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Mathematical modeling and problem solving: a systematic review

Modelado matemático y resolución de problemas: una revisión sistemática

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Abstract

Mathematics education faces a crisis stemming from the recurring use of pedagogical practices that hinder learning. In this context, the objective of this study was to analyze mathematical modeling as a pedagogical strategy for problem-solving through a systematic review. The research adopted a qualitative, documentary approach and, following the 2020 PRISMA guidelines, a search was conducted in seven databases (Scopus, Web of Science, Redalyc, ERIC, SciELO, Dialnet, and Latindex). From this search, 31 primary studies published between 2022 and 2026 were selected and their methodological quality assessed using the Mixed Methods Appraisal Tool (MMAT). Among the main findings, it is noteworthy that the implementation of mathematical modeling significantly improves performance in problem-solving, conceptual understanding, and critical thinking. However, its effectiveness is mediated by teacher training and the educational level. It is concluded that the success of this strategy lies not in the linear application of the modeling cycle, but in mastering its initial structuring and final validation phases. Consequently, it is recommended to strengthen teacher training in these phases and expand the use of mathematical modeling in basic education.

Keywords: teaching, mathematical modeling, problem-solving.

Resumen

La enseñanza de la matemática enfrenta una crisis derivada del uso recurrente de prácticas pedagógicas que obstaculizan su aprendizaje. En este contexto, el objetivo del estudio fue analizar el modelado matemático como estrategia pedagógica para la resolución de problemas, mediante una revisión sistemática. La investigación adoptó un enfoque cualitativo de tipo documental y, siguiendo la declaración PRISMA 2020, se realizó una búsqueda en siete bases de datos (Scopus, Web of Science, Redalyc, ERIC, SciELO, Dialnet y Latindex). De esta búsqueda se seleccionaron 31 estudios primarios publicados entre 2022 y 2026, los cuales fueron evaluados en su calidad metodológica con la Herramienta de Evaluación de Métodos Mixtos (*Mixed Methods Appraisal Tool*, MMAT). Entre los principales hallazgos destaca que la implementación del modelado matemático mejora significativamente el desempeño en la resolución de problemas, la comprensión conceptual y el pensamiento crítico. No obstante, su efectividad está mediada por la formación docente y el nivel educativo. Se concluye que el éxito de esta estrategia no reside en la aplicación lineal del ciclo de modelado, sino en el dominio de sus fases de estructuración inicial y validación final. En consecuencia, se recomienda fortalecer la formación docente en estas fases y ampliar el uso del modelado matemático en la educación básica.

Palabras clave: enseñanza, modelado matemático, resolución de problemas.

Introduction

Understanding and optimizing the cognitive mechanisms underlying school learning remains one of the central concerns of contemporary educational research. Logical-mathematical thinking, in particular, is essential for shaping analytical citizens capable of confronting the challenges of today's world. Yet the situation across Latin America falls well short of this ideal. Delprato (2025) found that a substantial proportion of students fail to reach basic mathematical competencies, a shortfall driven by structural factors such as poverty, inadequate infrastructure, and low teaching quality.

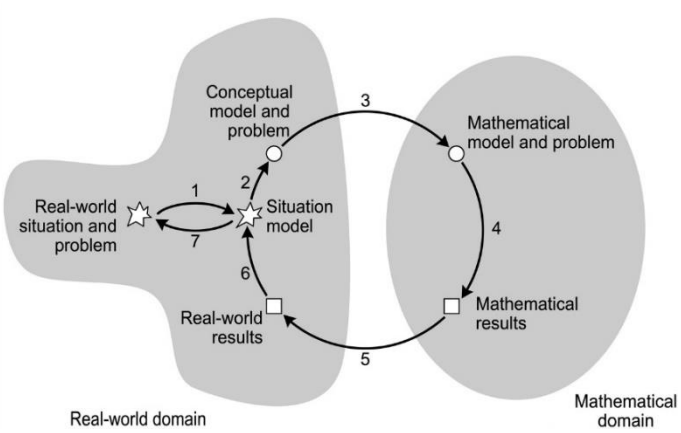
Compounding this picture are the traditional methodologies still prevalent in many classrooms, which favor rote memorization over genuine understanding. Vidal (2024) points out that this approach severely limits students' appropriation of course content. Far from being a minor issue, mechanized learning heightens mathematics anxiety (Hermoza, 2024) and becomes more acute when prior cognitive limitations contribute to poor performance during secondary school (Stelzer et al., 2023). Among these limitations, dyscalculia stands out, defined by Salisa and Meiliasari (2023) as a specific learning condition that affects the comprehension and manipulation of numerical concepts, with the potential to undermine students' academic performance and well-being in mathematics education (p. 1).

The lack of timely diagnosis largely explains why these difficulties persist without adequate attention. In most cases, teachers lack the training needed to identify learning difficulties, which forecloses early intervention (Bisso, 2024). Compounding this are gaps in teachers' own mathematical skills, which affect both problem solving and mathematical communication in the classroom (Aguilar & Ortiz, 2024). Nor can the role of families be overlooked: parental education and students' motivation are variables that directly shape outcomes (Castro & Rivadeneira, 2022). Geographic context is another determining factor, as students display uneven performance depending on their setting, with greater difficulties observed in rural areas marked by persistent educational gaps (Guadalupe, 2025).

The present study examines mathematical modeling as a pedagogical strategy for problem solving. Mathematics education is not only key to understanding the challenges of sustainable development and making decisions geared toward social well-being (Moreno-Pino et al., 2022), but also drives technological and scientific progress (Bayug, 2022). Problem-solving modeling is addressed here because it promotes the representation of real-world situations, the design of solution strategies, and reasoning applied to complex problems (Schukajlow et al., 2023). It also fosters meaningful learning and reduces the anxiety that arises when mathematics is presented as a set of abstract, meaningless rules (Flores & Caamaño, 2024), all within an approach centered on active learning and curricular understanding (Damerval, 2024).

It is worth noting that modeling is not limited to solving problems already posed; it also entails formulating problems, developing models, and generating strategies that foster advanced mathematical reasoning (Hartmann et al., 2023). For this reason, it calls for a pedagogical design that promotes critical thinking and the transfer of knowledge to everyday life (Cobeña & Cedeño, 2023), enabling students to analyze real situations and validate solutions in authentic contexts (Kohen & Nitzan, 2022). Through this process, students develop inquiry skills, creativity, and self-confidence (Blum & Niss, 1985, as cited in Guerrero-Ortiz, 2024). For Cai et al. (2014), modeling is the art or process of constructing a mathematical representation of reality that captures, simulates, or represents selected features or behaviors of the aspect of reality being modeled (p. 150). This is a demanding process for students, as it is bound up with other competencies, such as reading and formal mathematical work (Blum & Borromeo, 2009). To understand it more fully, it is useful to consider the following seven-step cycle:

Figure 1
Modeling cycle



Note. Figure reproduced from the article *Mathematical Modelling: Can It Be Taught And Learnt?*, by Blum and Borromeo (2009). The cycle depicts the transit between the "real world" and the "mathematical world" involved in solving everyday problems with mathematical tools

Modeling cycle

The mathematical modeling cycle is organized around two fundamental domains: the “real world” and the “mathematical world.” The former, shown in the gray area on the left, encompasses everyday life situations as well as phenomena drawn from science, economics, and other spheres of human experience. The latter, located in the gray area on the right, corresponds to the domain of equations, formulas, numbers, and abstract variables that characterize formal mathematical thinking.

The movement between these two worlds unfolds across four phases that describe the complete modeling process. The first phase, which runs from reality to a structured problem, begins with understanding a complex real-world situation, from which an initial mental model is built. This is followed by simplification and structuring, the point at which irrelevant details are discarded and only the variables essential to the analysis are retained.

The second phase marks the leap into the mathematical world through mathematization. Here the problem is translated into mathematical language, converting ideas drawn from the real-world context into variables, functions, equations, or graphical representations that allow for formal treatment.

Once inside the mathematical domain, the third phase consists of the mathematical work itself. This is where the equation or system is solved using techniques, algorithms, or specialized software, with emphasis on the accuracy of the operations and the derivation of valid mathematical results.

The fourth and final phase corresponds to the return to reality, which unfolds across three successive moves. First, interpretation, which involves translating the numerical value obtained back into the real-world context. Second, validation, through which the result is checked for sense and consistency with the original situation. Third, application and communication: if the result passes validation, it is communicated to support decision-making; otherwise, the cycle restarts with the initial assumptions adjusted. This iterative quality reflects the dynamic nature of modeling as a tool for understanding and solving problems.

It should be noted that these steps, when refined with the support of emerging technologies such as artificial intelligence or augmented reality, strengthen reflective thinking and the capacity to formulate, analyze, and evaluate models (Sanjari & Manouchehri, 2024; Özbek & Cho, 2023). This underscores the importance of examining not only the effectiveness of modeling as a strategy but also the conditions that favor its optimal implementation across diverse educational settings.

Research questions

The research questions were formulated using the PECO framework (Population, Exposure, Comparison, and Outcome), appropriate for the design of this systematic review. The population (P) comprises students and teachers in basic, secondary, and higher education within mathematics-teaching contexts; the exposure (E) refers to the implementation of mathematical modeling as a pedagogical strategy for problem solving, while the comparison (C) refers to traditional teaching strategies or the absence of structured mathematical modeling. The outcomes (O) assessed include performance, conceptual understanding, critical thinking, and problem-solving competencies.

Accordingly, the first question seeks to determine the extent to which implementing mathematical modeling (E), relative to traditional teaching approaches (C), improves performance in mathematical problem solving (O) among students in basic, secondary, and higher education (P). The second question examines what competencies and training gaps teachers (P) display in the inquiry, validation, and communication phases of the mathematical modeling cycle (E), and how the absence of specific training in these phases (C) affects the quality of pedagogical mediation (O).

Finally, the third question explores the role that digital technological tools (E) play in developing modeling competencies and reducing mathematical anxiety (O) among students (P), compared with approaches that do not incorporate technological mediation (C).

Methodology

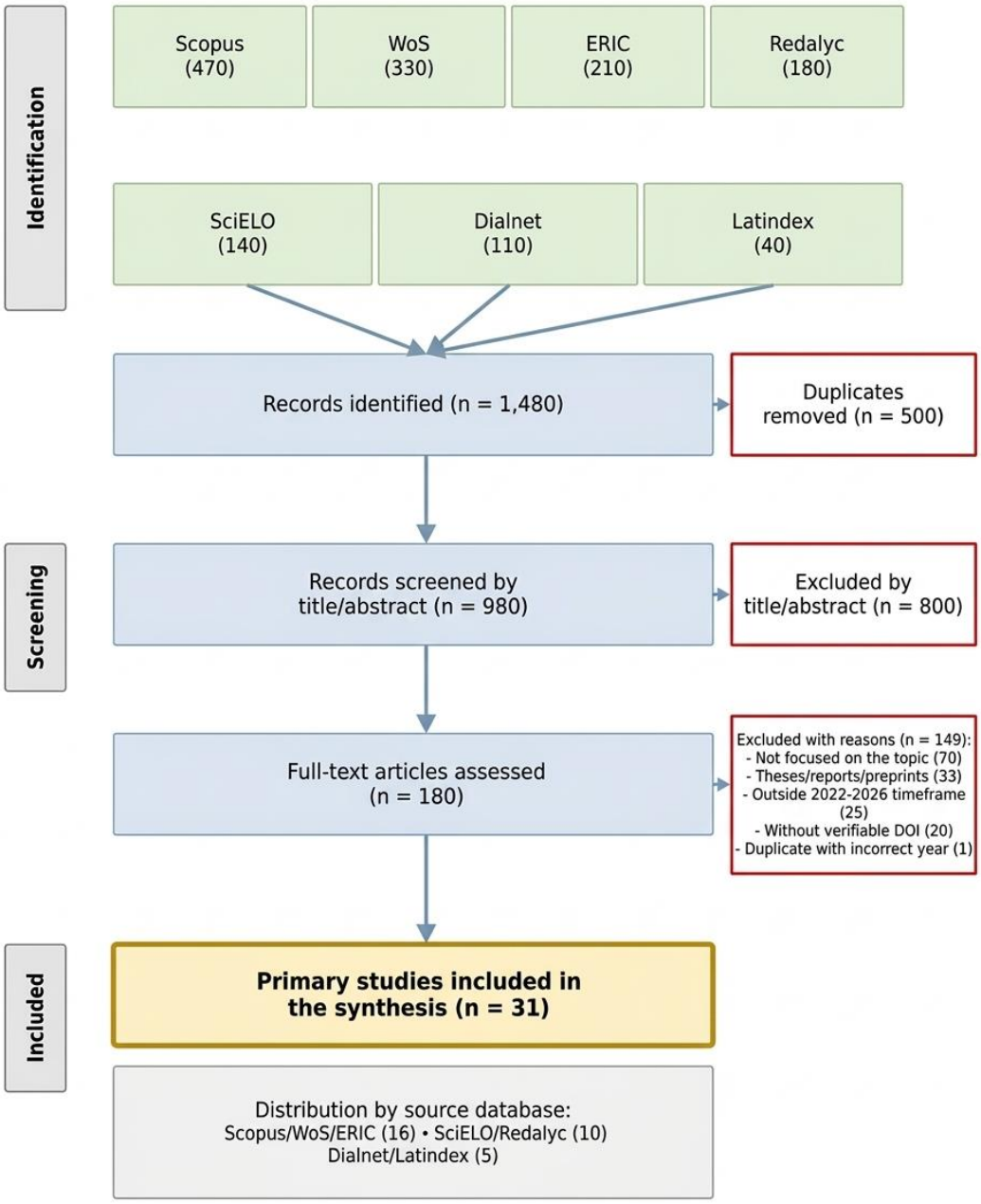
This study follows a qualitative, documentary approach, in line with systematic-review guidelines and the criteria set out in the PRISMA 2020 statement (Page et al., 2021), structured around three phases: identification, screening, and inclusion. The search was carried out across seven databases, Scopus, Web of Science (WoS), Redalyc, ERIC, SciELO, Dialnet, and Latindex, combining internationally indexed output with Ibero-American production. In Scopus and WoS, the following search string was applied: *TITLE-ABS-KEY*((“*mathematical modeling*” *OR* “*mathematical modelling*” *OR* “modelado matemático” *OR* “modelización matemática” *OR* “modelación matemática”) *AND* (“*problem solving*” *OR* “resolución de problemas”) *AND* (*education OR teaching OR* “enseñanza” *OR*“educación”)), limited to articles and reviews in Spanish and English. In ERIC, the free-text search was combined with the descriptors *DE* “*Mathematical Models*” *AND DE* “*Problem Solving*”, filtered to peer-

reviewed literature; in Redalyc and SciELO, the search used ("modelado matemático" *OR* "modelización matemática" *OR* "modelación matemática") *AND* ("resolución de problemas") *AND* (educación *OR* enseñanza) applied to the title, abstract, and keyword fields; and in Dialnet and Latindex, given their limited Boolean syntax, a combined field-based search was carried out with documented manual screening. The time frame was set between 2022 and 2026.

The search identified 1,480 records (Scopus n = 470; WoS n = 330; ERIC n = 210; Redalyc n = 180; SciELO n = 140; Dialnet n = 110; Latindex n = 40). After removing 500 duplicates, 980 records were screened by title and abstract, and 800 of these were excluded for not addressing the study variables. Of the 180 articles assessed in full text, 149 were excluded because they did not focus on the target variables (n = 70), were theses, technical reports, or *preprints* (n = 33), fell outside the 2022–2026 period (n = 25), lacked a verifiable DOI or URL (n = 20), or were a duplicate listed under the wrong year (n = 1). Inclusion criteria considered original or review articles, published between 2022 and 2026, in Spanish or English, focused on mathematical modeling and/or problem solving in educational contexts. The final corpus comprised 31 studies (Figure 2), distributed across Scopus/WoS/ERIC (n = 16), SciELO/Redalyc (n = 10), and Dialnet/Latindex (n = 5).

Methodological quality was assessed with the Mixed Methods Appraisal Tool (MMAT), 2018 version (Hong et al., 2018), which appraises qualitative, non-randomized quantitative, and mixed-methods designs, predominant in this corpus, through two screening questions and five criteria per design category; two reviewers applied it independently and resolved any discrepancies by consensus. For the experimental and meta-analytic subset (Amao & Vicuña, 2026; Charalambous & Charalambous, 2023), the Cochrane Risk of Bias 2 tool (RoB 2; Sterne et al., 2019) was additionally applied, assessing five domains: randomization, deviations from intended interventions, missing data, measurement, and selection of the reported result. No study was excluded on grounds of low quality; scores were instead used to weight each finding within the narrative synthesis.

Figure 2
Flow diagram resulting from the PRISMA protocol



Results

The final corpus of this systematic review comprises 31 studies published between 2022 and 2026, selected after applying the inclusion and exclusion criteria set out under the PRISMA 2020 statement. What follows is a characterization of the corpus in terms of geographic origin, source databases, and thematic distribution, followed by a description of the eight emerging categories. This organization makes it possible to visualize both the diversity of approaches and the predominant trends in recent research on mathematical modeling as a pedagogical strategy.

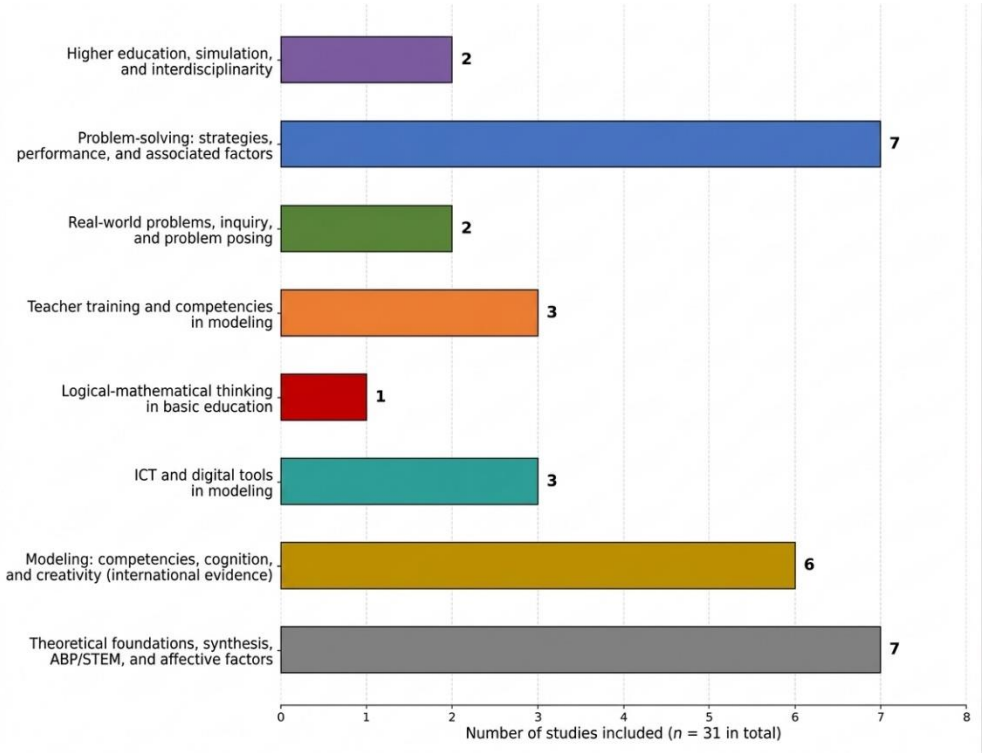
Table 1
Characteristics of the corpus of included studies (n = 31), classified by thematic category

Article citation	Country / Database	Category (3.1)
Mejía et al., (2022)	Peru / Scielo	B
Barquero-Ocampo et al., (2025)	Costa Rica/Scielo	D
Malusín et al., (2025)	Ecuador/Dialnet	B
Reyes (2025).	Ecuador/Dialnet	C
Malaspina (2022)	Peru/Dialnet	C
Tambaco et al., (2025)	Ecuador/Latindex	E
Paredes Morán et al. (2025)	Ecuador/Latindex	A
Fonseca et al., (2025)	Ecuador/Latindex	A
Orihuela De la Cruz (2025)	Peru / Scopus, Google Scholar	B
Melo Albornoz & Miyagui Miyagui (2026)	Peru / Scopus	H
Amao Llaulli & Vicuña Parra (2026)	Peru / SciELO	H
Yupanqui Valverde (2023)	Peru / Scopus, SciELO, Redalyc, EBSCO	B
Heredia Ponce et al. (2024)	Spain / Scopus, Redalyc	B
Chavarría-Vásquez & Gamboa-Araya (2024a)	Costa Rica / SciELO, Redalyc, DOAJ	D
Díaz & Gastello (2025)	Peru / Scopus, WoS, SciELO (Rev. ESPACIOS)	B
Martínez-Miraval et al. (2025)	Peru / SciELO, Redalyc, Scopus	F
Hidayat et al. (2025)	Malaysia / Scopus, WoS	H
Charalambous & Charalambous (2023)	Cyprus / Scopus, WoS	G
Koyunkaya & Dede (2024)	Turkey / Scopus, WoS	F
Kaygısız & Şenel (2023)	Turkey / ERIC, Scopus	G
Wang et al. (2023)	China / Scopus, WoS, PMC	G
Cevikbas et al. (2022)	Germany / WoS, Scopus, ERIC, PsycINFO	H
Krawitz et al. (2022)	Germany/Taiwan / Scopus, WoS	G
Lehmann (2023)	Australia / Scopus, WoS	G
Cohen-Nissan, O., & Kohen, Z. (2023)	Israel / Scopus, WoS	G
Coa-Mamani & Obregón-Ramos (2023)	Peru/Bolivia / SciELO, Latindex	H
Martínez-Miraval et al. (2024)	Peru / SciELO, Scopus	F
Velázquez & Goñi (2024)	Uruguay/Peru / SciELO, Dialnet	B
Chavarría-Vásquez & Gamboa-Araya (2024b)	Costa Rica / Redalyc, SciELO	D
Wahyuni et al. (2024)	Indonesia / Scopus	H
Arias-De-La-Cruz & Vergara-Ibarra (2024)	Ecuador / Latindex, DOAJ	H

Source. Author's own elaboration.

Figure 3

Thematic distribution of the corpus (31 studies, 2022-2026)



Thematic distribution of the corpus

Figure 3 shows the distribution of the final corpus (n = 31) across eight emerging thematic categories, derived from a content analysis of the objectives, variables, and findings of each study included in the review. These categories make it possible to visualize the predominant lines of research in the recent literature on mathematical modeling as a pedagogical strategy, as well as to identify gaps and opportunities for future studies. Each category is described below, together with its associated studies and the most salient findings that characterize it.

Category A, Higher Education, Simulation, and Interdisciplinarity (n = 2), groups the studies by Fonseca et al. (2025) and Paredes et al. (2025). This category shows the greatest concentration of authorship at the university level, where the findings show that modeling reaches its fullest development as a tool for connecting theory with practice and simulating complex phenomena.

By contrast, Category B, Problem Solving: Strategies, Performance, and Associated Factors (n = 7), is the category with the largest number of studies in the corpus. It includes the work of Mejía et al. (2022), Malusín et al. (2025), Orihuela De la Cruz (2025), Yupanqui (2023), Heredia et al. (2024), Díaz and Gastello (2025), and Velázquez-Tejeda and Goñi (2024). The results confirm the impact of modeling on calculation and arithmetic (Mejía et al., 2022; Malusín et al., 2025), with additional evidence on the role of metastrategies and reading comprehension as mediators of performance.

For its part, Category C, Real Problems, Inquiry, and Problem Posing (n = 2), brings together the studies by Reyes (2025) and Malaspina (2022). Both emphasize that creating and inventing contextualized problems increases students' motivation and theoretical understanding.

Cutting across the preceding categories is teacher training, addressed specifically in Category D, Teacher Training and Modeling Competencies (n = 3), which includes the studies by Barquero-Ocampo et al. (2025) and Chavarría-Vásquez and Gamboa-Araya (2024a, 2024b). The findings confirm that the success of modeling in the classroom is held back by methodological gaps among preservice teachers when it comes to inquiring into and validating models. Confusion between modeling and problem solving likewise persists, even among teacher educators.

At the opposite end of the education system, Category E, Logical-Mathematical Thinking in Basic Education (n = 1), is represented by the study by Tambaco et al. (2025). This work applies modeling in the early stages of

General Basic Education, with an emphasis on the transition to abstract thinking. It is the least represented category in the corpus, suggesting an opportunity for future research at this level.

Category F, ICT and Digital Tools in Modeling (n = 3), groups the studies by Martínez-Miraval et al. (2025, 2024) and Koyunkaya and Dede (2024). The results show that tools such as GeoGebra facilitate connections among numerical, algebraic, and geometric representations. It is also observed that teachers integrate multiple tools when technology is embedded coherently within the curriculum.

Beyond the Latin American context, Category G, Modeling: Competencies, Cognition, and Creativity, International Evidence (n = 6), includes the work of Charalambous and Charalambous (2023), Kaygısız and Şenel (2023), Wang et al. (2023), Krawitz et al. (2022), Lehmann (2023), and Cohen-Nissan and Kohen (2023). These studies provide experimental and quasi-experimental evidence on how modeling competency relates to creativity, reading comprehension, motivation, and algorithmic thinking in the contexts of Cyprus, Turkey, China, Germany, and Israel.

Finally, Category H, Theoretical Foundations, Literature Synthesis, PBL/STEM, and Affective Factors (n = 7), brings together studies of a varied nature. On one hand, the work of Melo and Miyagui (2026), Hidayat et al. (2025), Cevikbas et al. (2022), and Coa-Mamani and Obregón-Ramos (2023) systematizes the state of the art. On the other, the studies by Amao Llaulli and Vicuña Parra (2026) and Arias-De-La-Cruz and Vergara-Ibarra (2024) focus on PBL/STEM and performance. Finally, the study by Wahyuni et al. (2024) is the only one centered on mathematical anxiety and self-confidence. Taken together, this set of studies confirms an already identified gap: the socio-affective factors associated with mathematical anxiety, first raised in relation to Hermoza (2024), remain underexplored in the recent empirical literature.

Discussion

The results of this review, assessed using the Mixed Methods Appraisal Tool, indicate that mathematical modeling extends well beyond improvements in academic performance: its effectiveness is mediated by educational level, teacher training, and task design, in dialogue with the seven-step cycle proposed by Blum and Borromeo (2009), which reveals both its potential and its limitations.

First, the modeling cycle proves to be a highly useful analytical reference. Mejía et al. (2022) and Malusín et al. (2025) show that its implementation, even when implicit or fragmented, produces significant gains in solving calculation and basic arithmetic problems. Its effectiveness, however, hinges on the “simplification and structuring” phase, which is frequently overlooked. Malusín et al. (2025) report a 74.3% deficiency rate on arithmetic problems tackled without a modeling strategy, confirming that practical success depends on explicitly working through the “comprehension and simplification” phase, the one given the least attention relative to the more algorithmic “mathematical work” phase.

Second, the cycle posits a movement between the “real world” and the “mathematical world,” which lies at the core of the proposals by Reyes (2025) and Malaspina (2022), who emphasize the creation of contextualized problems and validate the “interpretation” and “validation” phases. Barquero-Ocampo et al. (2025), however, note that preservice teachers show gaps precisely in these closing phases: the weakest link is not solving the equation but returning to the real world and judging the model’s relevance, a gap that positions teacher training as a structural factor in the process. This is confirmed by Chavarría-Vásquez and Gamboa-Araya (2024b), who document confusion even among teacher educators, while Charalambous and Charalambous (2023) show, through a randomized trial, that an intervention focused on structuring and validation produces sustained gains; in other words, these phases can indeed be trained.

Third, the thematic analysis reveals a concentration of research in higher education, with an emphasis on interdisciplinarity and simulation (Fonseca et al., 2025; Paredes et al., 2025), confirming that modeling is perceived as a powerful tool for addressing complex phenomena. This contrasts with the scant attention paid to logical thinking in basic education (Tambaco et al., 2025), a gap that raises the question of why this level, where the foundations of abstract thinking are laid, is not explored with equal intensity, likely owing to curricular barriers that constrain its scale-up.

The analysis of the corpus yields two further relevant findings. International evidence confirms that modeling fosters creativity (Wang et al., 2023) and that reading comprehension bears on the construction of the situational model (Krawitz et al., 2022), an obstacle that also affects the first phase of the cycle. In addition, mathematical anxiety (Wahyuni et al., 2024) reduces performance in problem solving, whereas self-confidence protects against it; this connects with the anxiety documented by Hermoza (2024) among Peruvian students and suggests that modeling could serve as a strategy for affective mitigation, a promising avenue for future research.

Finally, a contradiction persists: cycle theory offers a structured path toward developing higher-order competencies, yet its implementation is constrained by poverty, inadequate infrastructure, and low teaching quality

(Delprato, 2025; Guadalupe, 2025). To become firmly established, modeling requires teachers trained in inquiry and validation, flexible curricula, and technological resources. Integrating emerging technologies, as Sanjari and Manouchehri (2024) suggest, could help overcome some of these barriers, but it does not resolve the underlying problem: teacher training and policies that place critical thinking at the center of the curriculum.

Conclusions

This systematic review, based on a corpus of 31 studies drawn from seven databases and assessed with the Mixed Methods Appraisal Tool, supports the conclusion that mathematical modeling is a multidimensional approach that, when implemented effectively, improves performance, fosters critical thinking, and connects learning with reality. Its theoretical power, however, exemplified in the cycle proposed by Blum and Borromeo (2009), is weakened by practical factors that constrain its widespread implementation.

It is concluded that the success of modeling lies not in the linear application of the cycle but in mastering its least-valued phases: initial structuring and final validation. Students improve when guided through the simplification of reality, and teachers fall short when they lack the skills to inquire into and validate models, indicating that the critical link is teacher competency at the entry and exit phases of the cycle.

A gap emerges that fragments the potential of modeling: studies are concentrated at the university level and around modeling competencies with an interdisciplinary focus, while basic education and the socio-affective factors underlying mathematical anxiety remain neglected. This suggests that the benefits of modeling are being harnessed to train specialists, yet squandered at the very stages where the anxiety and cognitive shortfalls identified in the introduction could be prevented.

Mathematical modeling is not a pedagogical recipe but a practice that depends on teacher training, curricular flexibility, and the availability of resources; workshops that fail to address these factors will have a limited impact. Future lines of research should explore models that integrate teacher training, curricular redesign, and supporting technologies, addressing the educational gaps that shape student performance.

Mathematical modeling is a pedagogically valuable strategy whose adoption calls for a paradigm shift that reaches beyond the classroom: it is not enough to teach modeling; what is needed is to train professionals capable of teaching students to think, simplify, and validate knowledge.

References

Aguilar, C., & Ortiz, T. (2024). Habilidades matemáticas docentes y sus perspectivas acerca de cómo desarrollan las competencias matemáticas de los estudiantes. *SCIÉNDO, 27*(2), 251-256. https://doi.org/10.17268/sciendo.2024.036

Amao Llaulli, W. L., & Vicuña Parra, J. R. (2026). Impacto del aprendizaje basado en problemas en matemáticas de secundaria: revisión sistemática y meta-análisis. *Horizontes. Revista de Investigación en Ciencias de la Educación, 10*(41), 554-571. https://doi.org/10.33996/revistahorizontes.v10i41.1224

Arias-De-La-Cruz, I. A., & Vergara-Ibarra, J. L. (2024). Metodología STEM para mejorar el aprendizaje de las matemáticas en la Educación Básica Superior. *MQRInvestigar, 8*(4), 5845-5867. https://doi.org/10.56048/MQR20225.8.4.2024.5845-5867

Barquero-Ocampo, A., Chaves-Montero, D., Chavarría-Vásquez, J., & Gamboa-Araya, R. (2025). Competencias en modelización matemática de docentes de secundaria quienes se están formando en Educación Matemática: un análisis a partir del abordaje en resolver situaciones problema. *Uniciencia, 39*(1), 1-25. https://www.scielo.sa.cr/scielo.php?pid=S2215-34702025000100541&script=sci_arttext

Bayug, J. (2022). The impact of mathematics in shaping the understanding of nature and humanity. *International Journal of Arts, Sciences and Education, 3*(2), 165-178. https://www.ijase.org/index.php/ijase/article/view/134

Bisso, P. (2024). *Conocimientos sobre las dificultades específicas de aprendizaje de estudiantes de educación de dos universidades peruanas de Piura y Trujillo según su formación* [Tesis de maestría, Pontificia Universidad Católica del Perú]. Repositorio Institucional PUCP. http://hdl.handle.net/20.500.12404/26956

Blum, W., & Borromeo, R. (2009). Mathematical modelling: Can it be taught and learnt? *Journal of Mathematical Modelling and Application, 1*, 45-58. https://eclass.uoa.gr/modules/document/file.php/MATH601/3rd%20%26%204rth%20unit/3rd%20unit_Modelling%20cycle.pdf

Cai, J., Cirillo, M., Pelesko, J. A., Borromeo Ferri, R., Borba, M. C., Geiger, V., Stillman, G., English, L. D., Wake, G., Kaiser, G., & Kwon, O. (2014). Mathematical modeling in school education: Mathematical, cognitive, curricular, instructional, and teacher educational perspectives. En *Mathematical modeling in school education: Mathematical, cognitive, curricular, instructional, and teacher educational perspectives* (pp. 1-

29). Cambridge University Press. https://scispace.com/pdf/mathematical-modeling-in-school-education-mathematical-14kbgf9lyp.pdf
Castro Velásquez, M. J., & Rivadeneira Loor, F. Y. (2022). Posibles causas del bajo rendimiento en las matemáticas: Una revisión a la literatura. *Polo del Conocimiento, 7*(2), 1089-1098. https://polodelconocimiento.com/ojs/index.php/es/article/view/3635
Cevikbas, M., Kaiser, G., & Schukajlow, S. (2022). A systematic literature review of the current discussion on mathematical modelling competencies. *Educational Studies in Mathematics, 109*, 205-236. https://doi.org/10.1007/s10649-021-10104-6
Charalambous, C. Y., & Charalambous, C. (2023). Examining the effects of an intervention on mathematical modeling in problem solving at upper elementary grades: A cluster randomized trial. *Mathematical Thinking and Learning, 27*(2), 168-193. https://doi.org/10.1080/10986065.2023.2270088
Chavarría-Vásquez, J., & Gamboa-Araya, R. (2024a). Mathematical modeling in the training process of secondary mathematics teachers. *Educare, 28*(1), 1-20. https://www.scielo.sa.cr/scielo.php?script=sci_abstract&pid=S1409-42582024000100084&lng=en&nrm=iso
Chavarría-Vásquez, J., & Gamboa-Araya, R. (2024b). Significados y perspectivas en modelización matemática de un cuerpo docente formador en Enseñanza de la Matemática de una universidad pública costarricense. *Revista Actualidades Investigativas en Educación, 24*(1), 1-27. https://doi.org/10.15517/aie.v24i1.55560
Coa-Mamani, R., & Obregón-Ramos, J. (2023). Modelación matemática como estrategia didáctica: Una perspectiva procedimental de formación académica y científica. *Revista Docentes 2.0, 16*(2), 259-270. https://doi.org/10.37843/rted.v16i2.410
Cobeña Moreira, S. P., & Cedeño Loor, F. O. (2023). Estrategia metodológica basada en la resolución de problemas para la enseñanza del razonamiento lógico-matemático. *Revista Cognosis, 8*(EE1), 207-216. https://doi.org/10.33936/cognosis.v8iEE1.5274
Cohen-Nissan, O., & Kohen, Z. (2023) Secondary school students' competencies and motivation to engage in mathematical modelling tasks in a virtual learning environment. *Frontiers in Education, 8,* 1140364. https://doi.org/10.3389/feduc.2023.1140364
Damerval Ayora, L. (2024). *Modelado matemático: Estrategia didáctica en la resolución de problemas* [Trabajo de Integración Curricular, Universidad Nacional de Loja]. Repositorio Institucional UNL. https://dspace.unl.edu.ec/items/27913cda-b40b-4212-a2a3-edff47d860a0/full
Delprato, M. (2025). *Identifying the post-pandemic determinants of low performing students in Latin America through interpretable Machine Learning SHAP Values: Insights from PISA 2022*. arXiv. https://arxiv.org/abs/2509.24508
Díaz, L. Y., & Gastello, W. (2025). Competencia matemática en educación secundaria: revisión sistemática. *Revista ESPACIOS, 46*(4), 121-134. https://doi.org/10.48082/espacios-a25v46n04p12
Flores Mayorga, C. A., & Caamaño Zambrano, R. M. (2024). El impacto de la modelación matemática en la enseñanza y aprendizaje de las matemáticas en el contexto actual. *Polo del Conocimiento, 9*(12), 3558-3562. https://polodelconocimiento.com/ojs/index.php/es/article/view/9029
Fonseca Loya, N. S., Caiza García, D. D., Cevallos Taimal, M. R., Vargas Chavarrea, S. del P., & Casa Chicaiza, M. Á. (2025). Aplicaciones de la modelación matemática en la solución de problemas complejos en ciencias y sociedad. *Ciencia y Educación, 6*(10.2), 852-860. https://doi.org/10.5281/zenodo.17857710
Guadalupe, C. (2025). Desempeños diferenciados en una evaluación de matemáticas en Perú: entorno local y abstracción en escuelas rurales. *Revista Peruana de Investigación Educativa, 16*(21). https://doi.org/10.34236/rpie.v16i21.487
Guerrero-Ortiz, C. (2024). Modelización en la educación matemática: Tendencias, perspectivas e implicancias en la formación de profesores. *Revista Venezolana de Investigación en Educación Matemática (REVIEM), 4*(3), 1-29. https://doi.org/10.54541/reviem.v4i3.117
Hartmann, L.-M., Krawitz, J., & Schukajlow, S. (2023). Posing and solving modelling problems—Extending the modelling process from a problem posing perspective. *Journal für Mathematik-Didaktik, 44*, 533-561. https://doi.org/10.1007/s13138-023-00223-3
Heredia Ponce, H., Gutiérrez Molero, S., & Romero Oliva, M. F. (2024). Comprensión lectora y resolución de problemas matemáticos: un estudio de caso. *Perfiles Educativos, 46*(185). https://doi.org/10.22201/iisue.24486167e.2024.185.61367
Hermoza Cárdenas, D. (2024). *"La matemática me pone nervioso": Cómo varió la ansiedad hacia la matemática en los estudiantes peruanos en los últimos años*. Ministerio de Educación del Perú. https://hdl.handle.net/20.500.12799/10815

Hidayat, R., Mohd Ayub, A. F., Setambah, M. A. B. B., & Mazlan, N. H. (2025). A systematic review of the best practices for teaching mathematical modelling in education context. *European Journal of Science and Mathematics Education, 13*(4), 255-272. https://doi.org/10.30935/scimath/17155

Hong, Q. N., Fàbregues, S., Bartlett, G., Boardman, F., Cargo, M., Dagenais, P., ... Gagnon, M.-P. (2018). The Mixed Methods Appraisal Tool (MMAT) version 2018 for information professionals and researchers. *Education for Information, 34*(4), 285-291. https://doi.org/10.3233/EFI-180221

Kaygısız, İ., & Şenel, E. A. (2023). Investigating mathematical modeling competencies of primary school students: Reflections from a model eliciting activity. *Journal of Pedagogical Research, 7*(1), 1-24. https://doi.org/10.33902/JPR.202317062

Kohen, Z., & Nitzan-Tamar, O. (2022). Contextual mathematical modelling: Problem-solving characterization and feasibility. *Education Sciences, 12*(7), 454. https://doi.org/10.3390/educsci12070454

Koyunkaya, M. Y., & Dede, A. T. (2024). Using different digital tools in designing and solving mathematical modelling problems. *Education and Information Technologies*, *29*, 19035–19065. https://doi.org/10.1007/s10639-024-12577-3

Krawitz, J., Chang, Y. P., Yang, K. L., & Schukajlow, S. (2022). The role of reading comprehension in mathematical modelling: Improving the construction of a real-world model and interest in Germany and Taiwan. *Educational Studies in Mathematics, 109*, 337-359. https://doi.org/10.1007/s10649-021-10058-9

Lehmann, T. H. (2023). Mathematical modelling as a vehicle for eliciting algorithmic thinking. *Educational Studies in Mathematics, 115,* 151–176. https://doi.org/10.1007/s10649-023-10275-4

Malaspina Jurado, U. V. (2022). Estimulando la modelización matemática mediante la creación de problemas. *UNIÓN - Revista Iberoamericana de Educación Matemática, 18*(64). https://union.fespm.es/index.php/UNION/article/view/661

Martínez-Miraval, M., García-Cuéllar, D., & Poveda, W. (2024). Explorando estrategias de resolución de problemas en cálculo integral con GeoGebra: un enfoque colaborativo. *Formación Universitaria, 17*(2), 161-172. https://www.scielo.cl/scielo.php?script=sci_arttext&pid=S0718-50062024000200161&lng=en&nrm=iso&tlng=en

Martínez-Miraval, M., García-Cuéllar, D., Tejera, M., & Curo Cubas, A. (2025). Modelización matemática en temas de Cálculo: dos aproximaciones tecnológicas a un problema de optimización. *Uniciencia, 39*(1). https://www.scielo.sa.cr/scielo.php?pid=S2215-34702025000100315&script=sci_arttext&tlng=en

Mejía Alemán, L. V., Gallo Águila, C. I., & Quintana Sánchez, D. J. (2022). La modelación matemática como estrategia didáctica para la resolución de problemas matemáticos. *Horizontes Revista de Investigación en Ciencias de la Educación, 6*(26), 2204-2218. https://doi.org/10.33996/revistahorizontes.v6i26.485

Melo Albornoz, M., & Miyagui Miyagui, M. (2026). El modelado matemático en secundaria: revisión bibliográfica narrativa del proceso de enseñanza. *IGOBERNANZA, 9*(34). https://doi.org/10.47865/igob.vol9.n34.2026.468

Moreno-Pino, F. M., Jiménez-Fontana, R., Cardeñoso Domingo, J. M., & Azcárate Goded, P. (2022). Training in mathematics education from a sustainability perspective: A case study of university teachers' views. *Education Sciences, 12*(3), 199. https://doi.org/10.3390/educsci12030199

Orihuela De la Cruz, C. R. (2025). Resolución de problemas y habilidades matemáticas en estudiantes de secundaria: revisión sistemática. *Tribunal. Revista en Ciencias de la Educación y Ciencias Jurídicas, 5*(10). https://doi.org/10.59659/revistatribunal.v5i10.131

Özbek, G., & Cho, S. (2023). Effects of mathematical modelling based project production and management program on gifted students' mathematical modelling and reflective thinking for real-life problem solving. *Gifted Education International, 39*(3), 327-345. https://doi.org/10.1177/02614294221118005

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., ... Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *The BMJ, 372*(71). https://doi.org/10.1136/bmj.n71

Paredes Morán, J. G., Muñoz Sigcha, B. N., Quijandria Lavarello, J. C., & Torres Cabrera, M. U. (2025). El papel de la modelación matemática en la educación universitaria: un enfoque interdisciplinario para la comprensión de fenómenos reales. *Reincisol, 4*(8), 4287-4306. https://doi.org/10.59282/reincisol.V4(8)4287-4306

Reyes Ramírez, J. B. (2025). Modelos matemáticos aplicados a la resolución de problemas reales en entornos educativos. *Educational Regent Multidisciplinary Journal, 2*(4), 1-14. https://www.researchgate.net/publication/397667049_Modelos_matematicos_aplicados_a_la_resolucion_de_problemas_reales_en_entornos_educativos

Salisa, R. D., & Meiliasari, M. (2023). A literature review on dyscalculia: What dyscalculia is, its characteristics, and difficulties students face in mathematics class. *Alifmatika: Jurnal Pendidikan Dan Pembelajaran Matematika, 5*(1), 82–94. https://doi.org/10.35316/alifmatika.2023.v5i1.82-94

Sanjari, A., & Manouchehri, A. (2024). Interactive learning: Unpacking the influence of computer simulations on students' mathematical modeling processes. *Education Sciences, 14*(4), 397. https://doi.org/10.3390/educsci14040397

Schukajlow, S., Krawitz, J., Kanefke, J., Blum, W., & Rakoczy, K. (2023). Open modelling problems: Cognitive barriers and instructional prompts. *Educational Studies in Mathematics, 114*, 417-438. https://doi.org/10.1007/s10649-023-10265-6

Stelzer, F., Aydmune, Y., García-Coni, A., Vernucci, S., & Introzzi, I. (2023). Factores cognitivos y actitudinales involucrados en el desempeño en matemáticas en estudiantes de secundaria. *Liberabit, 29*(1), e659. https://doi.org/10.24265/liberabit.2023.v29n1.659

Sterne, J. A. C., Savović, J., Page, M. J., Elbers, R. G., Blencowe, N. S., Boutron, I., ... Higgins, J. P. T. (2019). RoB 2: A revised tool for assessing risk of bias in randomised trials. *The BMJ, 366*, l4898. https://doi.org/10.1136/bmj.l4898

Tambaco Quintero, A. R., Barcia Cedeño, E. I., Simisterra Muñoz, J. M., Franco Valdez, J. L., & Ponce Quiñonez, D. D. (2025). Resolución de problemas de multiplicación mediante modelado: una aproximación al pensamiento matemático en la Educación General Básica. *Ciencia y Reflexión, 4*(2), 311-324. https://doi.org/10.70747/cr.v4i2.330

Velázquez-Tejeda, M. E., & Goñi, F. F. (2024). Modelo de estrategia metacognitiva para el desarrollo de la resolución de problemas matemáticos. *Páginas de Educación, 17*(1). https://doi.org/10.22235/pe.v17i1.3313

Vidal Valverde, G. V. (2024). El aprendizaje invertido en la competencia matemática: Una experiencia en la educación básica peruana. *Ciencia Latina Revista Científica Multidisciplinar, 8*(2), 99-118. https://doi.org/10.37811/cl_rcm.v8i1.10384

Wahyuni, R., Juniati, D., & Wijayanti, P. (2024). How do math anxiety and self-confidence affect mathematical problem solving? *TEM Journal, 13*(1), 550-560. https://doi.org/10.18421/TEM131-58

Wang, X., Zhang, J., Xie, F., & Liu, C. (2023). How does mathematical modeling competency affect the creativity of middle school students? The roles of curiosity and guided inquiry teaching. *Frontiers in Psychology, 13*. https://doi.org/10.3389/fpsyg.2022.1044580

Yupanqui Valverde, Y. N. (2023). Estrategias didácticas para la resolución de problemas matemáticos en alumnos de educación básica regular. *Horizontes. Revista de Investigación en Ciencias de la Educación, 7*(30). https://doi.org/10.33996/revistahorizontes.v7i30.638

Declaration on the Use of Artificial Intelligence (AI)

The use of artificial intelligence (Claude, Anthropic) is declared as a support tool in revising this manuscript, specifically for academic literature searches, spelling and writing corrections, the preparation of Figures 2 and 3, and adaptation to the style guidelines of Revista InveCom. All AI-generated content was reviewed and validated by the author, who assumes full responsibility for the scientific accuracy and conclusions of the study.