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Psychological Challenges in Fostering Mathematical Thinking: A Systematic Review

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ABSTRACT

Purpose: This study aimed to systematically identify, synthesize, and conceptualize the psychological challenges that hinder the fostering of mathematical thinking across educational systems.

Methods and Materials: A systematic review methodology was employed following PRISMA guidelines to ensure transparency and rigor in the review process. Searches were conducted in major international databases, including ERIC, IEEE Xplore, ScienceDirect, and Google Scholar, covering studies published between 1990 and November 2024. A comprehensive search strategy based on predefined keywords related to mathematical thinking and its development was applied. Inclusion and exclusion criteria were defined to filter relevant studies, focusing on peer-reviewed journal articles, books, book chapters, and theses published in English. After identification, screening, eligibility assessment, and quality appraisal, 29 high-quality studies were selected for final analysis. Data were extracted using qualitative content analysis, and codes, subthemes, and overarching themes were developed through iterative comparison and synthesis.

Findings: The synthesis revealed 11 core psychological challenges that significantly constrain the development of mathematical thinking: mathematics anxiety, negative self-concept, weak understanding of abstract concepts, low self-confidence, mathematical learning disorder, low mathematical aptitude, passive thinking, individual cognitive differences, lack of motivation, cognitive barriers, and inability in self-regulation. Inferential analysis indicated that affective challenges (e.g., anxiety and negative self-beliefs) and cognitive-regulatory constraints (e.g., working memory limitations and poor self-regulation) are not isolated factors but interact dynamically to impede reasoning, abstraction, and problem-solving processes essential to mathematical thinking.

Conclusion: The findings demonstrate that fostering mathematical thinking requires integrated educational approaches that simultaneously address cognitive, affective, motivational, and self-regulatory dimensions, positioning psychological challenges as central determinants rather than peripheral obstacles in mathematics education.

Keywords: *mathematical thinking; psychological challenges; mathematics education; systematic review; learning and cognition*

1. Introduction

Mathematical thinking has increasingly been recognized as a core outcome of contemporary education, not merely because it supports competence in computation and routine problem solving, but because it cultivates higher-order reasoning, abstraction, generalization, and the capacity to model situations systematically. In many national curricula, mathematical thinking is positioned as a cross-cutting competency that underpins scientific literacy, digital literacy, and evidence-based decision-making, and it is therefore closely tied to the broader mission of schooling in preparing learners for complex, uncertain, and data-saturated environments. Conceptually, mathematical thinking is not reducible to a single ability; rather, it encompasses a family of cognitive practices such as pattern recognition, relational reasoning, representational fluency, conjecturing, justifying, and metacognitive regulation while working through tasks. Classic and contemporary scholarship has emphasized that mathematical thinking is expressed through multiple facets—ranging from informal, intuitive reasoning to formal deductive argumentation—and that its development is shaped by task structures, representational tools, classroom discourse, and the learner's developmental trajectory (Dreyfus & Eisenberg, 2012; Ernest, 2002; Sternberg, 1997). At the same time, mathematical thinking is increasingly conceptualized as a developmental construct that begins in early childhood, grows through interaction with materials and symbols, and gradually becomes more explicit, reflective, and theory-like as learners engage with more sophisticated mathematical ideas (Gelman, 2000; Ginsburg et al., 2006; Ginsburg et al., 1998). This developmental perspective positions mathematical thinking as a learnable, fosterable capacity—one that can be advanced through deliberate instructional design and systematic attention to how learners interpret, represent, and reason about quantitative and spatial relationships.

From a learning-sciences standpoint, fostering mathematical thinking requires an explicit shift from transmission-oriented instruction toward environments that orchestrate meaningful problem solving, sense-making, and justification. Classroom studies demonstrate that learners' mathematical thinking becomes visible when teachers design tasks that invite multiple solution pathways, elicit students' reasoning, and support the refinement of ideas through dialogue and representation. In this regard, the pedagogical challenge is not only to "teach mathematics," but to promote forms of thinking that enable students to connect concepts, test conjectures, and articulate reasons. Research in everyday classroom contexts has shown that teachers can advance children's mathematical thinking by posing purposeful questions, pressing for explanation, and connecting students' strategies to more general mathematical structures (Fraivillig et al., 1999). In parallel, scholarship on advanced mathematical thinking argues that the nature of mathematical thinking evolves across the lifespan: as students encounter algebraic structures, proof, and abstraction, the barriers to developing sophisticated reasoning often intensify, and instructional supports must become correspondingly more strategic and developmentally sensitive (Harel & Sowder, 2005; Selden & Selden, 2005). A further implication is that fostering mathematical thinking is not solely an individual cognitive matter; it is also a socio-cognitive process mediated by language, representations, and classroom norms for explaining and validating ideas.

Recent research trends also highlight that mathematical thinking is increasingly intertwined with adjacent constructs such as computational thinking and critical thinking, reflecting a broader shift in education toward integrative reasoning competencies. Bibliometric evidence indicates a growing scholarly interest in the intersection of computational thinking and mathematical thinking—particularly at the elementary level—suggesting that the field is moving toward frameworks that address how algorithmic reasoning, decomposition, and patterning relate to mathematical sense-making and representation (Abidin et al., 2025; Wu & Yang, 2022). Similarly, systematic evidence from higher education indicates that mathematics can serve as a structured domain for strengthening learners' critical thinking, especially when instruction foregrounds argumentation, justification, and reflective evaluation of solutions (Wang & Abdullah, 2024). At the level of conceptual development in younger students, the notion of critical mathematical thinking has been advanced to emphasize the capacity to evaluate mathematical claims, interpret quantitative information responsibly, and engage in reasoning that is both logical and context-aware—an orientation that aligns mathematical learning with civic and epistemic aims (Monteleone et al., 2023). These developments reinforce the argument that mathematical thinking is not an optional enrichment outcome, but a foundational educational target that supports broader competencies needed for participation in modern societies.

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Despite this consensus, substantial evidence suggests that fostering mathematical thinking remains difficult in practice because it is constrained by learner-level, instructional, and contextual factors. A major challenge is that the development of mathematical thinking is deeply mediated by communicative and representational tools, and learners' access to such tools is not uniform. In early learning and play-based contexts, mathematical thinking emerges through the ways children coordinate actions, language, and artifacts to express and refine quantitative relations; however, the availability and pedagogical use of communicative tools can either expand or limit this emergence (Van Oers, 1990, 2010, 2023). Moreover, language is not merely a channel for expressing mathematical ideas but a constitutive element of meaning-making, especially in bilingual settings where the language of instruction can shape students' development of mathematical thinking in the earliest grades (Bermejo et al., 2021). At the level of teacher expertise, the capacity to professionally notice children's mathematical thinking—attending to, interpreting, and responding to students' strategies—has been shown to vary systematically among teachers and to function as a key lever for supporting students' reasoning and conceptual growth (Jacobs et al., 2024). Taken together, these strands suggest that fostering mathematical thinking requires coherent alignment among tasks, discourse practices, representational supports, and teacher interpretive expertise.

Within this complex landscape, psychological challenges constitute a critical, yet sometimes under-specified, barrier to the development of mathematical thinking. The literature on affect and cognition in mathematics learning indicates that emotions and motivational states are not peripheral variables; rather, they shape attention, working memory, strategy selection, and persistence, thereby directly influencing the quality of mathematical reasoning learners can mobilize. Foundational work on affect in mathematical thinking describes how emotional dynamics interact with cognitive processes across learning episodes, influencing whether students approach tasks with curiosity and resilience or with avoidance and threat-based appraisals (Hannula, 2011). Empirical studies further show that mathematics anxiety is associated with disrupted performance and diminished engagement, and that it can coexist with attitudes that erode students' willingness to participate in reasoning-intensive activities (Kargar et al., 2010; Lutfiyya, 1998). Importantly, psychological challenges are not confined to one age group: as mathematical demands shift from concrete operations to abstraction and proof-like reasoning, students may experience intensified vulnerability to fear of failure, reduced confidence, and reliance on surface strategies that inhibit deep thinking (Harel & Sowder, 2005; Selden & Selden, 2005). At the same time, early childhood research demonstrates that the seeds of mathematical thinking emerge in everyday interactions and play, implying that early psychological climates—such as experiences of success, autonomy, and supportive feedback—may set developmental trajectories that later affect engagement with more formal mathematics (Ginsburg et al., 2006; Miyakawa et al., 2005).

Psychological constraints also intersect with cognitive-linguistic and neurodevelopmental factors that can systematically limit the resources available for reasoning. For example, evidence indicates that children with developmental language disorder may display vulnerabilities in mathematical thinking that are partly explained by limitations in verbal working memory and pattern skills—capacities that are essential for holding relational information, tracking multi-step procedures, and articulating reasoning (Fyfe et al., 2019). In addition, research on learning difficulties emphasizes that mathematical thinking can be undermined by persistent challenges in foundational number concepts and arithmetic structures, which can cascade into broader difficulties in problem solving and strategic reasoning (Jordan et al., 2003). These findings highlight that psychological experiences in mathematics—such as frustration, anxiety, or helplessness—often occur in tandem with cognitive constraints, making it insufficient to interpret affective barriers as merely "attitudinal." Instead, psychological challenges should be understood as part of an interconnected system where cognition, emotion, language, and instruction jointly shape learners' capacity to engage in mathematical thinking.

Another emerging line of work suggests that targeted pedagogical interventions may mitigate psychological barriers while simultaneously strengthening mathematical thinking. Instructional strategies that explicitly cultivate metacognitive regulation and reflective monitoring can help learners manage uncertainty, persist through complexity, and evaluate solution pathways—skills especially relevant for gifted learners who may still experience affective and strategic vulnerabilities in challenging tasks. For instance, evidence on the SWOM strategy points to positive influences on mathematical thinking and metacognitive

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thinking among gifted tenth-grade students, indicating that structured strategy instruction can support both cognitive performance and regulatory processes (AlAli et al., 2023; Er et al., 2023). Likewise, digital game-based learning environments have been investigated as tools for enhancing mathematical thinking in primary students, with the potential to increase engagement and reduce avoidance by situating reasoning within interactive and motivationally supportive contexts (Al-Barakat et al., 2025). In early childhood settings, problem-solving approaches that strengthen seriation and counting have also been presented as pathways to enhance mathematical thinking, suggesting that carefully designed activities can build foundational reasoning while supporting positive learning experiences (Torres-Peña et al., 2025). However, while these interventions and contexts are promising, the field still requires an integrated understanding of which psychological challenges most consistently obstruct mathematical thinking across age groups and educational contexts, and how these challenges cluster and interact in the literature.

Given the breadth of research on mathematical thinking—spanning developmental psychology, mathematics education, cognitive science, and instructional design—systematic synthesis is essential for clarifying the state of knowledge and for identifying robust patterns that can guide practice and future research. Prior reviews have emphasized the need to understand and promote students' mathematical thinking through coherent syntheses of empirical findings, especially across diverse contexts and methodological approaches (Goos & Kaya, 2020). Moreover, systematic review methodology provides transparent procedures for identifying, screening, and synthesizing evidence, thereby reducing selection bias and enabling replicable knowledge accumulation in the social sciences (Petticrew & Roberts, 2008). In this regard, rigorous reporting standards such as PRISMA provide a widely accepted framework for documenting systematic review processes, including search strategies, inclusion/exclusion decisions, and study selection flow (Moher et al., 2009). At the same time, educational review work has increasingly recognized that synthesis benefits from methodological pluralism, including qualitative content analysis approaches that can capture conceptual nuances and thematic structures within a body of literature (Hoghoughi & Salehi, 2019). Recent systematic syntheses related to mathematical or critical thinking within educational contexts further underscore the value of mapping constructs, identifying gaps, and clarifying implications for curriculum and pedagogy (Wang & Abdullah, 2024). Additionally, systematic review scholarship in adjacent Iranian educational domains illustrates how evidence mapping over multi-decade periods can reveal persistent challenges, methodological tendencies, and under-explored areas, reinforcing the utility of systematic synthesis for educational policy and practice (Zivari Rahman et al., 2022).

In sum, the literature indicates that mathematical thinking is a multifaceted, developmentally grounded, and instructionally mediated capacity that is essential for learners' academic progression and broader reasoning competencies; yet, its cultivation is frequently constrained by psychological barriers that shape engagement, persistence, strategy use, and conceptual understanding. Although many individual studies have identified challenges such as mathematics anxiety, negative self-perceptions, cognitive barriers, and self-regulatory difficulties, these findings are dispersed across contexts, age groups, and research traditions, making it difficult to derive a coherent evidence-based picture for educators and researchers. Therefore, the aim of this study was to systematically review and synthesize the literature on the psychological challenges of fostering mathematical thinking in educational systems.

2. Methods and Materials

A systematic review is a tool for identifying, evaluating, and interpreting all available research related to a specific research question or subject area. A systematic review is essential in the field of fostering mathematical thinking because it clarifies the challenges and opportunities associated with the development of mathematical thinking within educational systems. Accordingly, the purpose of this review was to comprehensively examine studies conducted in the field of fostering mathematical thinking by employing a systematic review of the literature. This approach enables answering the predefined research questions and assists researchers and practitioners in achieving a clearer and deeper understanding of issues related to this domain. This review was conducted based on the well-established PRISMA guidelines, which are presented in Figure 1.

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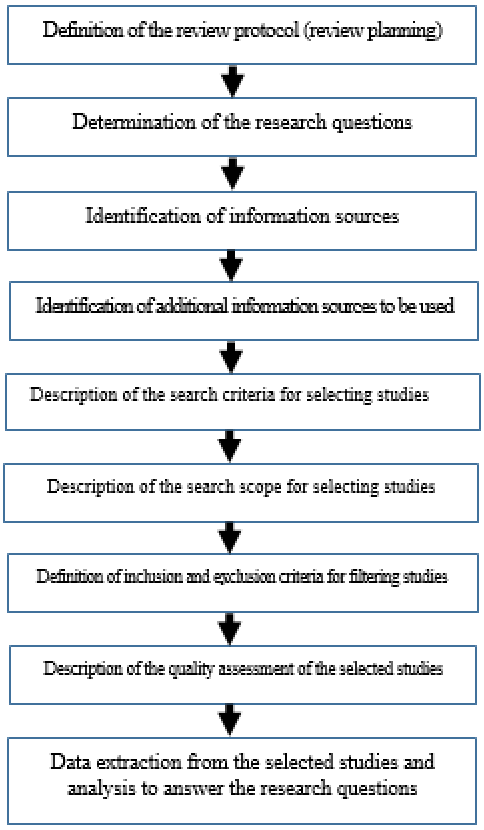
Figure 1

Framework of the Systematic Literature Review



The present study selected an appropriate set of databases to ensure broad coverage of the literature and to increase the likelihood of identifying highly relevant studies. Accordingly, the search encompassed the electronic source databases listed in Table 2.

Table 1

Information Sources for the Systematic Review

Source	URL
ERIC	https://eric.ed.gov/
IEEE Xplore	https://ieeexplore.ieee.org/
ScienceDirect	https://www.sciencedirect.com/
Google Scholar	https://scholar.google.com/

The primary objective of the search criteria was to identify studies focused on fostering mathematical thinking. In this regard, previous review articles were used to understand the background, keywords, and key references. In addition, the Population, Intervention, Comparison, Outcome, and Context (PICO) criteria (Petticrew & Roberts, 2008) were employed as a guiding framework for defining the research scope (Table 2). In this approach, abbreviations, synonyms, related terms, and Boolean operators were taken into account. The search scope involved retrieving source studies from the selected electronic databases using structured keywords (Table 3). The search began in early 1990 and was updated at the end of November 2024. This selected time frame was considered appropriate and comprehensive because the majority of studies in mathematics education have been conducted during this period.

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Table 2

Definition of Search Criteria

Criterion	Definition
Population	Keywords including mathematical thinking, fostering mathematical thinking, mathematical thinking in the educational system, challenges in fostering mathematical thinking, approaches to fostering mathematical thinking, and their synonyms
Intervention	Search terms including mathematical thinking, fostering mathematical thinking, and other expressions with similar meanings
Comparison	Comparison of tools, methods, and settings
Outcome	Methods and processes of fostering mathematical thinking; mathematical thinking
Context	Education, school, educational system

Table 3

Keywords and Search Strategy for the Systematic Review

Searching strings	Operation	Searching field
("Mathematical thinking" OR "development of mathematical thinking" OR "development of mathematical thinking in school" OR "Mathematical thinking in the educational system" OR "Challenges in developing mathematical thinking" OR "Mathematical Education" OR "Approaches to developing mathematical thinking" OR "New approaches to fostering mathematical thinking" OR "Conditions for developing mathematical thinking")	OR	Title–Abstract–Keywords
("Mathematical thinking" OR "development of mathematical thinking" OR "Mathematical thinking in the educational system" OR "Challenges in developing mathematical thinking" OR "development of mathematical thinking in school")	OR	Title–Abstract–Keywords
(("Mathematical thinking" OR "development of mathematical thinking" OR "development of mathematical thinking in school") AND ("New approaches to fostering mathematical thinking" OR "Challenges in developing mathematical thinking" OR "Conditions for developing mathematical thinking"))	OR	Title–Abstract–Keywords

After retrieving the studies, inclusion and exclusion criteria were applied to select studies that met the inclusion requirements for further screening and content evaluation, while those deemed irrelevant based on the exclusion criteria were removed. These criteria were defined for the purpose of this review as shown in Table 4. In general, sources such as grey literature, extended abstracts, presentations, keynote papers, and non-English articles were excluded.

Based on the inclusion and exclusion criteria, studies were first filtered to identify relevant literature. Initially, articles containing the predefined keywords in their title, abstract, or keywords were considered eligible for inclusion. Subsequently, studies written in English and published in reputable journals or selected conferences were approved. Various types of publications, including research articles, review papers, conceptual studies, and empirical investigations, were also accepted. Furthermore, studies addressing the teaching and fostering of mathematical thinking were included. In contrast, studies that did not explicitly address mathematical thinking, were not considered original research, or for which full-text access was unavailable were excluded. To ensure the comprehensiveness of the review, the search was not strictly limited to the exact term “mathematical thinking,” and related studies were considered even if they referred to mathematical thinking indirectly.

Table 4

Inclusion and Exclusion Criteria for Selecting Relevant Literature

Criteria	Decision
Predefined keywords appear as a whole or at least in the title, keywords, or abstract	Inclusion
Studies are written in English	Inclusion
Journal articles are published in peer-reviewed journals	Inclusion
Non-journal articles are published in conferences or symposia/workshops indexed in the selected databases	Inclusion
Articles may be research-based, review, conceptual, or empirical	Inclusion
Studies may include books, book chapters, and theses	Inclusion
Studies addressing the teaching of mathematical thinking	Inclusion
Studies that do not address fostering mathematical thinking	Exclusion
Studies that do not focus on mathematical thinking as a topic	Exclusion
Non-original studies such as presentations, keynote papers, and extended abstracts	Exclusion
Duplicate articles	Exclusion
Studies without accessible full text	Exclusion
Studies published before 1990	Exclusion

After applying the inclusion and exclusion criteria to select relevant studies on fostering mathematical thinking, a quality assessment was conducted for the remaining studies. The selected studies were evaluated based on criteria related to research objectives, contextualization, literature review, related work, methodology, as well as results and conclusions. To reduce empirical bias in filtering full texts, a set of questions presented in Table 5, proposed by Roehrs et al. (2017), was used. Studies that met these criteria were considered valid for inclusion.

Table 5

Questions for Quality Assessment of Relevant Studies

Code	Full-text evaluation questions
C1	Does the study clearly state the research objectives?
C2	Does the study adequately describe the background or literature review?
C3	Does the study present related work in relation to the main innovation?
C4	Does the study clearly describe the research methodology?
C5	Does the study report research results?
C6	Does the study provide conclusions aligned with the research objectives?
C7	Does the study refer to future work, improvements, or further research?

The process of selecting and filtering the relevant literature is presented as a PRISMA flow diagram in Figure 2. In the first stage (1), searching the constructed keywords in the selected information sources yielded a total of 48,300 records, most of which were related to mathematics or mathematical problem solving, thinking (approximately 65%), and mathematics teaching and instruction (approximately 15%). In the second stage (2), a number of studies were removed, including duplicates (based on title and authors), studies conducted in the mathematics domain such as mathematics education and mathematics instruction; mathematical aptitude, grey literature, extended abstracts, presentations, keynote papers, non-English studies, inaccessible studies, and studies that did not address mathematical thinking as a topic. In addition, conference and symposium/workshop papers not indexed in the selected information sources were excluded because such papers often lack adequate quality. As a result, the number of studies was reduced to 1,279 for further review. In the final stage (3), studies were filtered through full-text screening because some of the remaining studies were largely not relevant to this review—for example, studies that did not address students' mathematical thinking and studies that did not address fostering students' mathematical thinking. Some empirical or conceptual papers had been published across different databases; however, after full-text reading, we found that they followed similar methodological frameworks and reached similar results. Therefore, to avoid duplication, only one was retained and the others were removed.

In addition, theses for which derived journal articles were also found in the search were excluded, and the corresponding articles were retained. Ultimately, 55 studies remained that met all inclusion criteria used in this systematic review. For assurance, the quality of these 55 studies was assessed; as a result, 26 studies were excluded due to low quality. Therefore, a total of 29 studies remained for analysis and review in this systematic review, all of which addressed fostering mathematical thinking.

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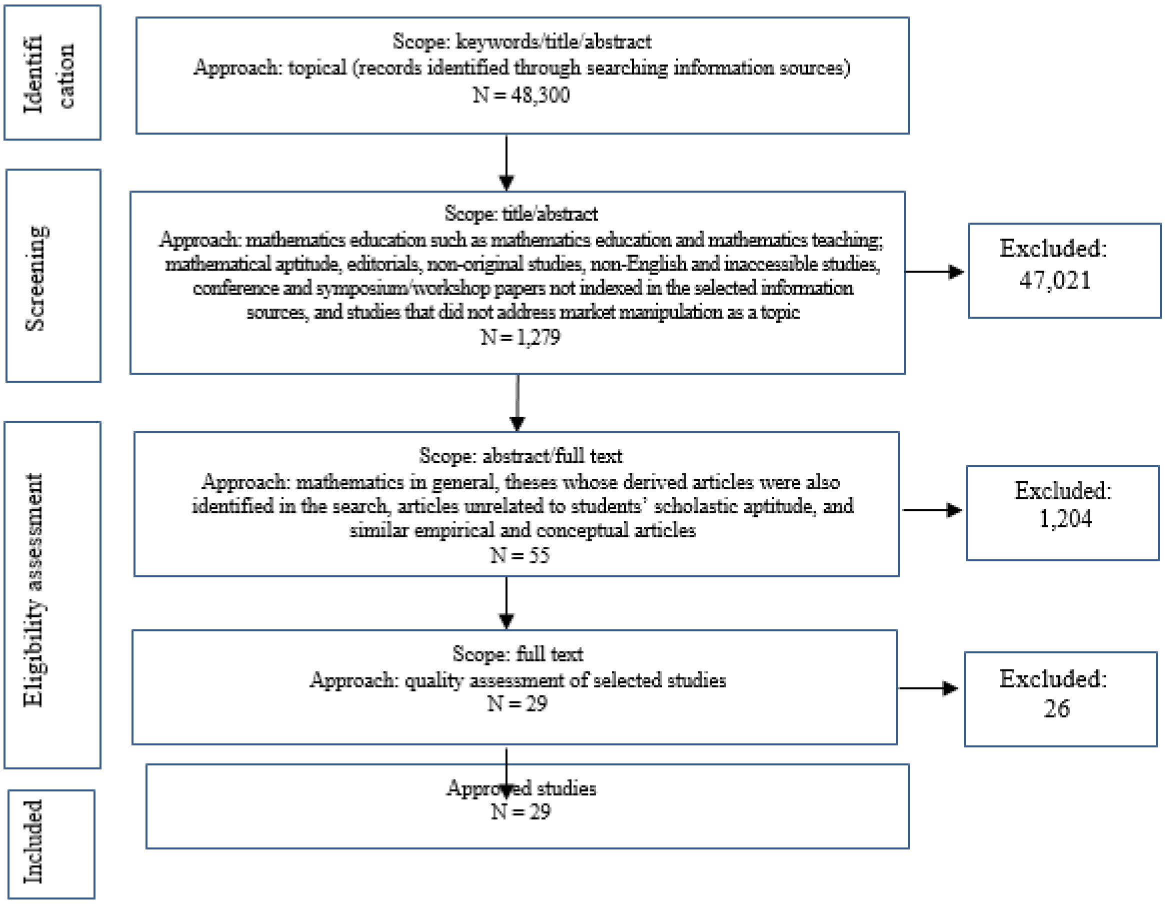
Figure 2

PRISMA Flow Diagram: The Process of Selecting and Filtering the Relevant Literature



3. Findings and Results

The data extraction stage involved identifying and extracting relevant data from the 29 selected studies. In this subsection, we address the research questions. The selected articles were read thoroughly and in depth so that, through qualitative analysis as well as critical appraisal, we could help audiences and those interested in this field better understand the current state of the existing studies.

To examine the selected documents, the researcher first arranged the studies in order of importance and relevance to the topic of psychological challenges in fostering mathematical thinking, and then used the Elo and Kyngäs qualitative content analysis strategy to analyze the documents. This method is regarded as one of the most appropriate approaches for analyzing written documents in order to conduct systematic content analysis and to extract target concepts from written sources (Wach & Ward, 2013, as cited in Hoghooghi & Salehi, 2018). Accordingly, the researcher began purposeful reading of the documents based on their importance and relevance (from most to least). During the reading process, the researcher's attention was focused on key points and note-taking (excerpting), which ultimately resulted in a file compiling the major and required points and sections of each study. During the review, due to close relevance to the topic, the researcher could also identify the strengths and weaknesses of each work and record them as notes. Finally, the researcher integrated the data from all studies and then conducted thematic development by coding the data. Given the very large volume of data, the researcher summarized the data in two rounds; in the second round, repetitive concepts were removed, after which the materials were compiled and categorized based on the research problems. Therefore, Table 6 provides a concise summary of the psychological challenges in fostering mathematical thinking.

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Table 6

Summary of Psychological Challenges in Fostering Mathematical Thinking in Prior Studies

Author (Year)	Research Aim	Identified Psychological Challenge(s)
1. van Oers (2024)	Examining the role of communicative tools in mathematical thinking	Difficulty linking concepts to real-world applications, inability to think logically, and difficulties analyzing complex problems as psychological challenges.
2. Er et al. (2023)	Developing a mathematical thinking scale for gifted students	Individual cognitive differences, low mathematical aptitude, lack of motivation, and low self-confidence; differences in learning speed, learning styles, and problem-solving abilities may negatively affect gifted students' progress in mathematical thinking.
3. Wu & Yang (2022)	Examining relationships between computational thinking and mathematical thinking	Cognitive barriers, information-processing disruption, inability to think logically, inability to solve basic problems, difficulties understanding computational concepts, and difficulty in mathematical analysis as psychological challenges.
4. Bermejo et al. (2021)	Effects of language of instruction on mathematical thinking	Weakness in understanding numerical relationships, information-processing disruption, and difficulties analyzing complex problems as psychological challenges.
5. Monteleone et al. (2021)	Examining Critical Mathematical Thinking (CMT)	Passive thinking, lack of creative thinking, reliance on rote memory, and inability to use diverse strategies as psychological challenges.
6. Fyfe et al. (2019)	Effects of pattern skills and working memory on mathematical thinking in children with DLD	Working-memory weakness, information-processing disruption, inability to think logically, and difficulties analyzing complex problems as psychological challenges.
7. Fernández et al. (2018)	Examining features and challenges of teaching mathematical thinking	Lack of motivation, difficulties visualizing concepts, difficulty in mathematical analysis, and weak emotion regulation as psychological challenges.
8. Hannah et al. (2016)	Examining conceptual understanding in linear algebra	Difficulty understanding abstract concepts, difficulty visualizing concepts, inability to understand complex concepts, and weak abstract analysis as psychological challenges.
9. Morsanyi et al. (2018)	Examining the role of reasoning in mathematical thinking	Inability to analyze complex problems, weak understanding of numerical relationships, and difficulties in mathematical reasoning as psychological challenges.
10. Jordan et al. (2013)	Relationship between mathematical learning difficulties and skill development	Mathematical learning disorder, inability to solve basic problems, difficulties understanding computational concepts, and inability to retain and apply formulas as psychological challenges.
11. Krummheuer (2013)	Examining diagrammatic and narrative reasoning	Difficulty in mathematical analysis, difficulty visualizing concepts, weak abstract analysis, and inability to understand complex concepts as psychological challenges.
12. Dreyfus & Eisenberg (2012)	Various aspects of mathematical thinking	Difficulties in mathematical reasoning, inability to use diverse strategies, and reliance on memory as psychological challenges.
13. Hannula (2011)	Effects of emotions on mathematical thinking and learning	Mathematics anxiety, test stress, and fear of evaluation as psychological challenges.
14. Kargar et al. (2010)	Relationships among mathematics anxiety, attitudes, and mathematical thinking in university students	Mathematics anxiety, worry about mistakes, fear of evaluation, beliefs of inability to solve problems, and feelings of incompetence in mathematics as psychological challenges.
15. van Oers (2010)	Examining mathematical thinking through play	Lack of motivation, difficulty visualizing concepts, and difficulties analyzing complex problems as psychological challenges.
16. Ginsburg et al. (2006)	Mathematical thinking and learning in childhood	Difficulty visualizing concepts, difficulties understanding computational concepts, and weak abstract analysis as psychological challenges.
17. Harel & Sowder (2005)	Advanced mathematical thinking from elementary school onward	Difficulty in mathematical analysis, inability to understand complex concepts, weak abstract analysis, and fear of failure when facing problems as psychological challenges.
18. Selden & Selden (2005)	Advanced mathematical thinking	Difficulty analyzing complex problems, inability in mathematical reasoning, and inability to solve basic problems as psychological challenges.
19. Miyakawa et al. (2005)	Development of logical–mathematical thinking in children aged 1 to 3 years	Weak understanding of numerical relationships, difficulty visualizing concepts, difficulty in mathematical reasoning, and inability in mathematical analysis as psychological challenges.
20. Jordan & Hanich (2003)	Effects of mathematical learning disabilities	Mathematical learning disorder, inability to solve basic problems, difficulties understanding computational concepts, and working-memory weakness as psychological challenges.
21. Pape et al. (2003)	Mathematical thinking and self-regulated learning in seventh-grade students	Self-regulation difficulties, problems with planning, and weak emotion regulation as psychological challenges.
22. Henderson et al. (2002)	Developing online resources for mathematical thinking in computer science education	Cognitive barriers such as information-processing disruption and difficulties with attention and concentration as psychological challenges.
23. Ernest (2002)	Linking mathematical thinking with cognitive psychology	Inability to think logically, information-processing disruption, and difficulties analyzing complex problems as psychological challenges.
24. Gelman (2000)	Development of mathematical thinking in children	Difficulty visualizing concepts, weak understanding of numerical relationships, and inability in abstract analysis as psychological challenges.
25. Fraivillig et al. (1999)	Developing mathematical thinking in mathematics classrooms	Lack of motivation, difficulty visualizing concepts, and difficulty linking concepts to real-world applications as psychological challenges.
26. Lutfiyya (1998)	Assessing students' mathematical thinking	Mathematics anxiety, test stress, fear of evaluation, and worry about mistakes as psychological challenges.
27. Ginsburg et al. (1998)	Applying research to foster children's mathematical thinking	Information-processing difficulties, disruption in analyzing mathematical concepts, and inability to think logically as psychological challenges.
28. Sternberg (1997)	Examining the concept of mathematical thinking	Difficulty in abstract analysis, inability to use diverse strategies, and reliance on memory as psychological challenges.
29. van Oers (1990)	Comparing two psychological approaches in teaching mathematical thinking	Difficulty visualizing concepts, difficulties analyzing complex concepts, and information-processing disruption as psychological challenges.

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Psychological challenges in fostering mathematical thinking within educational systems refer to factors that can hinder effective learning and mathematical problem solving. These challenges not only affect students' mathematical performance but may also undermine their psychological and emotional structures. Based on the results of the conducted content analysis, 11 main themes were identified as psychological challenges in fostering mathematical thinking, including mathematics anxiety, negative self-concept, weak understanding of abstract concepts, low self-confidence, mathematical learning disorder, low mathematical aptitude, passive thinking, individual cognitive differences, lack of motivation, cognitive barriers, and inability in self-regulation. As shown in Table 5, the psychological challenges of fostering mathematical thinking comprise 152 indicators (open codes), 45 subthemes, and 11 main themes. Based on the identified psychological challenges in fostering mathematical thinking, the following section examines and explains the 11 main challenges in detail.

– **Mathematics anxiety:** This challenge was reported in 86% of the studies and includes the subthemes of "fear of evaluation," "test anxiety," and "worry about making mistakes." Students who experience mathematics anxiety are usually afraid of being evaluated, as concerns about poor results, fear of low grades, and losing opportunities generate stress. This anxiety may also stem from worries about making mistakes while solving problems, leading to reduced self-confidence and poor performance on assessments.

– **Negative self-concept:** This challenge was identified in 75% of the studies and encompasses subthemes such as "feelings of inability," "belief in failure," "negative past experiences," "negative perception of abilities," and "feelings of incompetence in mathematics." In this context, students may perceive themselves as incapable of learning and solving mathematical problems. Negative past experiences, such as low grades or previous failures, can form a negative self-image of one's abilities and result in feelings of inadequacy and lack of success when facing new problems.

– **Weak understanding of abstract concepts:** This challenge was reported in 48% of the studies and relates to subthemes including "difficulty visualizing concepts," "inability to understand complex concepts," and "weak abstract analysis." Many students struggle to understand complex and abstract mathematical concepts, such as those in geometry or algebra. Difficulties in visualizing these concepts and the inability to analyze and apply them across different problems can lead to incomplete and inaccurate understanding of mathematical ideas.

– **Low self-confidence:** This challenge was noted in 41% of the studies and includes subthemes such as "belief in inability to solve problems," "fear of failure when facing challenges," "feelings of weakness in mathematics," and "lack of belief in personal abilities." Students with low self-confidence in mathematics may struggle with feelings of incapacity and inadequacy when confronted with mathematical problems. These difficulties can also lead to avoidance of new challenges, persistent fear of failure, and a vicious cycle that reinforces negative beliefs about one's own abilities.

– **Mathematical learning disorder:** This challenge appeared in 79% of the studies and includes subthemes such as "inability to solve basic problems," "difficulties in understanding computational concepts," "inability to retain and apply formulas," and "difficulties in analyzing complex problems." Students with fundamental difficulties in learning mathematics may struggle with solving basic problems or learning computational concepts. These difficulties can also result in an inability to use formulas effectively and to analyze complex mathematical problems.

– **Low mathematical aptitude:** This challenge was identified in 38% of the studies and includes subthemes such as "weak understanding of numerical relationships," "inability to perform mental calculations," "difficulty in spatial understanding," and "difficulty in mathematical reasoning." Students with low mathematical aptitude may have difficulty understanding relationships among numbers and visualizing geometric concepts. These difficulties can also lead to an inability to perform calculations without external tools and to construct logical reasoning for problem solving.

– **Passive thinking:** This challenge was reported in 55% of the studies and refers to subthemes such as "reliance on memory," "lack of creative thinking," "inability to use diverse strategies," and "surface-level learning approaches." Students who rely on passive thinking tend to depend solely on memorization rather than employing multiple strategies to solve mathematical problems, and they do not engage in creative thinking when addressing complex tasks. This superficial approach can hinder the development of deep and flexible mathematical thinking.

– **Individual cognitive differences:** This challenge appeared in 72% of the studies and includes subthemes such as "differences in learning speed," "differences in learning styles," "differences in problem-solving abilities,"

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"differences in attention and concentration," and "differences in study habits." Students vary in their rates of learning mathematics, and some may require specific approaches to understand more complex concepts. These differences in cognitive and learning abilities can lead to difficulties in achieving deeper understanding of mathematical concepts.

– **Lack of motivation:** This challenge was identified in 59% of the studies and includes subthemes such as "disinterest in mathematics," "lack of connection between concepts and real life," "avoidance of problem solving," and "absence of goals and vision." Students experiencing low motivation in mathematics may be unwilling to participate in learning activities or engage with complex concepts. These issues can result in avoidance of mathematical challenges, inability to perceive the practical applications of concepts, and lack of planning for progress in this subject.

– **Cognitive barriers:** This challenge was reported in 89% of the studies and encompasses various subthemes such as "working memory weakness," "information-processing deficits," "inability to think logically," "attention and concentration problems," and "lack of motivation." Students facing cognitive barriers may struggle to retain and process information and may be unable to properly analyze mathematical problems. These cognitive difficulties can also reduce attention and concentration, ultimately impairing learning.

– **Inability in self-regulation:** This challenge appeared in 65% of the studies and includes subthemes such as "difficulty in planning," "inability to manage time," "inability to evaluate progress," and "weak emotion regulation." Difficulties in self-regulation and time management can hinder students' progress in learning mathematics. Inability to monitor progress and regulate emotions may lead to increased anxiety and stress and, ultimately, to reduced performance in solving mathematical problems.

Table 7

Identified Themes Related to the Psychological Challenges of Fostering Mathematical Thinking

Open codes (indicators)	Subtheme	Main theme
Fear of poor outcomes (5, 12), fear of others' judgment (7, 12), fear of low grades and losing opportunities (2, 17), concern that the teacher will interpret grades negatively (9, 13, 16)	Fear of evaluation	Mathematics anxiety
Concern about limited time in examinations (3, 6, 11), perceived pressure to achieve excellent grades (4, 18), apprehension and anxiety during exam days (11, 15), fear of forgetting important information in the exam (8, 14)	Test stress	
Fear of making mistakes in front of classmates (9, 24, 29), worry about making computational errors (10, 19), feelings of embarrassment due to mistakes in solving mathematical problems (13, 28), fear of errors during group work or in class (14, 26), reluctance to make mistakes and attempts to prevent them (6, 25, 28)	Worry about mistakes	
Inability to solve mathematical problems (2, 5, 11), inability to learn new mathematical concepts (6, 8, 13), feeling weak in learning (3, 25, 18)	Feelings of inability	Negative self-concept
Fear of failing mathematics exams (4, 23, 1), feeling unsuccessful when facing mathematical challenges (7, 15, 10), belief in inability to succeed (2, 19)	Belief in failure	
Recalling past failures in mathematics (9, 22, 5), impact of low grades in creating feelings of failure (6, 8, 1), lack of success in prior examinations (7, 14)	Negative past experiences	
Feeling incompetent compared with others (3, 10, 21), weak self-image in solving mathematical problems (4, 11, 23), negative views about one's abilities (18, 22)	Negative perception of abilities	
Lack of belief in one's ability to learn mathematics (5, 6, 27), lack of confidence in one's abilities to solve problems (8, 2, 16), feeling unable to understand complex concepts (9, 18)	Feelings of incompetence in mathematics	
Difficulty visualizing graphs (4, 22, 23), difficulty visualizing geometric relations (1, 6), difficulty visualizing formulas (5, 15)	Difficulty visualizing concepts	Weak understanding of abstract concepts
Difficulty understanding algebra and equations (2, 9, 14), inability to understand complex functions (3, 18), difficulty understanding complex geometric concepts (1, 27)	Inability to understand complex concepts	
Difficulty analyzing complex problems (6, 22, 19), weakness in analyzing abstract concepts (10, 15, 24, 23), difficulty understanding mathematical data (5, 27)	Weak abstract analysis	
Difficulty relating mathematical concepts to everyday life (2, 9, 14), weakness in applying mathematical concepts to real-world problems (4, 17, 22)	Difficulty connecting concepts to real-world applications	
Inability to solve complex problems (4, 16, 28, 17), feeling incapable of solving mathematical problems (10, 15, 22, 27), inability to solve basic problems (1, 18, 23), weakness in using diverse strategies (2, 12, 16)	Belief in inability to solve problems	Low self-confidence
Fear of failure (3, 7, 13, 20), avoidance of solving problems due to fear (2, 4, 5, 10), refusal to accept challenges (8, 21, 15), fear of evaluation (11, 20, 23)	Fear of failure when facing challenges	
Feeling unable to understand mathematical concepts (6, 16, 24, 28), weak analysis of mathematical problems (9, 12, 22, 20), inability to understand concepts (3, 27, 19), feelings of incompetence in mathematics (5, 13, 24)	Feeling weak in mathematics	

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Belief in lack of ability in mathematics (5, 14, 23, 18), inability to use diverse strategies (2, 10, 13), feeling incompetent in problem solving (15, 28, 21), lack of confidence in personal abilities (6, 12, 23), belief in failure in learning mathematics (14, 18, 27)	Lack of belief in personal abilities	
Inability to solve simple problems (9, 22, 17), inability to understand basic concepts (4, 12, 23), problems in solving initial problems (1, 19, 27)	Inability to solve basic problems	Mathematical learning disorder
Lack of understanding of basic mathematical concepts (10, 14, 23), difficulties understanding mathematical operations (5, 6, 28), weakness in analyzing mathematical computations (11, 23, 15)	Difficulties understanding computational concepts	
Forgetting formulas (18, 11, 28), difficulties recalling mathematical formulas (3, 15, 22, 24), inability to use formulas correctly (4, 6, 20)	Inability to retain and apply formulas	
Difficulty analyzing complex problems (16, 28, 27), inability to analyze multi-step problems (3, 24, 29), difficulties solving complex and multi-step problems (4, 6, 19, 23)	Difficulties analyzing complex problems	
Weak understanding of relations among numbers (3, 6, 27), difficulty recognizing numerical relations (4, 18, 22), inability to understand mathematical relations (2, 9, 26)	Weak understanding of numerical relationships	Low mathematical aptitude
Difficulty solving mental problems without writing (7, 14, 21), inability to perform rapid calculations (8, 17, 22, 5), difficulty performing complex mental calculations (5, 19, 26)	Inability to perform mental calculations	
Difficulty with geometric visualization (2, 12, 16), inability to understand spatial concepts (6, 15, 27, 13), difficulty in geometric imagery (9, 4, 18)	Difficulty in spatial understanding	
Difficulty in logical and mathematical reasoning (6, 25, 10, 17), inability to construct complex arguments (3, 15, 29, 1), weakness in using reasoning for problem solving (1, 22, 12)	Difficulty in mathematical reasoning	
Difficulty analyzing complex problems (6, 17, 23), inability to analyze a mathematical problem (8, 21, 29, 3), weakness in analyzing and solving complex problems (10, 5, 18)	Difficulty in mathematical analysis	
Reliance on memory to learn formulas (3, 24, 11), difficulty memorizing and recalling mathematical data (1, 4, 27, 19), weakness in remembering abstract concepts (3, 24)	Reliance on memory	Passive thinking
Inability to use creative methods to solve problems (4, 19, 23, 25), inability to evaluate and select different solutions (2, 5, 7, 24), inability to generate new ideas in solving mathematical problems (9, 25)	Lack of creative thinking	
Difficulty changing strategies for complex problems (1, 4, 12, 23), inability to use different strategies to solve a single problem (7, 18, 27), reliance on one strategy for solving all problems (3, 24, 19)	Inability to use diverse strategies	
Learning without deep understanding of mathematical concepts (5, 22, 15, 16), using repetitive methods to memorize information without considering applications (1, 2, 27, 12), inability to conduct deep analysis of problems (3, 12, 18)	Surface-level learning approaches	
Difficulty rapidly learning complex concepts (3, 16, 22), differences in speed of processing mathematical information (6, 27, 12), slow learning of new content (4, 22, 18)	Differences in learning speed	Individual cognitive differences
Using learning methods not aligned with mathematical modes of thinking (1, 4, 25), need for diverse learning approaches to better understand concepts (2, 19, 11), preference for visual or auditory learning styles (9, 27, 13, 24)	Differences in learning styles	
Difficulties solving complex mathematical problems (1, 6, 23), inability to decompose and analyze problems (3, 15, 22, 28), differences in the degree of ability to solve problems using various methods (5, 17, 9)	Differences in problem-solving abilities	
Difficulty maintaining focus while solving problems (2, 7, 13), low accuracy in analyzing complex problems (4, 16, 21), inability to attend to problem details (3, 6, 18)	Differences in attention and concentration	
Inability to use time optimally for studying mathematics (2, 15, 7, 18), failure to develop effective study habits (6, 3, 10, 19), tendency to use surface-level study methods (2, 11, 25)	Differences in study habits	
Disinterest in mathematics (2, 9, 17), unwillingness to participate in mathematical activities (1, 7, 22), lack of motivation to learn complex concepts (3, 25, 15)	Disinterest in mathematics	Lack of motivation
Inability to understand real-world applications of mathematical concepts (4, 22, 12), difficulties finding connections between mathematics and everyday life (2, 17, 19), neglecting practical applications in learning (8, 24, 26)	Lack of connection between concepts and real life	
Tendency to avoid complex problems (5, 13, 16), fear of failure in problem solving (2, 7, 12, 20), lack of effort to find a solution (3, 18, 23)	Avoidance of problem solving	
Inability to set educational goals for mathematics (6, 11, 20), lack of planning for progress in mathematics (5, 23, 29), absence of a vision for success in problem solving (2, 4, 15)	Lack of goals and vision	
Difficulties retaining information in long-term memory (4, 8, 23), difficulty recalling important details of problems (6, 18, 27), weakness in using stored information to solve complex problems (3, 13, 20), forgetting steps of problem solving (2, 5)	Working memory weakness	Cognitive barriers
Slow speed of information processing (9, 23, 27), difficulty segmenting information for problem solving (11, 15, 22), inability to organize information effectively (6, 10, 14), producing ineffective outcomes from data processing (4, 12)	Information-processing deficits	
Inability to reason logically to solve complex problems (2, 12, 20), difficulties analyzing mathematical situations (3, 15, 17), inability to use logical methods to solve complex problems (5, 6, 21), forgetting logical procedures in problem solving (9, 22)	Inability to think logically	
Disrupted concentration when solving problems (7, 11, 29), inability to sustain attention on a problem for an extended period (4, 17, 22), forgetting important aspects of the problem due to inattention (10, 18, 19), difficulty maintaining accuracy during problem solving (2, 3, 8)	Attention and concentration problems	
Difficulty regulating schedules (2, 7, 15), forgetting to plan for completing assignments (3, 12, 19), inability to set work priorities (4, 16, 23), difficulty breaking tasks into manageable components (10, 27)	Difficulty in planning	Inability in self-regulation
Inability to allocate sufficient time for each activity (5, 9, 21), difficulty completing tasks within a specified time (12, 15, 24), stress due to inability to manage time (1, 10, 25), difficulty meeting deadlines (2, 18)	Inability to manage time	
Inability to accurately evaluate learning progress (3, 7, 22), difficulty identifying errors in problem solving (11, 14, 23), inability to determine the degree of progress (5, 16, 28)	Inability to evaluate progress	
Anxiety when solving complex problems (6, 10, 23), inability to control negative emotions such as anxiety and stress (4, 18, 27), difficulty managing emotional reactions when facing failure (7, 9, 16)	Weak emotion regulation	

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4. Discussion and Conclusion

The findings of the present systematic review demonstrate that psychological challenges play a decisive and multi-layered role in shaping the development of mathematical thinking across educational levels. Synthesizing evidence from 29 high-quality studies revealed 11 major psychological challenges—mathematics anxiety, negative self-concept, weak understanding of abstract concepts, low self-confidence, mathematical learning disorder, low mathematical aptitude, passive thinking, individual cognitive differences, lack of motivation, cognitive barriers, and inability in self-regulation—that collectively constrain students' engagement with mathematical reasoning, abstraction, and problem solving. These results reinforce the view that mathematical thinking cannot be understood solely as a cognitive or instructional outcome; rather, it emerges from the dynamic interaction between cognitive capacities, affective states, motivational orientations, and regulatory processes within specific educational contexts (Ernest, 2002; Hannula, 2011).

One of the most prominent findings concerns the pervasive role of mathematics anxiety, which was identified in a substantial majority of the reviewed studies. Consistent with earlier work, mathematics anxiety manifests through fear of evaluation, test stress, and worry about making mistakes, all of which directly interfere with working memory, attention, and strategic reasoning during mathematical tasks (Kargar et al., 2010; Lutfiyya, 1998). The high prevalence of this challenge across age groups suggests that anxiety is not merely a reaction to assessment pressure but a structural barrier that undermines the conditions required for mathematical thinking, such as exploration, conjecturing, and justification. This finding aligns with affective models of mathematical learning that conceptualize emotions as integral components of thinking processes rather than external modifiers (Hannula, 2011). When anxiety dominates learners' experiences, cognitive resources are diverted from reasoning and sense-making toward threat management, thereby promoting avoidance and surface-level strategies instead of deep engagement with mathematical ideas.

Closely related to mathematics anxiety is the challenge of negative self-concept, which emerged as another dominant theme in the review. Studies consistently report that students' beliefs about their own mathematical competence—shaped by past failures, low grades, and social comparison—strongly influence their willingness to engage in complex reasoning tasks (Ginsburg et al., 1998; Jordan et al., 2003). A negative self-concept in mathematics often leads students to interpret difficulty as evidence of personal inadequacy rather than as a normal feature of mathematical inquiry. This attributional pattern discourages persistence and experimentation, both of which are essential for developing mathematical thinking (Dreyfus & Eisenberg, 2012). The reviewed evidence supports the argument that fostering mathematical thinking requires not only instructional clarity but also psychological environments that normalize struggle, support positive identity formation, and decouple errors from judgments of ability (Fraivillig et al., 1999).

Another central result of the review is the widespread difficulty students experience with abstract concepts, particularly in domains such as algebra, geometry, and advanced symbolic reasoning. Weak understanding of abstract concepts was frequently linked to difficulties in visualization, abstraction, and transfer of knowledge across contexts. This finding resonates with developmental accounts of mathematical thinking that emphasize the gradual progression from concrete, action-based reasoning to symbolic and theoretical forms of understanding (Gelman, 2000; Ginsburg et al., 2006). When learners lack sufficient representational support or opportunities to connect abstract symbols to meaningful contexts, mathematical thinking becomes fragmented and procedural rather than relational. Research on conceptual understanding in linear algebra and advanced mathematics further confirms that abstraction without adequate cognitive and affective scaffolding can exacerbate confusion, reduce confidence, and intensify avoidance behaviors (Hannah et al., 2016; Harel & Sowder, 2005).

Low self-confidence and mathematical learning disorders were also identified as substantial barriers to mathematical thinking. The reviewed studies suggest that students with persistent difficulties in foundational number concepts, working memory, or procedural fluency often struggle to engage in higher-order reasoning, even when instructional opportunities are available (Fyfe et al., 2019; Jordan et al., 2003). These findings support models that view mathematical thinking as hierarchically structured, where weaknesses at basic levels constrain the development of more advanced forms of reasoning (Selden & Selden, 2005). Importantly, the evidence indicates that learning disorders and low confidence often interact: repeated failure experiences reinforce negative beliefs, which in turn reduce

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engagement and strategic flexibility, creating a self-perpetuating cycle that limits mathematical thinking over time.

The review also highlights passive thinking as a recurring challenge, characterized by reliance on memorization, limited strategy use, and avoidance of creative or flexible approaches to problem solving. This pattern is particularly problematic because mathematical thinking, by definition, involves adapting strategies, evaluating alternatives, and constructing arguments rather than reproducing memorized procedures (Ernest, 2002; Sternberg, 1997). Studies focusing on critical and advanced mathematical thinking emphasize that students must be encouraged to move beyond algorithmic imitation toward reflective and generative reasoning (Monteleone et al., 2023; Morsanyi et al., 2018). The prevalence of passive thinking in the reviewed literature suggests that many educational environments still reward correctness and speed over reasoning quality, inadvertently reinforcing surface-level engagement at the expense of deeper mathematical thinking.

Individual cognitive differences emerged as another key theme, underscoring variability in learning speed, representational preferences, attention, and problem-solving styles. These differences do not inherently impede mathematical thinking; however, when instructional approaches fail to accommodate such diversity, they can become sources of psychological strain and disengagement (Er et al., 2023; Fernández et al., 2018). Research on professional noticing of students' mathematical thinking indicates that teachers' ability to recognize and respond to diverse reasoning patterns is crucial for supporting equitable development of mathematical thinking (Jacobs et al., 2024). The current findings reinforce the need to view cognitive diversity not as a deficit but as a design challenge that requires flexible pedagogical strategies and differentiated support.

Motivational challenges and cognitive barriers further compound these difficulties. Lack of motivation—often rooted in the perceived irrelevance of mathematics to real life—was frequently associated with avoidance of challenging tasks and reduced persistence. This aligns with research emphasizing the importance of meaningful contexts, problem-based learning, and real-world applications in sustaining engagement and supporting mathematical thinking (Fraivillig et al., 1999; Goos & Kaya, 2020). Cognitive barriers such as working memory limitations and information-processing difficulties were also prominent, echoing findings from studies on computational and mathematical thinking that highlight the cognitive load imposed by complex tasks (Wu & Yang, 2022). Without adequate scaffolding, these barriers can overwhelm learners and restrict opportunities for reasoning and abstraction.

Finally, the inability in self-regulation—encompassing difficulties in planning, time management, monitoring progress, and regulating emotions—emerged as a critical cross-cutting challenge. Mathematical thinking requires sustained effort, strategic decision-making, and reflection, all of which depend on effective self-regulatory skills (Dreyfus & Eisenberg, 2012). Evidence from intervention studies suggests that explicit support for metacognitive and self-regulatory processes can enhance both mathematical thinking and students' confidence in managing complex tasks (AlAli et al., 2023; Er et al., 2023). The prominence of self-regulation difficulties in the reviewed literature indicates that fostering mathematical thinking must involve systematic attention to how students plan, monitor, and evaluate their own reasoning processes.

Overall, the results of this systematic review converge with and extend previous research by demonstrating that psychological challenges are not peripheral obstacles but central determinants of whether and how mathematical thinking develops. The reviewed studies collectively suggest that effective cultivation of mathematical thinking requires integrated approaches that address affective, cognitive, and regulatory dimensions simultaneously, rather than treating them as separate or secondary concerns (Goos & Kaya, 2020; Wang & Abdullah, 2024).

Despite its contributions, this study has several limitations. First, although rigorous inclusion and quality criteria were applied, the review was limited to English-language publications, which may have excluded relevant studies published in other languages. Second, the synthesis relied on qualitative content analysis, which, while suitable for identifying themes and patterns, does not allow for quantitative estimation of effect sizes or causal relationships. Third, the heterogeneity of study designs, educational levels, and contexts limited the possibility of fine-grained comparisons across subgroups. Finally, publication bias may have influenced the available evidence, as studies reporting significant challenges or interventions are more likely to be published.

Future research should aim to integrate longitudinal and mixed-methods designs to examine how psychological challenges in mathematical thinking evolve over time and interact with instructional practices. Greater attention is needed to underrepresented contexts, including diverse

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cultural and educational systems, to test the generalizability of existing findings. Researchers should also explore the mechanisms through which specific interventions—such as metacognitive training or affective support—mediate changes in mathematical thinking. Additionally, quantitative meta-analyses could complement qualitative syntheses by estimating the relative impact of different psychological challenges on mathematical thinking outcomes.

From a practical perspective, educators and curriculum designers should explicitly address psychological challenges as part of mathematics instruction rather than treating them as external or secondary issues. Classroom practices should normalize struggle, encourage multiple solution strategies, and emphasize reasoning over rote performance. Teachers can support mathematical thinking by creating emotionally safe environments, providing formative feedback focused on processes, and embedding self-regulation supports into daily instruction. At the policy level, professional development programs should equip teachers with tools to recognize and respond to students' psychological needs, ensuring that efforts to foster mathematical thinking are inclusive, sustainable, and developmentally responsive.

Authors' Contributions

Authors equally contributed to this article.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

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