset to a growth mindset (Boaler & Dweck, 2016).
- *Provide Role Models and Stories of Success:* Share stories of individuals who have overcome challenges and achieved success through perseverance and a growth mindset. Role models inspire students and demonstrate that intelligence and mathematical ability are not fixed traits but are developed through dedication and hard work.
- *Implement Mindset-Focused Interventions:* Introduce mindset-focused interventions in the classroom, such as growth mindset workshops or activities that explicitly promote growth and effort in learning mathematics. Research by Paunesku et al. (2015) and Blackwell et al. (2007) demonstrated the effectiveness of mindset interventions in improving academic performance.
- *Encourage Self-Reflection:* Encourage students to reflect on their beliefs and attitudes towards mathematics. Self-reflection helps students identify fixed mindset thoughts and replace them with growth-oriented perspectives. Teachers engage students in discussions and journaling about their mindset beliefs.
- *Encourage Growth Mindset Language:* Use growth mindset language in classroom discussions and instructional materials. Teachers use phrases like "I do not know it yet" instead of "I cannot do it" to

reinforce the idea that learning is a continuous process.

Sub-theme: Potential Unintended Consequences of Mindset Interventions

While mindset interventions have shown promising results in fostering positive mathematical mindsets, there are potential unintended consequences that educators and researchers should consider. Implementing mindset interventions without careful consideration leads to unforeseen outcomes that could impact students' attitudes, behaviors, and academic performance. The following section explores some potential unintended consequences of mindset interventions, drawing insights from research and literature.

- *Overemphasis on Effort without Support:* While promoting the importance of effort is essential, an exclusive focus on effort without providing appropriate support and guidance is problematic. Students feel overwhelmed if they believe that effort alone is sufficient for success. Teachers must strike a balance by offering targeted instruction, feedback, and resources alongside emphasizing effort (Yeager & Dweck, 2012).
- *Increased Pressure to Succeed:* Mindset interventions that emphasize the malleability of intelligence and abilities inadvertently create additional pressure for students to succeed. Students interpret the growth mindset message as a mandate to improve constantly, leading to higher stress levels and anxiety about not meeting high expectations (Sisk et al., 2018).
- *Stereotype Threat Amplification:* For students who belong to stigmatized groups, mindset interventions inadvertently amplify stereotype threat. Studies by Aparicio et al. (2019) suggest that highlighting the importance of effort in the face of stereotype threat leads students to interpret their struggles as evidence of low effort rather than the impact of negative stereotypes.
- *Superficial Adoption of Growth Mindset:* Some students superficially adopt a growth mindset without genuinely internalizing the belief in their ability to improve. This could lead to a performative response rather than a shift in attitudes and behaviors (Haimovitz & Dweck, 2017).
- *Unrealistic Expectations:* Mindset interventions inadvertently lead to unrealistic expectations about the speed and extent of academic progress. Students become discouraged if they do not experience immediate improvements, leading to disillusionment with the growth mindset concept (Boaler & Dweck, 2016).
- *Disregard for Systemic Inequities:* Overemphasis on individual mindsets diverts attention away from the more significant systemic issues that hinder educational opportunities for certain groups of students. Addressing mindsets alone cannot overcome structural educational barriers (Hammer, 2020).

Discussion

Discussion of Results

Mathematical Mindsets

Mathematical mindsets refer to the beliefs, attitudes, and perceptions individuals hold about their mathematical abilities and the nature of math as a subject, influencing students' engagement, motivation, and performance (Dweck, 2006). A growth mindset in mathematics involves the belief that abilities can be developed through

effort and perseverance, leading students to embrace challenges and view mistakes as opportunities for learning (Blackwell et al., 2007). Conversely, a fixed mindset perceives mathematical ability as an innate trait, resulting in avoidance of challenges and a fear of failure (Dweck, 2006). Mindsets are not binary but exist on a continuum, with students displaying mixed tendencies based on context (Boaler et al., 2018).

Factors in Play

Several factors influence mathematical mindsets, including the beliefs and practices of teachers, parental attitudes, peer influence, and broader sociocultural factors. Teachers who demonstrate and encourage a growth mindset positively impact students' beliefs and practices (Hill et al., 2008). Parental support and attitudes towards mathematics also shape students' mindset development (Maloney et al., 2015). Additionally, a collaborative and supportive classroom culture fosters positive mindset development, whereas competitive or judgmental environments reinforce fixed mindset tendencies (Pomerance et al., 2016). Sociocultural factors and stereotypes related to gender, race, and socioeconomic status significantly impact students' mindset beliefs (Robinson-Cimpian et al., 2014).

Mindset Interventions

Interventions aimed at cultivating positive mathematical mindsets involve a range of strategies, including mindset workshops, curriculum integration, and reflective activities. Mindset workshops and curriculum integration explicitly teach students about growth mindset principles, emphasizing the malleability of abilities (Boaler & Dweck, 2016). Reflection activities encourage students to analyze their beliefs and identify fixed mindset tendencies, fostering self-awareness (Yeager et al., 2019). Feedback interventions focus on praising effort and specific strategies, reinforcing the belief that abilities can be developed through practice (Boaler & Dweck, 2016). Additionally, professional development for teachers equips them with the tools to model and promote growth mindsets in their classrooms (Hill et al., 2008).

Outcomes and Effectiveness

Mindset interventions have shown promising outcomes in improving academic performance, increasing persistence and effort, reducing math anxiety, and fostering positive attitudes towards mathematics. Studies demonstrate that students who receive mindset-focused interventions exhibit enhanced achievement and resilience, particularly those who previously struggled academically (Yeager et al., 2019). These interventions also contribute to more positive attitudes towards mathematics by reframing challenges as opportunities for growth (Dweck, 2006). Longitudinal studies indicate that mindset interventions have sustained impacts on students' mindset beliefs and academic performance over time (Raudenbush et al., 2018).

Challenges and Obstacles

Despite the potential benefits, several challenges and obstacles hinder the effectiveness of mindset interventions.

Fixed mindset beliefs are often reinforced through praise and feedback that emphasize innate talent rather than effort (Mueller & Dweck, 1998). Societal stereotypes about mathematics abilities further entrench fixed mindset tendencies among underrepresented groups (Gunderson et al., 2012). Additionally, math anxiety, past negative experiences, and a lack of supportive learning environments pose significant barriers to mindset development (Maloney & Beilock, 2012). Addressing these challenges requires personalized and differentiated approaches and consistent reinforcement of growth mindset principles (Boaler & Dweck, 2016).

Research Based Recommendations for Practice

Educators play a critical role in cultivating positive mathematical mindsets in their students. To effectively foster a growth-oriented culture in mathematics education, educators follow these practical guidelines, supported by research and best practices:

- *Create a Growth Mindset Classroom Culture:* Establish a growth mindset classroom culture where students are encouraged to embrace challenges and see mistakes as learning opportunities. Promote a supportive environment that values effort and perseverance (Rattan et al., 2012).
- *Provide Targeted Feedback:* Offer specific and constructive feedback that focuses on students' efforts, strategies, and areas for improvement. Feedback should be timely and encourage students to keep trying (Yeager & Dweck, 2012).
- *Teach the Science of Brain Plasticity:* Educate students about the brain's ability to grow and change through effort and practice. Help students understand that intelligence is not fixed and that their abilities are developed with hard work (Dweck, 2006).
- *Use Growth Mindset Language:* Incorporate growth mindset language in classroom discussions and instructional materials. Encourage students to use phrases like "I improve with practice" to reinforce a growth-oriented perspective (Mueller & Dweck, 1998).
- *Personalized Instruction:* Differentiate instruction to meet individual students' needs and learning styles. Provide additional support and resources to help struggling students build confidence and competence in mathematics (Boaler & Dweck, 2016).
- *Promote Collaboration and Peer Support:* Encourage collaborative learning and peer support in the classroom. Peer interactions reinforce a growth mindset by demonstrating that learning is a shared and ongoing process (Gunderson et al., 2012).
- *Address Math Anxiety:* Create a positive and stress-reducing environment to help alleviate math anxiety. Incorporate relaxation techniques and mindfulness practices to help students manage anxiety (Maloney & Beilock, 2012).
- *Set Realistic Expectations:* Set realistic and achievable student goals, emphasizing progress over perfection. Avoid placing undue pressure on students to achieve immediate and exceptional results (Sisk et al., 2018).
- *Integrate Mindset in Curriculum:* Integrate mindset principles into the mathematics curriculum, connecting growth mindset concepts to specific learning objectives and activities (Paunesku et al., 2015).
- *Model a Growth Mindset:* Demonstrate a growth mindset by sharing personal stories of overcoming

challenges and learning from mistakes. Model a positive attitude towards learning and problem-solving (Yeager & Dweck, 2012).

- *Foster Parental Engagement:* Involve parents in mindset development efforts through regular communication, workshops, and resources that promote growth mindset beliefs at home (Good et al., 2003).

Research Based Recommendations for Policy

School administrators and policymakers play a crucial role in shaping the educational landscape and supporting the cultivation of positive mathematical mindsets. By implementing evidence-based strategies, administrators and policymakers create conducive environments that foster growth mindsets in mathematics education. The following are practical strategies for administrators and policymakers, supported by research and literature:

- *Promote Professional Development:* Support the professional development of teachers to enhance their understanding of growth mindset principles and effective instructional practices. Offer workshops, seminars, and training programs that equip educators with the tools to foster classroom growth mindsets (Boaler & Dweck, 2016).
- *Establish Mindset-Oriented School Policies:* Integrate growth mindset principles into school policies and practices. Emphasize the importance of effort, resilience, and continuous improvement in school mission statements and educational plans (Yeager & Dweck, 2012).
- *Allocate Resources for Mindset Initiatives:* Allocate resources, including funding and time, to implement school mindset initiatives and interventions. Prioritize programs that promote growth mindsets and support equitable access to mathematics education (Paunesku et al., 2015).
- *Create Supportive Learning Environments:* Encourage the establishment of supportive learning environments where students feel safe to take risks and embrace challenges. Implement initiatives that reduce math anxiety and promote student well-being (Maloney & Beilock, 2012).
- *Foster Collaboration Among Educators:* Encourage collaboration and knowledge-sharing among educators to promote the effective implementation of growth mindset strategies. Facilitate discussions and opportunities for educators to learn from one another's experiences (Gunderson et al., 2012).
- *Incorporate Mindset in Teacher Evaluation:* Include growth mindset practices in teacher evaluation criteria to incentivize educators to prioritize mindset development in their teaching methods (Haimovitz & Dweck, 2017).
- *Support Research on Mindset Interventions:* Promote and fund research on mindset interventions to understand their efficacy and identify best practices. Use evidence-based findings to guide decision-making and policy development (Yeager et al., 2019).
- *Collaborate with Parents and Communities:* Engage parents and communities in mindset development efforts. Organize workshops and informational sessions to share growth mindset principles and strategies with parents and community members (Good et al., 2003).
- *Implement Culturally Responsive Mindset Strategies:* Recognize the influence of cultural and social contexts on mindset development. Implement culturally responsive strategies considering students' diverse backgrounds and experiences (Hammer, 2020).

- *Support Long-Term Impact Evaluation:* Support the long-term evaluation of mindset interventions and their impact on students' academic performance and attitudes toward mathematics. Use evaluation findings to continuously refine and improve mindset initiatives (Sisk et al., 2018).

Future Research Directions

While significant progress has been made in understanding the importance of cultivating mathematical mindsets, there are still several promising areas for future research. Exploring these areas deepens our understanding of mindset development and informs the design of more effective interventions. The following are some critical areas for future research in cultivating mathematical mindsets:

- *Long-Term Impact of Mindset Interventions:* Research on the long-term impact of mindset interventions is essential to assess the sustainability of mindset development over time. Longitudinal studies that track students' mindset beliefs and academic outcomes over several years shed light on the lasting effects of mindset interventions.
- *Intersectionality and Mindset Development:* It is crucial to understand how race, gender, socioeconomic status, and cultural background intersect with mindset development. Investigating how different identity groups experience and respond to mindset interventions helps develop more inclusive and culturally responsive strategies.
- *Mindset Development in Underrepresented Groups:* Further research is needed to explore mindset development in underrepresented groups in mathematics, such as girls and minority students. Identifying barriers and effective mindset interventions for these groups promote equity and diversity in STEM fields.
- *Mindset Interventions across Educational Levels:* Exploring the effectiveness of mindset interventions across different educational levels, from early childhood to higher education, is essential. Investigating age-appropriate strategies and the impact of early mindset development on later academic success inform targeted interventions.
- *Mindset Development in Online Learning:* With the increasing use of online learning platforms, research is needed to understand how digital environments impact mindset development. Identifying effective strategies for promoting growth mindsets in online settings enhances virtual education experiences.
- *Mindset Interventions in Different Cultural Contexts:* Comparative studies across diverse cultural contexts reveal how mindset development varies across societies with different educational systems and cultural norms. Examining the transferability of mindset interventions to different cultures informs global educational practices.
- *Mindset Interventions for Educators:* Investigating the impact of mindset interventions on educators is an essential area of research. Understanding how teachers' mindset beliefs influence their teaching practices and student outcomes informs professional development approaches.
- *Integrating Mindset and Skillset Development:* Research on the integration of mindset and skillset development explores how the two intersect and mutually reinforce each other. Investigating the most effective ways to promote growth mindsets and specific mathematical skills enhances overall academic

achievement.

- *Scale and Sustainability of Mindset Initiatives:* Studying the scalability and sustainability of mindset initiatives is critical to ensure wide-scale implementation and long-term impact. Research on the cost-effectiveness and institutional support required for successful mindset interventions guide policy decisions,
- *Mindset Interventions in Other Subject Areas:* While research has primarily focused on mindset interventions in mathematics, exploring the effectiveness of mindset interventions in other subjects provides insights into the generalizability of growth mindset principles across disciplines.

By directing research into these promising areas, mindset development advances, leading to more targeted and impactful interventions that benefit students' academic achievements, attitudes, and well-being.

Conclusion

Summary of Key Insights

This study on fostering mathematical mindsets in education has provided several critical insights into how mindset beliefs influence students' attitudes, motivation, and performance in mathematics. These insights highlight the complex interplay between individual beliefs, environmental factors, and educational practices:

- *Defining Mathematical Mindsets:* Mathematical mindsets encompass students' beliefs, attitudes, and perceptions regarding their mathematical abilities and the nature of mathematics as a subject. Growth mindsets are characterized by the belief that mathematical abilities can be developed and improved through effort, effective learning strategies, and perseverance. Students with growth mindsets view mathematics as a subject that offers opportunities for learning and growth, embrace challenges, and approach complex problems confidently. Mistakes and setbacks are considered essential aspects of the learning process, encouraging students to seek help and persist in enhancing their mathematical proficiency. Conversely, a fixed mindset is characterized by the belief that mathematical abilities are fixed traits and cannot be significantly altered. Students with fixed mindsets perceive mathematics as a subject requiring innate talent and often avoid challenging tasks to protect their self-perceived intelligence.
- *Influencing Factors:* Several factors significantly influence the development of mathematical mindsets. Teacher beliefs and practices play a crucial role, as teachers who demonstrate growth mindsets and emphasize effort and learning over innate ability foster similar beliefs in their students. Parental involvement is also important, with parents who value mathematics and support their children's learning promoting growth mindsets. Peer interactions and classroom culture further shape students' mindset beliefs, with collaborative and supportive environments fostering growth-oriented attitudes. Sociocultural factors, such as cultural norms and stereotypes, impact students' mindset beliefs by influencing their perceptions of their abilities and opportunities in mathematics.
- *Effectiveness of Interventions:* Mindset interventions have proven effective in fostering growth mindsets and improving students' attitudes and performance in mathematics. These interventions often include workshops and curriculum integration that explicitly teach growth mindset concepts, reflection

activities that encourage self-awareness and mindset development, and feedback interventions that emphasize effort and specific strategies. Interventions targeting teacher professional development equip educators with tools to model and promote growth mindsets in the classroom. Engaging parents through workshops and communication further extends the impact of interventions beyond the classroom. Technology-based interventions, such as mindset apps and online workshops, provide innovative ways to deliver mindset-focused content and engage students in interactive learning experiences.

- *Challenges and Obstacles:* Despite the effectiveness of mindset interventions, several challenges hinder the development of growth mindsets in mathematics. Fixed mindset reinforcement through praise and feedback that emphasizes innate talent, societal stereotypes about mathematics, and math anxiety are significant barriers. Students' past negative experiences and fear of failure also contribute to resistance to adopting growth-oriented beliefs. Addressing these challenges requires creating supportive learning environments, emphasizing effort and process, and providing personalized and differentiated approaches to mindset cultivation.
- *Long-Term Impact and Sustainability:* While mindset interventions have shown immediate positive outcomes, their long-term impact and sustainability require further exploration. Longitudinal studies suggest that mindset beliefs can have a sustained impact on students' academic performance and motivation, but consistent reinforcement and support are necessary to maintain growth-oriented attitudes. Educators and policymakers should focus on embedding growth mindset principles into educational practices and policies to ensure lasting change.

Limitations

While the research on fostering mathematical mindsets provides valuable insights, several limitations must be acknowledged. These limitations highlight areas for further exploration and consideration in future studies:

- *Generalizability of Findings:* The findings from mindset interventions and studies may not be universally applicable across all educational contexts and cultural settings. Variations in educational systems, cultural norms, and societal expectations influence the effectiveness and implementation of mindset interventions. Further research is needed to explore how these factors impact the generalizability of findings.
- *Measurement of Mindset:* Measuring mindset beliefs and changes in mindset orientation presents challenges. Self-report measures used in many studies may not accurately capture students' true beliefs and attitudes. Additionally, the complexity of mindset development and its interaction with other psychological factors make it difficult to isolate the impact of mindset interventions.
- *Potential Unintended Consequences:* Mindset interventions have potential unintended consequences, such as increased pressure to succeed and superficial adoption of growth mindset beliefs. Educators and researchers should consider these potential outcomes when designing and implementing mindset interventions to ensure they are effectively addressing students' needs without inadvertently causing harm.
- *Longitudinal Impact:* While some studies indicate the long-term impact of mindset interventions, more

longitudinal research is needed to understand the sustained effects of mindset development over time. Investigating how mindset beliefs evolve and influence students' academic and personal growth beyond the immediate educational context will provide a more comprehensive understanding of mindset development

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