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Reframing mathematics anxiety through equity and emotional support: A four-pillar conceptual framework

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Abstract

Mathematics anxiety is associated with lower achievement, avoidance and restricted participation, yet it is often addressed primarily through individual coping strategies. This conceptual synthesis reframes mathematics anxiety as a classroom-mediated affective and equity concern. Seven topic-specific Scopus searches identified 2,688 records, which were reduced to 1,485 unique publications and examined alongside foundational and policy sources. The synthesis integrates cognitive, pedagogical, sociocultural and equity-oriented evidence into four analytically distinct but conditionally interacting classroom conditions: agency-supportive participation, instructional clarity and formative support, adaptive mathematical beliefs and self-regulation, and equitable belonging and emotional safety. Technology is positioned as a conditional cross-cutting enabler. The framework specifies mechanisms, interactions, boundary conditions, and testable propositions, while distinguishing established associations from evidence of direct intervention. It offers a theoretically explicit basis for classroom inquiry, teacher development and future empirical testing.

Keywords: mathematics anxiety, equity, emotional safety, self-regulation, formative assessment, mathematical well-being

INTRODUCTION

Mathematics anxiety refers to apprehension, tension or fear that interferes with engagement in mathematical situations. Several aggregate-data meta-analyses have established a robust negative association between mathematics anxiety and mathematics achievement (Barroso et al., 2021; Caviola et al., 2022; Namkung et al., 2019). More recently, Brunner et al. (2026) confirmed this association using individual participant data from 452 probability samples of students and adults across 90 countries. The relation is nevertheless heterogeneous rather than deterministic. Its magnitude varies with the anxiety measure, the mathematical task, student characteristics, and the educational context, and reciprocal longitudinal evidence indicates that anxiety may both follow and contribute to weaker achievement (Aldrup et al., 2020; Carey et al., 2016; Wang et al., 2020).

The evidence does not support a simple account in which anxiety is merely a personal weakness that precedes poor performance. Anxiety and achievement can develop reciprocally: difficulty and low performance may increase anxiety, while anxiety can disrupt performance and encourage avoidance, thereby reducing opportunities to learn (Carey et al., 2016; Dowker et al., 2016). Cognitive accounts explain part of this cycle through working-memory interference and reduced attentional control (Ashcraft & Kirk, 2001; Eysenck et al., 2007). However, recent evidence indicates that in-the-moment anxiety explains only part of the underperformance associated with trait mathematics anxiety and that mechanisms differ among students (Daker et al., 2023). A credible framework must therefore accommodate cognitive interference without treating it as the sole mechanism.

Mathematical activity is also socially and institutionally organized. Students encounter mathematics through tasks, languages, assessment routines, teacher expectations, peer relations and culturally established ideas about who is mathematically capable. From a sociocultural perspective, cognition and emotion are mediated through participation in

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Contribution to the literature

- This study reframes mathematics anxiety as a classroom-mediated affective and equity concern rather than solely as an individual psychological difficulty.
- Through a theory-synthesis process informed by seven topic-specific Scopus searches and an evidence-sensitive appraisal of empirical, review, conceptual and policy sources, the study integrates cognitive, pedagogical, sociocultural and equity-oriented scholarship.
- It proposes a mechanism-based four-pillar framework comprising agency-supportive participation, instructional clarity and formative support, adaptive mathematical beliefs and self-regulation, and equitable belonging and emotional safety. The framework positions technology as a conditional cross-cutting enabler, specifies interactions and boundary conditions, and advances testable propositions for future research.

historically and culturally organized practices rather than formed independently of them (Lerman, 2001; Vygotsky, 1978). Equity-oriented mathematics education further shows that recognition, identity, language and access affect whose reasoning is valued and whose participation is constrained (Gutiérrez, 2013). Mathematics anxiety can consequently be intensified by public comparison, linguistic exclusion, repeated deficit positioning, inaccessible instruction and resource deprivation. These conditions do not imply that anxiety is distributed uniformly across every marginalized group, but they require attention to how emotional threat and educational inequity may intersect.

Intervention evidence is more qualified than the strength of the anxiety-achievement association might suggest. Reviews and meta-analyses report promising effects for some skill-based, therapeutic and classroom approaches, but also identify small or uneven evidence bases, methodological limitations and heterogeneous outcomes (Balt et al., 2022; Codding et al., 2023; Sammallahti et al., 2023). This imbalance creates a conceptual problem: the field has substantial evidence that mathematics anxiety matters, but less certainty about how classroom conditions interact to reduce it equitably and sustainably.

Existing accounts illuminate important parts of this problem. Cognitive and attentional accounts explain performance disruption; appraisal and dynamic risk-factor models explain heterogeneous pathways; multilevel reviews organize individual, interpersonal and sociocultural contributors; and classroom-environment reviews identify potentially relevant instructional and relational factors (O'Hara et al., 2022; Ramirez et al., 2018; Retanal & Maloney, 2026; Rubinsten et al., 2018). However, these approaches do not, by themselves, provide a classroom-actionable model that links anxiety-reduction mechanisms to equity, implementation and boundary conditions.

To address this gap, the article undertakes a conceptual synthesis guided by the following question: How can affective-cognitive, pedagogical, sociocultural, and equity-oriented scholarship be integrated into a classroom-actionable conceptual framework to reduce mathematics anxiety and support mathematical well-being?

MATERIALS AND METHODS

Conceptual Synthesis Design

The article employed a theory-synthesis approach to conceptual research. Conceptual articles require an explicit research design because their contribution depends on how bodies of evidence and theory are selected, compared and reorganized to produce new explanatory relationships (Gilson & Goldberg, 2015; Jaakkola, 2020). A theory-synthesis approach was appropriate because mathematics anxiety is examined across psychology, mathematics education, affect studies, sociocultural theory, educational equity and technology research. The purpose was not to estimate a pooled effect or claim exhaustive coverage, but to integrate literature streams that address different levels of the same phenomenon.

The synthesis was guided by two analytic commitments. First, claims were differentiated according to evidentiary status. Meta-analyses and systematic reviews were used to establish recurring relationships and variation; intervention and longitudinal studies were used to examine mechanisms and change; correlational studies were treated as evidence of association rather than causality; conceptual and theoretical sources were used to clarify constructs and relationships; and policy reports were used to identify system-level conditions. Second, the synthesis prioritized explanatory usefulness. A source was not included merely because it endorsed a desirable practice, but because it helped explain how a practice, condition or relationship could influence mathematics anxiety, participation or well-being.

Literature Identification and Selection

Seven topic-specific searches were conducted in Scopus. The searches combined mathematics anxiety or math anxiety with terms related to:

(1) reviews, theories, mechanisms and frameworks,

(2) teaching, pedagogy and classroom conditions,

(3) mindset, self-regulation and student beliefs,

(4) equity, identity, language and belonging,

(5) technology and digital learning,

(6) mathematical well-being, and

(7) adjacent conceptual frameworks.

Searches covered publications from 1990 to 2026 and were limited to articles, reviews and book chapters. They returned 2,688 records. Deduplication by Scopus EID, DOI and normalized title produced 1,485 unique publications.

Titles and abstracts were examined for directness to the conceptual problem and for their potential evidentiary function. This prioritization identified 118 publications for closer consideration, comprising 48 core and 70 secondary sources. Core sources were appraised according to evidence type, population or literature base, directness to mathematics anxiety, principal finding, methodological limitation and role in framework construction. Backward reference checking, DOI verification and publisher or journal records were then used to retain foundational works, relevant policy sources and additional publications that did not necessarily appear in the Scopus results.

Sources were included when they provided direct empirical evidence about mathematics anxiety, synthesized that evidence, supplied a theoretical construct needed to explain a proposed mechanism, or addressed mathematics-specific pedagogy, equity, language, technology or well-being in a way that informed the framework. Sources were excluded from direct evidentiary use when bibliographic details could not be verified, when they concerned general anxiety or generic educational practices without a defensible connection to mathematics anxiety, or when they duplicated stronger evidence. Studies of growth mindset, active learning, formative assessment or technology were not treated as proof of reduced mathematics anxiety unless anxiety was measured. This was a purposive and iterative conceptual synthesis rather than a systematic review; the record counts document the search and prioritization process but are not presented as a PRISMA-style exhaustive study-selection flow.

Analytical Procedure

The synthesis proceeded through iterative comparison across four analytical dimensions: the extent to which mathematics anxiety was explained, the proposed mechanism, the type and strength of evidence, and the implications for equity and classroom enactment. Initial categories included cognitive interference, appraisal, reciprocal development, teaching and assessment, motivational beliefs and self-regulation, classroom relationships, identity and language, resource conditions, technology, and mathematical well-being. These categories were compared for overlap, explanatory distinctiveness and classroom relevance.

The synthesis yielded four classroom conditions, each representing a distinct pathway through which perceived mathematical threat could be altered: participation and agency; instructional clarity and formative support; adaptive beliefs and self-regulation; and equitable belonging and emotional safety. The conditions are analytically distinguishable, although their effects may interact in practice. Technology was positioned as cross-cutting because its affordances can enable or constrain each pathway rather than represent a single, uniform anxiety-reduction pathway. Mathematical well-being was positioned as a positive outcome because it describes feeling and functioning in mathematics rather than a classroom condition that produces change.

The four-part structure reflects distinctions in conceptual focus and explanatory function rather than an arbitrary division of related constructs. Agency-supportive participation was not merged with emotional safety because opportunities to speak, choose and collaborate concern participation and perceived control, whereas emotional safety concerns humiliation, identity threat and evaluative exposure; a classroom may offer participation without making that participation safe. Instructional clarity remained separate from participation because explanation, scaffolding and formative feedback primarily address uncertainty and cognitive overload, while participation addresses voice and action. Adaptive beliefs and self-regulation form a distinct pillar because appraisal, monitoring, strategy use and emotion regulation operate within the student, although they are shaped by instructional and relational conditions. Assessment, teacher support, language, and resources operate within the relevant pillars or as boundary conditions, as their influence flows through these four pathways rather than through an additional independent mechanism.

Analytical credibility was strengthened by distinguishing meta-analytic, longitudinal, intervention, cross-sectional, conceptual and policy evidence; recording limitations and contradictory findings; and avoiding causal wording where designs supported only association. The resulting framework was then compared directly with named adjacent approaches to identify its added explanatory function. The purpose was not to claim novelty for the component ideas themselves, but to specify their classroom-level mechanisms, conditional relations, equity implications and empirically testable propositions.

RESULTS OF THE CONCEPTUAL SYNTHESIS

Sociocultural, Affective, and Equity Framing

A sociocultural framing begins with the proposition that learning, identity and emotion are mediated through participation in social practice. Vygotsky (1978) situated development in the interaction among students, cultural tools, and more knowledgeable others. In mathematics education, Lerman (2001) extended this orientation by treating language and discourse as constitutive of mathematical meaning and student positioning. The classroom is therefore not a neutral location in which a pre-existing anxiety is merely displayed. It is a social setting in which norms of speed, correctness, explanation, help-seeking and authority can intensify or reduce threat.

This perspective also changes how affect is understood. Emotions are experienced personally, but they are shaped by histories, meanings and relations that attach fear, shame, pride or legitimacy to particular activities and identities (Ahmed, 2014). A student may fear mathematics because of prior failure, but the meaning of failure depends on whether mistakes are treated as information, public deficiency or evidence of fixed ability. The same mathematical difficulty can therefore be experienced as a productive challenge in one environment and as an identity threat in another.

Equity in this framework concerns access, participation, recognition and outcomes. It includes material resources, but it also includes whose language is accepted, whose reasoning is heard, what counts as mathematical competence and whether students can participate without humiliation or stereotype-based judgement (Gay, 2018; Gutiérrez, 2013). In multilingual settings, language can function as a resource for meaning-making or as an additional barrier when students must simultaneously manage unfamiliar mathematical ideas and restrictive linguistic expectations. South African mathematics education research shows sustained attention to language-responsive and multilingual teaching, while also identifying uneven coverage across languages and contexts (McLachlan & Essien, 2022).

Within this account, emotional safety refers to perceived freedom from humiliation, punitive exposure or degrading responses to error. Belonging refers to experienced membership and legitimacy within mathematical activity, while recognition concerns whether students' identities, languages and forms of reasoning are treated as worthy of attention. Identity threat refers to anticipated devaluation linked to social identity, whereas social-evaluative threat concerns fear of negative judgement in a performance situation. These constructs overlap, but they are not interchangeable (Gutiérrez, 2013; O'Hara et al., 2022; Spencer et al., 1999).

Mathematics anxiety is thus conceptualised as a multidimensional response produced through reciprocal relations among student histories, cognitive processes, beliefs, pedagogical practices, social relationships and structural conditions. Equity does not replace affective-cognitive explanation. It asks whose exposure to threat, uncertainty, exclusion and weak support is amplified, and whether proposed interventions require resources or forms of participation that are unequally available.

What the Literature Establishes, and What Remains Contested

A robust but heterogeneous anxiety-performance relationship

Meta-analytic evidence consistently indicates a moderate negative relation between mathematics anxiety and mathematical performance. Barroso et al. (2021) synthesized 747 effect sizes and reported an average correlation of r = -.28, while Namkung et al. (2019) reported r = -.34 across school-aged samples. Caviola et al. (2022) included 177 studies and 906,311 participants across all analyses; specifically, the mathematics-anxiety-performance estimate was r = -.30, based on 121 studies and 169 independent samples. Brunner et al. (2026), using individual participant data from 452 probability samples across 90 countries, reported an average association of r = -.26. These estimates establish robustness, but their variation also cautions against treating anxiety as a uniform or sufficient explanation of performance.

Directionality remains contested. Reciprocal models propose that weak performance can heighten anxiety while anxiety can subsequently impair engagement and achievement (Carey et al., 2016). Longitudinal studies provide support for reciprocal or developmentally changing relations rather than a single causal pathway (Aldrup et al., 2020; Wang et al., 2020). The framework, therefore, treats mathematics anxiety as dynamically produced and sustained, not as a fixed student attribute.

Cognitive interference, avoidance, and mechanistic heterogeneity

Cognitive accounts explain how worry and threat can consume resources required for mathematical reasoning. Attentional control theory and working-memory accounts remain influential (Ashcraft & Kirk, 2001; Eysenck et al., 2007). However, Finell et al.'s (2022) meta-analysis found a small negative relation between mathematics anxiety and working memory and noted that the evidence for working memory as a mediator rested on a comparatively small set of effects. Working-memory interference is therefore a plausible mechanism, but not a complete explanation of the anxiety-performance relation.

The same caution applies to time pressure and immediate anxious arousal. Caviola et al. (2017) showed that stress, time pressure and strategy selection are theoretically connected, but also documented a limited and methodologically varied evidence base. Daker et al. (2023) further questioned whether momentary anxious arousal fully explains underperformance among mathematics-anxious individuals. Cognitive mechanisms remain necessary to the framework, but they must be located within appraisal, avoidance, classroom evaluation and social experience.

Pedagogy and classroom relationships

The classroom learning environment is repeatedly associated with mathematics anxiety, although direct causal evidence remains limited. O'Hara et al. (2022) identified instructional, social, organizational and assessment-related factors across 28 studies, but much of the literature was observational. The review supports classroom relevance while also showing that broad claims about what teachers can reliably change require stronger intervention designs.

Available intervention studies are informative but bound. Hussein and Csíkos (2023) found that conceptual teaching improved achievement and attitudes, with anxiety reduction clearer for part of the sample. Pizzie and Kraemer (2023) reported that study-skills instruction was particularly useful for highly anxious high-school students' performance, whereas an emotion-regulation intervention did not produce the same performance pattern. Neither study supports the conclusion that one strategy will reduce anxiety across contexts, but both show that instructional and regulatory supports can alter how anxiety affects performance.

Teacher relationships and support also require a reciprocal interpretation. Aldrup et al. (2020) found some evidence that teacher sensitivity was associated with subsequent decreases in mathematics anxiety within a reciprocal anxiety-achievement process. By contrast, Luo et al. (2024) found that students' prior mathematics anxiety and attitudes predicted later perceptions of teacher support, rather than perceived support predicting later anxiety. Cross-sectional studies likewise show associations but cannot establish direction (Wang et al., 2024). Teacher support is therefore a plausible protective condition, but its effects may depend on students' prior experiences and on how support is interpreted.

Intervention syntheses reinforce this qualified conclusion. Sammallahti et al. (2023) reported moderate average effects across mathematics-anxiety interventions but substantial heterogeneity and generally weak methodological quality. Balt et al. (2022) similarly found a limited and diverse school-based evidence base. In sub-Saharan Africa, Luneta and Sunzuma (2022) identified only nine intervention studies; all reported improvements, but the small, contextually concentrated corpus limits the generalizability of these findings. The framework consequently uses intervention findings to identify plausible mechanisms rather than to certify universal practices.

Equity, identity, language, and resources

Gender differences in reported mathematics anxiety are frequently observed, but they are neither universal nor reducible to mathematical ability. Hill et al. (2016) found developmental and gender variation, while Brunner et al. (2026) showed that gender differences in the anxiety-achievement association were historically and contextually contingent. Stereotype threat and teacher anxiety offer credible explanations for some unequal experiences, but these mechanisms should not be generalized to all students or settings (Beilock et al., 2010; Spencer et al., 1999).

Language can add cognitive and social demands when mathematical participation is restricted to a language or discourse that students have not yet mastered. Mathematics-specific research in multilingual contexts shows that language choices shape access to explanation, participation and recognition (McLachlan & Essien, 2022). The evidence does not justify claiming that multilingualism itself causes mathematics anxiety. Instead, the framework treats linguistically restrictive participation and assessment as potential sources of uncertainty, exclusion and identity threat, an inference grounded in sociocultural and equity scholarship (García & Wei, 2014; Lerman, 2001).

Resource disparities also shape the feasibility of supportive practice. Large classes, limited instructional materials, unstable connectivity and insufficient teacher preparation constrain individual feedback, differentiated support and low-risk practice. Technology may partly extend access, but it can also reproduce inequity. UNESCO's (2023) technology report emphasizes that educational value depends on relevance, equity, scalability and sustainability. Structural conditions must therefore be treated as boundary conditions of classroom interventions rather than as background variables.

Positioning the Framework in Relation to Existing Models

The proposed framework was positioned against named approaches rather than against undifferentiated literature categories. **Table 1** compares seven adjacent accounts according to explanatory focus, contribution and the unresolved function addressed by the present model. The comparison shows that the framework's distinct contribution lies in the classroom-level articulation of mechanisms, equity relations, implementation conditions and interactions, not in

Table 1. Comparison of the proposed framework with adjacent conceptual approaches

Named approach	Central explanatory focus	Contribution to mathematics-anxiety research	Unresolved function addressed by the present framework
Interpretation account (Ramirez et al., 2018)	Appraisal of mathematical situations and interpretation of anxious arousal.	Explains why similar situations may be experienced differently and why interventions depend on appraisal.	Does not provide a multi-condition classroom model linking appraisal to equity, implementation and sequencing.
Dynamic risk-factor framework (Rubinsten et al., 2018)	Heterogeneous and dynamically interacting biological, cognitive, social and pedagogical risk factors.	Rejects single-cause explanations and foregrounds individual developmental pathways.	Maps risks more than it specifies classroom mechanisms teachers can diagnose and coordinate.
Individual-interpersonal-sociocultural review (Retanal & Maloney, 2026)	Contributors operating within and between three analytical levels.	Offers a comprehensive multilevel map of the development and maintenance of mathematics anxiety.	Provides broader explanatory coverage but less detail on integrated classroom enactment and boundary conditions.
RAMPS framework (Scheibe et al., 2023)	Metacognitive cues, regulated attention and working memory during mathematical problem-solving.	Connects interpretation of metacognitive experiences to attention and performance.	Concentrates on task-level regulation rather than participation, belonging, language and structural equity.
Mastery and mathematical-mindset approaches (Boaler, 2016; Bui et al., 2023; Furner & Gonzalez-DeHass, 2011)	Beliefs about ability, goals, mistakes, effort and classroom messages.	Shows how mastery-oriented climates can support challenge-seeking and adaptive interpretations of difficulty.	Mindset effects are mixed and cannot substitute for instructional access, emotional safety or resource equity.
Classroom-environment map (O'Hara et al., 2022)	Instructional, social, organizational and assessment features associated with mathematics anxiety.	Establishes the classroom as an important site of anxiety production and potential prevention.	Most evidence is observational and the factors are not organized into a mechanism-based, testable change model.
Mathematical well-being framework (Campbell, 2026; Hill et al., 2021)	Positive feeling and functioning in mathematics.	Provides a positive outcome lens extending beyond the absence of anxiety.	Describes desired functioning rather than the classroom mechanisms through which anxiety and inequity may be changed.

asserting that the four component ideas are individually new.

The framework's contribution does not rest on treating agency, feedback, adaptive beliefs, belonging or technology as new educational ideas. Its contribution is a middle-range account of classroom-mediated mathematics anxiety. It translates multilevel and cognitive insights into four conditions that teachers and researchers can examine together; identifies the immediate mechanisms through which each condition may alter threat; makes equity a constitutive analytical dimension rather than an additional recommendation; and specifies when apparently supportive practices can become counterproductive.

Mathematical well-being is positioned as an outcome rather than as a pillar. Hill et al. (2021) conceptualised mathematical well-being in terms of positive feelings and functioning, and Campbell (2026) further developed it as an emerging construct. Positioning it as an outcome preserves the distinction between the classroom conditions proposed to generate change and the positive mathematical state that may result.

Reduced anxiety is treated as an enabling condition for mathematical well-being, not as its equivalent or sufficient cause. Mathematical well-being is expected to emerge when a lower threat appraisal is accompanied by meaningful participation, credible evidence of competence, a sense of belonging, and sustained engagement. A student may experience less anxiety without yet demonstrating positive functioning in mathematics; the framework, therefore, positions well-being as a broader downstream outcome of coordinated affective, cognitive, participatory, and relational processes (Campbell, 2026; Hill et al., 2021).

The Four-Pillar Conceptual Framework

The framework proposes that mathematics anxiety is influenced by four analytically distinct but conditionally interacting classroom conditions. Each condition addresses a different route through which anxiety-

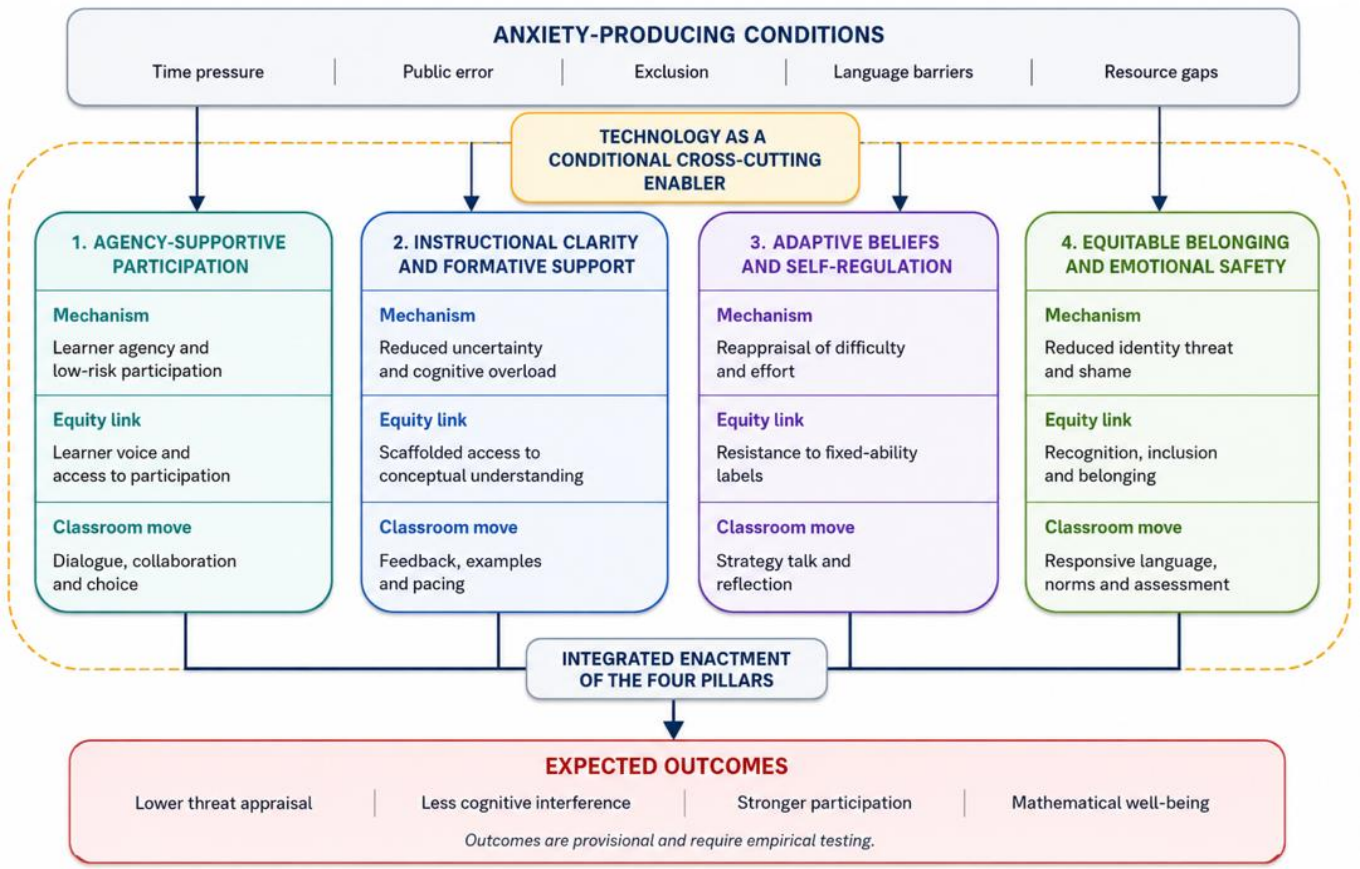


Figure 1. Four-pillar mechanism-based framework for reducing mathematics anxiety (the author's own elaboration)

producing pedagogical, relational or structural conditions may be altered: participation and perceived control; instructional predictability and competence evidence; appraisal and self-regulation; and recognition, belonging and emotional safety. The model does not assume a fixed causal sequence or direct dependence among the pillars. Each may be enacted separately, while coherent integration is expected to strengthen the likelihood of lower threat appraisal, reduced cognitive interference, stronger participation and mathematical well-being. Technology surrounds the four conditions as a conditional enabler rather than a fifth pillar. **Figure 1** represents this architecture.

Pillar 1: Agency-supportive participation

Agency-supportive participation refers to structured opportunities for students to contribute reasoning, make meaningful choices, ask for help and collaborate without premature public judgement. Its theoretical basis lies in sociocultural accounts of learning as mediated participation and in mastery-oriented approaches that reposition errors and struggle as part of learning (Furner & Gonzalez-DeHass, 2011; Lerman, 2001; Vygotsky, 1978). Agency is expected to reduce anxiety by increasing perceived control, reducing helplessness, and allowing students to rehearse their reasoning before public evaluation.

The empirical evidence is supportive but often indirect. Active learning improves achievement across science, engineering and mathematics, but achievement effects are not equivalent to reduced mathematics anxiety (Freeman et al., 2014). O'Hara et al. (2022) identified participation and classroom social conditions as relevant across the available literature, although mostly through observational evidence. Agency-supportive participation is therefore proposed as a plausible mechanism that requires direct anxiety-focused testing.

Agency has an equity function because classroom participation is often unevenly distributed. Teachers can broaden legitimate participation by allowing oral, written, visual and multilingual explanations; using think-pair-share before whole-class reporting; and structuring group roles so that confident students do not monopolize reasoning. Agency nevertheless requires structure. Open inquiry without adequate scaffolding may increase uncertainty, especially for students with knowledge gaps. Pillar 1, therefore, depends on instructional clarity and emotional safety rather than replacing teacher guidance.

Pillar 2: Instructional clarity and formative support

Instructional clarity and formative support concern the organization of mathematical ideas, tasks, explanations, feedback and assessment so that students

can understand what is expected, locate errors and identify attainable next steps. This pillar responds directly to uncertainty and cognitive overload. Clear representations, worked examples, purposeful questioning and connections between concepts and procedures increase predictability and reduce the need to manage avoidable confusion while coping with anxiety.

Evidence is strongest when instruction changes both mathematical understanding and the conditions of evaluation. Hussein and Csíkos (2023) found that conceptual teaching improved learning outcomes and reduced anxiety for part of their sample. Pizzie and Kraemer (2023) showed that study-skills support could buffer performance among highly anxious students. Formative assessment theory explains how feedback may clarify goals and next steps (Black & Wiliam, 2009; Hattie & Timperley, 2007), but the broader formative-assessment literature should not be treated as direct proof of mathematics-anxiety reduction.

The equity relationship lies in differentiated access to explanations, time, feedback and correction. A uniform pace or single representation may advantage students whose prior opportunities already match classroom expectations. Teachers can use multiple representations, low-stakes checks, private feedback and opportunities to revise. However, formative assessment becomes anxiety-producing when it is frequent grading in disguise, when errors are publicly ranked or when data are used primarily for surveillance. The defining feature is support for learning, not the number of assessments administered.

Pillar 3: Adaptive mathematical beliefs and self-regulation

This pillar concerns beliefs about mathematical ability, interpretations of difficulty, perceived control, strategy use, metacognitive monitoring and emotion regulation. It extends beyond a narrow growth-mindset message. Mastery-oriented goals can reduce the threat attached to mistakes and social comparison (Furner & Gonzalez-DeHass, 2011), while the Interpretation Account and RAMPS framework explain how appraisal and metacognitive cues may redirect attention and behavior during mathematical activity (Ramirez et al., 2018; Scheibe et al., 2023).

Self-regulation connects belief to action through planning, monitoring, help-seeking, strategy adjustment and emotion regulation. However, mindset interventions in mathematics classrooms have produced mixed outcomes, and their effects depend on intervention design and classroom context (Bui et al., 2023). Wang (2023) similarly found that teacher cognitive activation moderated the relationships among self-concept, anxiety, and performance, but the observational design does not establish causal inference. The framework, therefore, treats adaptive beliefs and self-regulation as a supported but conditional mechanism rather than a stand-alone remedy.

The equity risk is important. A discourse of perseverance can imply that students should overcome conditions that remain linguistically, materially or pedagogically exclusionary. Adaptive beliefs become credible only when students receive genuine opportunities to learn and evidence that effort is productive. Pillar 3 must therefore operate with pillar 2 and pillar 4. It cannot compensate for inaccessible instruction, humiliating assessment or inadequate resources.

Pillar 4: Equitable belonging and emotional safety

Equitable belonging and emotional safety refer to students' experience of being recognized as legitimate mathematical participants who can take intellectual risks without humiliation, stereotype-based judgement or exclusion. This pillar is grounded in sociopolitical and culturally responsive mathematics education, stereotype threat research, and evidence from classroom environments (Gay, 2018; Gutiérrez, 2013; O'Hara et al., 2022; Spencer et al., 1999). It is expected to reduce identity threat and anticipatory fear while widening access to recognition, support and participation.

Implementation requires more than friendly classroom language. Teachers must examine who is called on, whose methods are validated, which languages and examples are permitted, how errors are discussed and whether assessment rewards understanding rather than conformity to a single communicative form. In multilingual classrooms, students may need opportunities to reason through familiar languages and representations before producing formal mathematical discourse. Such practices support access and recognition, although direct causal evidence connecting multilingual teaching to reduced mathematics anxiety is not yet sufficient.

Emotional safety does not mean removing challenge. A low-anxiety classroom can include cognitively demanding mathematics when difficulty is accompanied by support, dignity and credible pathways to progress. Nor does inclusion mean that all students receive identical treatment. Equity may require additional time, alternative representations, assistive technology or targeted feedback. Pillar 4 provides the social condition within which agency and formative support can be used without increasing exposure or shame.

Technology as a conditional cross-cutting enabler

Technology is positioned as a conditional cross-cutting enabler rather than a fifth pillar because it does not represent a single anxiety-reduction pathway. Instead, its affordances may activate, strengthen or

Table 2. Mechanisms, equity relations, implementation, and boundary conditions of the four pillars

Pillar	Anxiety-reduction mechanism	Equity connection	Illustrative classroom enactment	Risk or boundary condition
Agency-supportive participation	Increases perceived control and reduces helplessness and public exposure.	Broadens whose reasoning, language and strategies are recognized.	Structured choice, think-pair-share, collaborative roles and multiple response modes.	Unstructured openness may increase uncertainty or reproduce peer hierarchies.
Instructional clarity and formative support	Reduces uncertainty and cognitive overload; provides competence evidence.	Differentiates access to explanation, time, representation and feedback.	Conceptual explanation, worked examples, low-stakes checks, private diagnostic feedback and revision.	Assessment may become surveillance or public comparison.
Adaptive beliefs and self-regulation	Strengthens perceived control, persistence, monitoring and approach behavior.	Makes success more attainable when strategies and support are explicitly taught.	Planning, self-testing, error analysis, help-seeking and strategy-focused feedback.	Mindset discourse may blame students or ignore structural or pedagogical barriers.
Equitable belonging and emotional safety	Reduces identity threat, shame and social-evaluative threat.	Addresses recognition, language, stereotype and differentiated support.	Inclusive discourse, multilingual resources, respectful error norms and flexible access.	Superficial inclusion may leave participation and assessment hierarchies unchanged.

constrain mechanisms across all four pillars, depending on their design, pedagogical use, duration, social organization and context (Dondio et al., 2023; Ersozlu, 2024; UNESCO, 2023). A recent conceptual model proposes that digital environments may support instructional clarity, low-risk participation, formative feedback, self-regulation and belonging through features such as adaptive difficulty, safe error handling, collaborative play, emotion-regulation tools, low-stakes practice and non-competitive progress tracking (Jukić Matić et al., 2026). Technology is therefore interpreted through the participatory, instructional, regulatory, and relational mechanisms that it enables or disrupts, rather than as a uniform, technology-specific pathway.

The empirical evidence remains mixed. Ersozlu's (2024) systematic review identifies potentially beneficial technology-supported approaches but also reports contexts in which online learning may heighten anxiety. Similarly, Dondio et al. (2023) found weak and non-robust evidence that games reduce mathematics anxiety, with negligible effects for digital games and stronger effects when interventions were collaborative and sustained. Technology should therefore be evaluated according to the mechanisms and learning conditions it supports, rather than according to its novelty.

Access, design and teacher readiness further condition its effects. A platform that provides useful feedback may still increase anxiety when connectivity is unreliable, interfaces are inaccessible, performance is displayed publicly or teachers lack sufficient preparation to integrate it pedagogically (Ersozlu, 2024; UNESCO, 2023). Technology can consequently extend supportive pedagogy, but it can also intensify comparison, surveillance and exclusion. Its placement across the framework signifies conditional support for the four pillars rather than independent causal priority. **Table 2** summarizes the mechanism, equity connection, classroom enactment and principal risk associated with each pillar.

Interactions, Sequencing, and Testable Propositions

The effects of the pillars are conditional and may interact rather than form a fixed sequence or an additive checklist. More pillars do not mechanically produce less anxiety. Agency can become exposed when emotional safety is absent; feedback can become a threat when it is comparative; growth-oriented messages can shift blame onto students when instruction is inaccessible; and culturally responsive examples can remain superficial when assessment and participation rules are unchanged. The framework therefore predicts that coherent integration matters more than isolated adoption, while recognizing that an individual pillar may be prioritized in response to a specific source of threat.

No pillar has universal precedence, but sequencing should respond to the dominant source of threat. Where students fear humiliation or stereotype-based judgement, emotional safety and belonging are immediate priorities. Where anxiety is driven by confusion or accumulated gaps, instructional clarity and competence-building require attention. Agency should increase as students acquire sufficient structure to participate productively, while adaptive beliefs are strengthened through repeated evidence that participation and strategy use lead to progress. Technology enters only after the pedagogical purpose and access conditions are established.

The framework advances five propositions for future testing. Proposition 1 states that mathematics anxiety is

more likely to decline when classroom practices increase perceived control and emotional safety simultaneously than when either is targeted alone. Proposition 2 states that agency-supportive participation reduces anxiety only when sufficient instructional structure and protection from public humiliation are present. Proposition 3 states that adaptive beliefs influence participation through credible evidence of competence, and that their effect will weaken when students face persistent structural or instructional barriers. Proposition 4 states that technology affects mathematics anxiety indirectly through the four pillars, with access, pedagogical alignment and teacher readiness moderating the direction and magnitude of its effects. Proposition 5 states that reduced anxiety is enabling but insufficient for mathematical well-being; sustained well-being develops through reciprocal feedback among successful participation, evidence of competence, belonging, self-efficacy, and continued engagement.

DISCUSSION

Conceptual Contribution

The synthesis reframes mathematics anxiety as a classroom-mediated affective and equity concern without denying individual cognitive processes. The proposed model adds value in four ways. First, it replaces a list of familiar practices with an explanatory pathway from classroom conditions to immediate mechanisms, affective-cognitive processes and outcomes. Second, it makes interactions and tensions explicit. Third, it positions technology as conditional and indirect. Fourth, it connects reduced anxiety to the broader positive outcome of mathematical well-being. These features define the framework's contribution; none depends on claiming that agency, feedback, self-regulation or belonging is individually new.

This positioning clarifies the framework's distinct scope. Retanal and Maloney's (2026) multilevel review offers broader explanatory coverage across individual, interpersonal and sociocultural levels. Ramirez et al. (2018) and Scheibe et al. (2023) provide more detailed accounts of appraisal and task-level regulation. Rubinsten et al. (2018) foreground heterogeneous developmental risk pathways, while O'Hara et al. (2022) maps classroom correlates. Boaler (2016), Furner and Gonzalez-DeHass (2011), and the intervention review by Bui et al. (2023) foreground mastery and mindset-oriented climates. The present framework is narrower but more operational at the classroom level: it specifies how four conditions interact through perceived control, predictability, adaptive interpretation and belonging, and it makes equity and counterproductive boundary conditions explicit.

Implications for Teachers

Teachers can use the framework as a diagnostic sequence rather than a checklist. The first question is what form of threat is currently operating: confusion, anticipated failure, public exposure, identity threat, limited access or ineffective self-regulation. Instruction can then be aligned to the relevant mechanism. A lesson might begin with clear goals and worked examples, allow private or paired rehearsal, invite multiple solution strategies, provide non-comparative feedback and conclude with reflection on strategies that supported progress. Such a sequence links all four pillars and avoids placing responsibility for anxiety solely on the student. Technology should be selected only when it expands representation, feedback, access or low-risk participation more effectively than available non-digital alternatives.

Implications for Schools

At the school level, professional development should connect mathematical content, assessment, classroom discourse, emotion and equity. Teachers require opportunities to examine how pace, ability grouping, public marking, language policy and digital systems may create threats. Collaborative lesson inquiry can focus on whether students receive credible competence evidence and whether participation is distributed equitably. Schools should also provide referral pathways for students whose anxiety is severe or extends beyond classroom intervention, because the framework is educational rather than clinical.

Implications for Policymakers

Policy should avoid framing mathematics anxiety as a resilience deficit while retaining high-stakes structures and unequal learning conditions. Curriculum and assessment guidance can encourage conceptual depth, low-stakes formative use of evidence and multiple forms of mathematical communication. Teacher education should include affective dimensions of mathematics teaching, multilingual pedagogies and the critical use of educational technology. Investment in infrastructure and student support is part of anxiety reduction because of the availability of time, feedback, devices, connectivity and specialist support conditions what teachers can implement.

Limitations and Research Agenda

This article is a conceptual synthesis and does not test the framework empirically. The Scopus searches documented the breadth of the literature base, but purposive prioritization and supplementary reference tracing do not provide the exhaustive coverage or risk-of-bias assessment of a systematic review. English-language and database-indexing biases remain possible. The evidence base is also uneven: associations between

mathematics anxiety and achievement are robust, but direct evidence for classroom mechanisms, interactions among mechanisms and equitable implementation remains comparatively limited. Several central sources were reviews or conceptual accounts rather than intervention studies, and some intervention literatures were marked by small samples, heterogeneous outcomes and weak designs.

Future research should test the model through longitudinal and mixed-methods designs that measure mathematics anxiety, participation, self-efficacy and mathematical well-being together. Classroom studies should examine interactions rather than isolated interventions, including whether agency produces different outcomes under high and low levels of instructional structure or emotional safety. Research in multilingual, rural and under-resourced settings is particularly important because many intervention studies assume resources and class conditions that are not universally available. Participatory designs can also help determine whether students experience intended supports as agency, feedback, recognition, or as exposure, surveillance, and lowered expectations.

CONCLUSIONS

Mathematics anxiety cannot be understood adequately as an internal emotional deficit detached from teaching, relationships and educational conditions. The four-pillar framework proposes that agency-supportive participation, instructional clarity and formative support, adaptive mathematical beliefs and self-regulation, and equitable belonging and emotional safety influence anxiety through perceived control, evidence of competence, predictability, recognition, and belonging. Technology can support these processes, but only conditionally. The framework's contribution lies in explaining interactions, tensions and boundary conditions and in offering propositions that can be tested across contexts. By linking lower anxiety to participation, self-efficacy, and mathematical well-being, the model provides a basis for classroom practice, professional learning, and research that treats emotional support and equity as integral to mathematics education.

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