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Mathematical Modeling in Mathematics Education: A Bibliometric-Systematic Literature Review Highlighting Current Research Trends and Future Research Directions

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Abstract
Mathematical modeling is a crucial skill in mathematics education that bridges conceptual knowledge and real-world problem-solving. This study aims to evaluate the global research landscape of mathematical modeling in mathematics education to delineate current empirical trends and future research directions. By analyzing 179 Scopus-indexed documents published between 2020 and 2026 through a Bibliometric–Systematic Literature Review (B-SLR) framework., this study reveals a significant upward trend in scientific production, peaking in 2025 with 47 documents (26.26%). Germany emerges as the most productive country (39 publications), with ZDM–Mathematics Education identified as the leading publication source. Keyword co-occurrence analysis highlights an evolutionary shift from fundamental modeling competencies toward broader interdisciplinary themes, including technology integration, sustainability, and computational thinking. Furthermore, the systematic review shows that pre-service teachers are the most frequently studied participants (32%), reflecting an upstream approach to teacher pedagogical readiness. Methodologically, current research is heavily dominated by qualitative approaches (51%) and descriptive study designs (37%), focusing on the holistic, nuanced dimensions of modeling goals. Future research directions suggest expanding empirical investigations into underrepresented cohorts such as primary and upper secondary students and exploring emerging AI-related learning contexts through experimental and longitudinal methodologies.

Keywords: Mathematical Modeling, Mathematics Education, Bibliometric-Systematic Literature Review, Problem Solving, Research Trends.

1. Introduction

Mathematical modeling is a crucial skill and pedagogical approach that involves applying mathematical concepts, techniques, and tools to address real-world problems (Haas et al., 2023; Ledezma et al., 2026). It serves as a bridge between mathematical knowledge and practical applications, helping individuals understand how mathematical principles can be used to solve problems across various fields (Kandemir & Eryilmaz, 2025). This approach can enhance learners' understanding, improve their focus, and help them retain learning expectations in mathematics (Bekene et al., 2025). It also promotes student-centered learning and helps train capable individuals to tackle complex, multifaceted problems (Lu et al., 2026). Therefore, Mathematical modeling is a powerful tool for developing problem-solving skills and competencies by applying mathematical concepts to real-world situations.

However, the implementation of mathematical modeling in learning also faces a few challenges. Several studies show that students often have difficulty making assumptions, simplifying problems, and connecting real-world situations with mathematical representations (Seçgin et al., 2024). In addition, limited learning time and the dominance of a learning approach oriented towards mathematical procedures also pose obstacles to the application of mathematical modeling in the classroom (Cambi & Caldeira, 2023). Another challenge relates to teachers' readiness in designing contextual modeling activities that are appropriate for students' cognitive levels (Cevikbas et al., 2025). These conditions indicate that although mathematical modeling has great potential in learning, a more comprehensive understanding of research developments in this field is still needed.

Although research on mathematical modeling in mathematics education has developed significantly, challenges remain in understanding its global development in a more structured and comprehensive way, as studies still vary widely in terms of focus, methodology, and research context (Diana et al., 2023). The increasing number of publications has not always been accompanied by a clear mapping of research development trends, leaving various studies examined from different perspectives fragmented. Following the increase in scientific publications on mathematical modeling, various literature reviews have been conducted to map the development of research in this field. A bibliometric study conducted by Fajri et al. (2025) that research on mathematical modeling at the elementary school level has increased significantly since 2015. Another bibliometric study conducted by Şahin, (2025) also identified the dynamics of research publications on mathematical modeling in mathematics education and showed that journals such as ZDM–Mathematics Education and Educational Studies in Mathematics are the main sources of publications in this field. Meanwhile, a systematic literature review conducted by (Krawitz et al., 2025) revealed a variety of objectives, task characteristics, and research perspectives in mathematical modeling studies in various countries. However, these existing reviews are limited because they either narrow their scope to isolated student level (elementary level only) or their reliance on single, fragmented methodological frameworks (pure bibliometrics or pure qualitative reviews alone). Consequently, they did not provide an integrated picture that simultaneously pairs macro-global trends with micro-operational characteristics (participants, designs, and modeling goals) across all educational levels.

Based on this background, this study aims to conduct a bibliometric-systematic literature review (B-SLR) on mathematical modeling in mathematics education globally using the Scopus database to map the direction of literature and identify existing gaps. Consequently, the following research questions have been formulated:1) What are the publication trends research on mathematical modeling in mathematics education from 2020 to 2026? 2) Who are the most productive authors in this research field and how do they conceptually define mathematical modeling? 3) What research themes and topic trends have emerged in the literature on mathematical modeling in mathematics education? 4) What are the characteristics of current research in terms of participants, methodologies, study design, and modeling goals? 5) What future research directions and practical implications are identified in the literature on mathematical modeling in mathematics education?

2. Methods

This study used a structured framework to conduct a systematic literature review, known as Bibliometric–Systematic Literature Review (B-SLR), with reference to the guidelines outlined in (Marzi et al., 2025). This methodology combines bibliometric analysis with SLR to offer a thorough picture of the state of mathematical modeling research from 2020 to 2026, mapping publishing trends, scientific collaboration patterns, and conceptual contributions.

The data collection process in this study completely relied on the Scopus database, which provides global coverage of scientific publications and is widely considered credible and frequently used in bibliometric analysis in the fields of social sciences (Dede & Ozdemir, 2022; Fajri et al., 2025). The analysis period was set from January 2020 to May 13, 2026. In the identification stage, document searches use the search code line : TITLE (model*) AND TITLE-ABS-KEY ("mathematical modeling" OR "mathematical modelling" OR "modeling in mathematics" OR "modelling in mathematics") AND TITLE-ABS-KEY (math* AND (learning OR teaching OR education)) AND LANGUAGE (english) AND PUBSTAGE (final) AND PUBYEAR > 2019 AND PUBYEAR < 2027 AND (LIMIT-TO (SUBJAREA , "SOCI") OR LIMIT-TO (SUBJAREA , "PSYC")) AND (LIMIT-TO (DOCTYPE , "re") OR LIMIT-TO (DOCTYPE , "ar"))

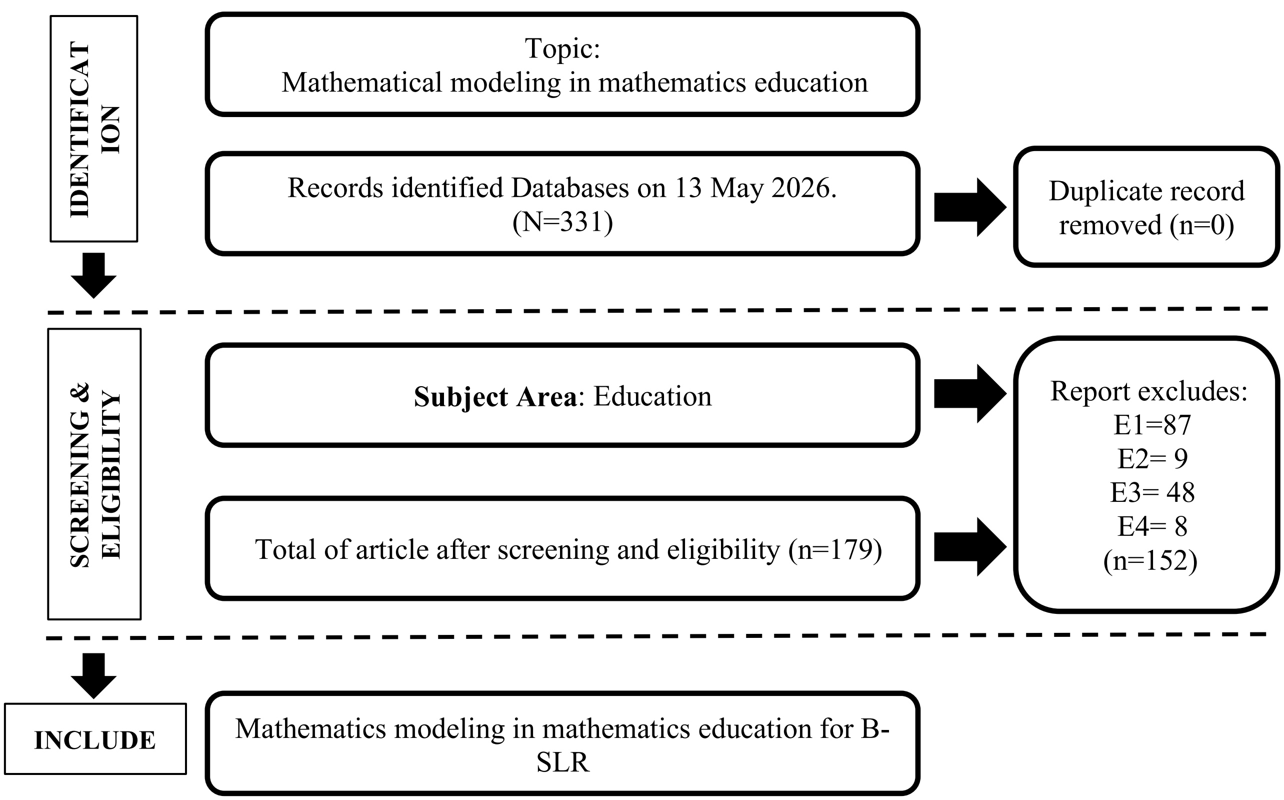
The search was limited to the subject areas of "Social Sciences" and "Psychology", since educational research is structurally indexed under these two categories within the Scopus database architecture and restricted to document types "Article" and "Review".

The initial search results obtained 331 documents. Explicit inclusion and exclusion criteria (Table 1) were then applied to determine the eligibility of primary studies, extracting relevant information to answer the research questions. After applying these screening and eligibility processes, 152 irrelevant records were excluded, producing a final consolidated set of 179 documents for the B-SLR analysis.

Table 1.
Criteria of Inclusion and Exclusion

Inclusion (I)	Exclusion (E)
I1: Research on mathematical modeling in the context of mathematics education	E1: Research outside the context of mathematics education
I2: Research published in English	E2: Research published not in English
I3: Full text is available	E3: Full text is not available
I4: Research article or review	E4: Conceptual paper or theoretical paper
I5: Research published between 2020 and 2026	E5: Research published earlier than 2020

Figure 1
PRISMA diagram



To map the conceptual structure, VOSviewer software was applied to perform a keyword co-occurrence analysis. This dataset was analyzed using the full counting method and Association Strength normalization, applying the standard clustering algorithm. The minimum occurrence threshold was set at two, screening the total 640 keywords into 101 eligible terms to visualize the dynamics of the research over time. For the systematic review component, research participants, methodologies, study designs, and operational modeling goals adapted from the framework developed by (Krawitz et al., 2025). Once relevant document data were extracted, Microsoft Excel was utilized for data tabulation, article characteristic extraction, and descriptive statistical chart formatting.

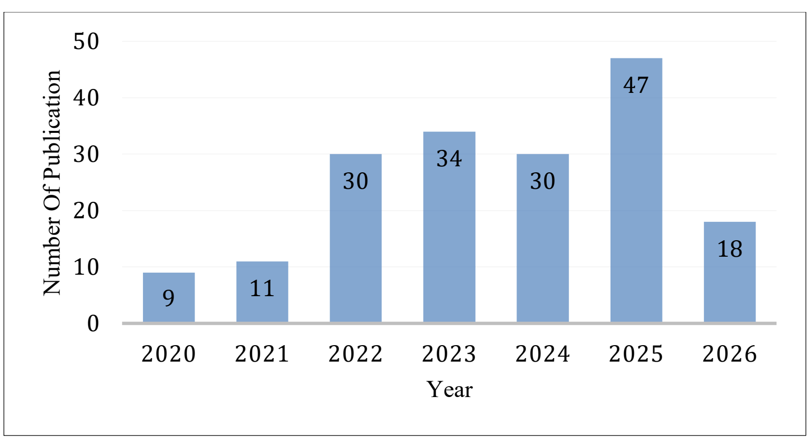
3. Result and Discussion

RQ1. What are the publication trends of research on mathematical modeling in mathematics education from 2020 to 2026?

To answer RQ1, 179 Scopus-indexed documents published from 2020 to 2026 were analyzed to examine publication trends in mathematical modeling within mathematics education (Figure 2). The publication trend started with 20 documents in 2020–2021 and continued to increase during 2022–2024 to 94 documents (52.51%). The trend reached its peak in 2025 with 47 documents (26.26%), showing that mathematical modeling has become a major topic in mathematics education research. The development of STEM education, the emergence of digital technologies, and the increasing value of contextual and 21st-century learning are probably factors related to this growth (Cevikbas et al., 2022). The 2026 publication count (18 documents) may still increase as database indexing is ongoing.

Figure 2

Annual scientific production related to mathematical modeling research in mathematics education between 2020 to 2026



RQ2. Who are the most productive authors in this research field and how do they conceptually define mathematical modeling?

To identify the key stakeholders driving the academic discourse on mathematical modeling, a comprehensive analysis of author productivity and geographical distribution was conducted. As shown in Table 2, the active development of this field is heavily spearheaded by a robust academic network in Germany, with prolific authors such as Greefrath (11 publications), Schukajlow (9 publications), and Kaiser, (8 publications) emerging as the top-3 most productive scholars. This German-centric academic dominance is further reflected in the geographical data in Figure 3, where Germany ranks first globally with 39 publications, followed by Turkey and the USA. Furthermore, Figure 3 indicates that ZDM–Mathematics Education serves as the leading publication source (23 publications) that amplifies and disseminates this research network's output.

Figure 3

Top-7 Country and Sources most productive publications on mathematical modeling in mathematics education between 2020 and 2026

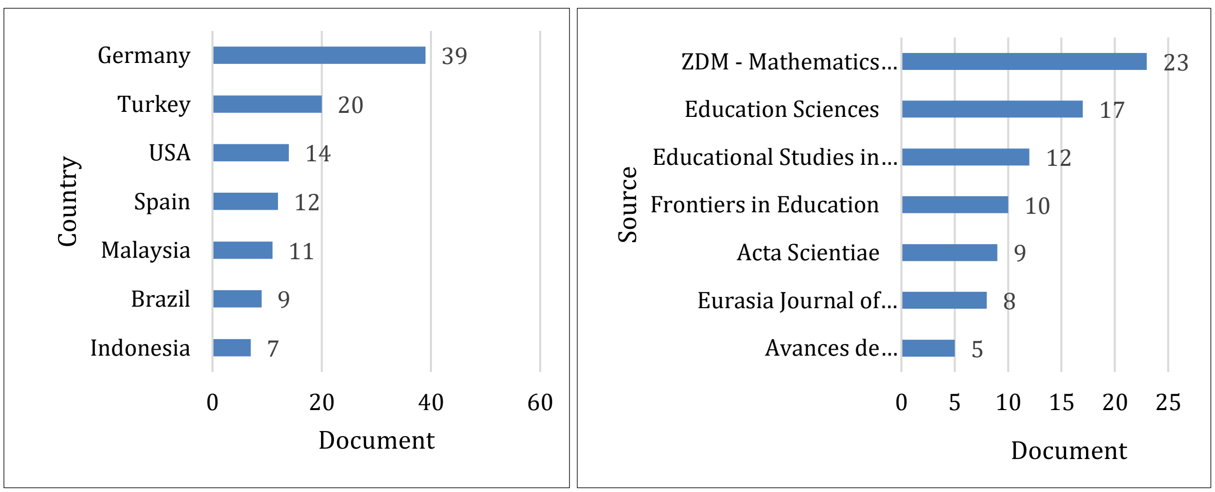


Table 2.

Top-7 Authors most productive publications on mathematical modeling in mathematics education between 2020 and 2026

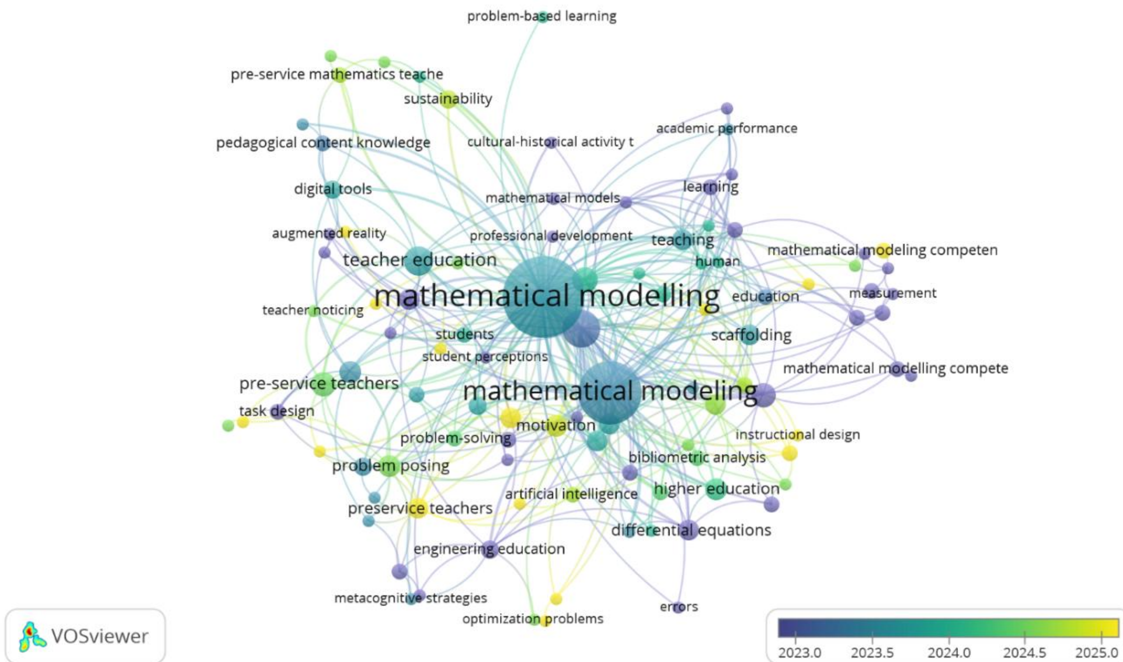
Authors	Affiliation	D
Greefrath, G.	University of Münster, Germany	11
Schukajlow, S.	University of Münster, Germany	9
Kaiser, G.	University of Hamburg, Germany	8
Siller, H.	University of Wuerzburg, Germany	7
Krawitz, J.	University of Cologne, Germany	7
Hidayat, R.	University of Putra, Malaysia	7
Ferri, R.B.	University of Kassel, Germany	5

This active core group of productive authors heavily shapes how mathematical modeling is understood globally. Contemporary literature conceptualizes mathematical modeling as an open-ended, multi-step cognitive process that bridges authentic real-world phenomena and abstract mathematical structures through iterative translation, solution, interpretation, and validation (Greefrath et al., 2022; Lu & Kaiser, 2022; Siller, Elschenbroich, et al., 2023). Their collective frameworks encompass holistic learning domains, shifting dynamically from Greefrath's focus on technology-driven cognitive cycles and digital scaffolding to Schukajlow's exploration of psychological-affective dimensions, such as student self-efficacy and motivation (Greefrath et al., 2022; Schukajlow et al., 2023). Furthermore, Kaiser emphasizes macro-level educational competencies and teacher professionalism, Siller spearheads interdisciplinary STEM task designs, Krawitz addresses classroom-level formative assessments, and Ferri introduces cognitive mathematical thinking styles (Borromeo Ferri & Greefrath, 2026; Krawitz et al., 2022; Siller, et al., 2023). Expanding these trends internationally, Hidayat provides a critical non-European perspective by shifting the focus toward the implementation readiness of mathematical modeling within developing Asian educational contexts using advanced quantitative methodologies (Hidayat et al., 2025).

This German-centric dominance is a reflection of an institutionalized epistemological bias rooted in the Stoffdidaktik tradition and the legacy of the Kassel modeling group (Blum, Kaiser, Greefrath). Backed by sustained national funding and the monumental influence of the International Community of Teachers of Mathematical Modelling and Applications (ICTMA), this network has effectively established a structural monopoly over what constitutes legitimate modeling competencies globally.

RQ3. What research themes and topic trends have emerged in the literature on mathematical modeling in mathematics education?

Figure 4
Co-occurrence of keywords of the topic of mathematical modeling research in mathematics education between 2020 and 2026



The keyword co-occurrence analysis mapped via VOSviewer revealed the conceptual mapping of the field, establishing three distinct thematic clusters as illustrated in Figure 4. The most frequently occurring keywords in this research field are mathematical modelling (76 times), mathematical modeling (46 times), mathematics education (17 times), teacher education (10 times), and mathematics (8 times). The relationship between keywords is represented by the size of the circles and the thickness of the connecting lines. Larger circles indicate higher keyword frequency, while thicker connecting lines indicate stronger relationships and more frequent co-occurrence between keywords. The visualization demonstrates that mathematical modelling or mathematical modeling function as the central themes connecting various research topics in mathematics education. These keywords show strong relationships with other important themes such as teacher education, pre-service teachers, problem solving, STEM education, technology, learning, and model-eliciting activities. In particular, the keyword mathematical modeling is strongly associated with topics such as pre-service teachers (19 times), stem education (18 times), problem posing (19 times), and technology (15 times), indicating that research in this field increasingly emphasizes instructional practices, teacher preparation, and contextual learning approaches.

Furthermore, the overlay visualization provides information regarding the evolution of research trends over time. Based on the color distribution in Figure 4, earlier studies are represented by blue-colored nodes, while more recent and emerging topics are represented by green and yellow-colored nodes. The findings indicate that recent trends in mathematical modeling research are increasingly related to themes such as sustainability, computational thinking, problem-based learning, digital tools, teacher noticing, and pre-service teachers.

This thematic shift toward sustainability and computational thinking reflects an epistemological transition where mathematical modeling is repositioned from a closed cognitive task into an open-ended tool for solving complex socio-scientific realities. However, because these emerging keywords remain heavily clustered around "pre-service teachers," it exposes an upstream systemic bias in the literature. This creates a critical structural gap, where high-level interdisciplinary modeling theories are heavily researched in teacher-education programs but remain under-tested among actual school-level students. The critical implication is that technology integration has shifted from a technical luxury to an epistemological necessity, fundamentally altering how multi-step real-world problems are simulated and solved in the modern classroom.

RQ4. What are the characteristics of current research in terms of participants, methodologies, and modeling goals?

Of the 179 documents analyzed, 17 were review articles and 162 were research articles. To obtain a deeper understanding of the characteristics and trends of current studies, the research articles were further analyzed based on their participants, methodologies, study designs, and modeling goals.

Considering the participants, the results indicate dominance of mathematical modeling research on educators (32% pre-service teachers, 15% teachers/lecturers) reflects an upstream-to-downstream approach prioritizing the pedagogical readiness of instructional agents to mitigate competence gaps and cognitive barriers in abstracting real-world problems, while the distribution among learners (19% university, 16% lower secondary, 7% primary, 7% upper secondary) is heavily influenced by cognitive maturity levels and curricular structures, with the minimal focus on mixed groups (3%) and the AI sector (1%) signaling methodological challenges and an early-stage research area

Figure 5
Distribution of publications by participants

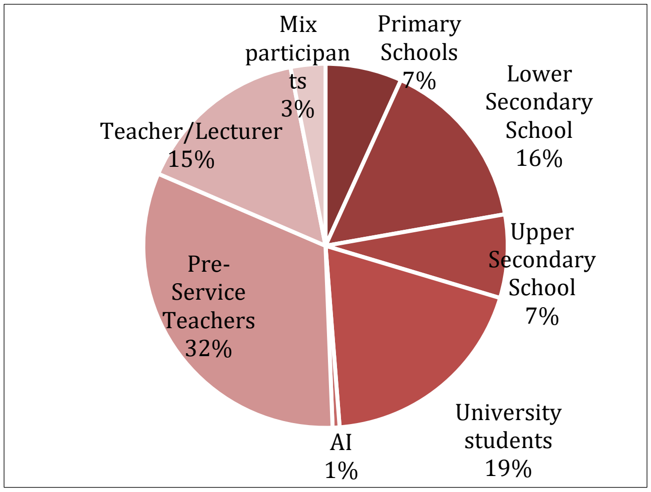
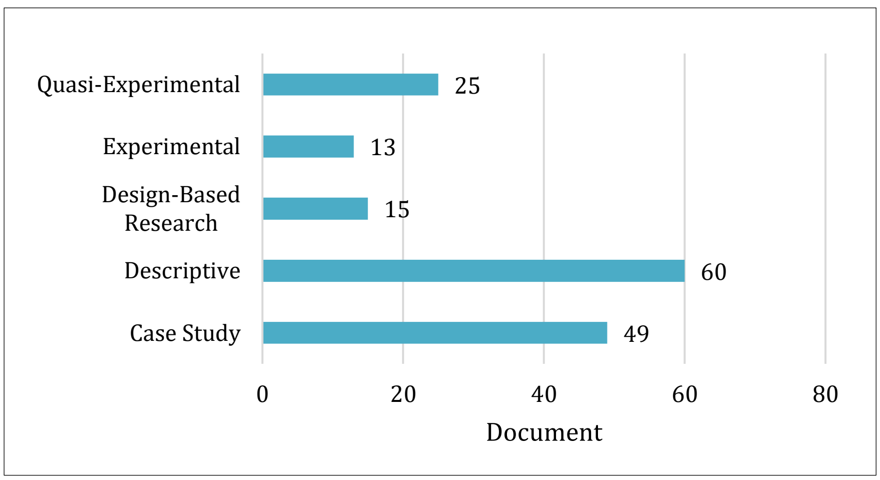


Figure 6
Distribution of publications by study design



To analyze the methodological approaches, we coded whether the researchers used qualitative, quantitative, or mixed methods. Most publications fell under the qualitative research approach (51%), with fewer publications using quantitative methods (26%) or mixed methods (23%). Additionally, the analysis of the study designs (Figure 6) showed that about most studies were descriptive (37%). Case studies comprised the second-largest category, followed by quasi-experimental studies, design-based studies, and a small number of experimental studies (8%). This methodological preference is driven by the nature of mathematical modeling (Cevikbas et al., 2022), which involves various levels of holistic learning encompassing cognitive, affective, and metacognitive aspects for competency development (Zbiek et al., 2024) where qualitative methods are deemed most effective at capturing these nuanced dimensions in depth (Lindl et al., 2025), including the identification of learners' academic strengths, rather than merely testing causality or statistical generalization.

Table 3.
Frequencies of modeling goals

Modeling goals	Document	Short description	Example
Pragmatic	28	using mathematics to solve real-world problems	Jablonski et al. (2023)
Formative	54	Fostering competencies	Govender & Machingura (2023)
Cultural (emancipatory)	9	Supporting critical thinking about mathematics in society	Maass et al. (2023)
Cultural (mathematics)	6	Structuring both mathematical and nonmathematical field	Junger & Lipovec (2025)
Psychological (learning)	28	Enhancing the learning of mathematical content	Fasinu et al. (2023)
Psychological (motivational and sense-making)	13	Motivating and providing a sense purpose	(Lu et al., 2026)
No or other goal mentioned	20	No goal mentioned or goal different to the above mentioned	Kontorovich (2023)
Mix-Goals	4	Different goals presented without emphasizing which one was the most important.	Albarracín et al. (2023)

Utilizing the operational framework adapted from (Krawitz et al., 2025) the documents were coded into specific modeling goals (Table 3). Analysis of the modeling goals reveals that formative goals significantly dominate literature (33.33%), followed closely by pragmatic goals (17.28%) and psychological goals related to learning (17.28%). This dominance of formative goals plausibly aligns with Germany's geographic leadership and its focus on pre-service teachers, where recent regional studies utilize modeling seminars to selectively enhance prospective educators' didactic skills, TPACK, and professional beliefs rather than raw student performance (Bulut & Borromeo Ferri, 2025; Zhang et al., 2025)

RQ5. What future research directions and practical implications are identified in the literature on mathematical modeling in mathematics education?

The findings of this review indicate several important future research directions and practical implications in the field of mathematical modeling in mathematics education. Based on the keyword trend analysis and study characteristics, future research is expected to focus more on the integration of technology, computational thinking (Beyazhancer & Cepni, 2026), sustainability education (Bulut & Borromeo Ferri, 2025), and digital tools in mathematical modeling activities (Koyunkaya & Dede, 2024). The emergence of keywords such as teacher noticing, problem-based learning, and pedagogical content knowledge also suggests that future studies should further explore how teachers design and implement modeling tasks effectively in classroom practice. In addition, the increasing attention to pre-service teachers indicates the importance of strengthening teacher education programs to improve modeling competencies and instructional readiness. Future studies are also recommended to involve more diverse participants, particularly primary school students, upper secondary students, and AI-related learning contexts, which are still rarely explored in current research. From a methodological perspective, most studies still employ qualitative and descriptive approaches, suggesting the need for more experimental, longitudinal, and mixed-method studies to provide stronger empirical evidence regarding the effectiveness of mathematical modeling instruction. Practically, the findings imply that mathematical modeling should be more widely integrated into mathematics curricula because it supports real-world problem solving, creativity, technology integration, and 21st-century skills.

4. Conclusion

This study successfully maps the global landscape of mathematical modeling in mathematics education from 2020 to 2026 through a comprehensive Bibliometric–Systematic Literature Review (B-SLR) framework. The findings reveal an accelerating upward trend in scientific production, highlighting a growing global consensus on the importance of embedding modeling paradigms into contemporary mathematics curricula. Territorially and intellectually, the field is heavily spearheaded by a robust academic network in Germany, led by prolific scholars such as Greefrath, Schukajlow, and Kaiser. Conceptually, these leading experts define mathematical modeling as an open-ended, multi-step cognitive loop bridging real-world applications and abstract mathematical structures, with their frameworks dynamically balancing technology-driven cognitive cycles, micro-level teacher scaffolding, and psychological-affective dimensions. Furthermore, thematic cluster mapping showcases an evolutionary transition from foundational modeling competencies toward integrated interdisciplinary frontiers, such as STEM education, digital technology, and computational thinking. Methodologically, current empirical research relies heavily on qualitative predominantly driven by descriptive and case study designs, focusing predominantly on pre-service teachers to fulfill formative and psychological modeling goals.

Despite its significant contributions, this study possesses inherent limitations. The dataset was completely restricted to Scopus-indexed documents published in English, which may omit relevant localized insights and non-English publications within developing educational systems. Additionally, the analysis for the year 2026 only captures partial database coverage up to mid-May. Moving forward, future research should cross-examine these trends by integrating multi-database searches (such as Web of Science and Eric) and prioritize exploring the real-time operationalization of artificial intelligence (AI) scaffolding within diverse classroom environments. Pragmatically, these insights urge educational stakeholders and policymakers to shift teacher training programs toward longitudinal, continuous professional development designs that empower educators with advanced diagnostic and formative assessment competencies in handling non-linear student modeling behaviors.

References

Albarracín, L., Segura, C., Ferrando, I., & Gorgorió, N. (2023). Supporting mathematical modelling by upscaling real context in a sequence of tasks. *Teaching Mathematics and Its Applications*, *41*(3), 183–197. https://doi.org/10.1093/teamat/hrab027

Bekene, T., Machaba, M., & Kuona, G. (2025). Grade 11 learners' views on their engagement with mathematics through mathematical modelling. *Eurasia Journal of Mathematics, Science and Technology Education*, *21*(6). https://doi.org/10.29333/ejmste/16514

Beyazhancer, R., & Cepni, S. (2026). Computational thinking as a mediator between modeling self-efficacy and flexible thinking in pre-service science teachers. *Frontiers in Psychology*, *17*(February), 1–11. https://doi.org/10.3389/fpsyg.2026.1699956

Borromeo Ferri, R., & Greefrath, G. (2026). Pre-service teachers' assessment competence for grading students' solutions of mathematical modelling problems. *Teaching and Teacher Education*, *169*, 105281. https://doi.org/10.1016/j.tate.2025.105281

Bulut, N., & Borromeo Ferri, R. (2025). Bridging mathematical modelling and education for sustainable development in pre-service primary teacher education. *Education Sciences*, *15*(2). https://doi.org/10.3390/educsci15020248

Cambi, B., & Caldeira, A. D. (2023). Mathematical modeling, mediatorguiding teacher, and constructivism: discursive interlacements in the constitution of the teaching figure. *Revista Brasileira de Educacao*, *28*, 1–22. https://doi.org/10.1590/S1413-24782023280026

Cevikbas, M., Kaiser, G., & Schukajlow, S. (2022). A systematic literature review of the current discussion on mathematical modelling competencies: state-of-the-art developments in conceptualizing, measuring, and fostering. In *Educational Studies in Mathematics* (Vol. 109, Issue 2). https://doi.org/10.1007/s10649-021-10104-6

Cevikbas, M., Mießeler, D., & Kaiser, G. (2025). Pre-service mathematics teachers' experiences and insights into the benefits and challenges of using explanatory videos in flipped modelling education. *ZDM - Mathematics Education*, *57*(2), 245–258. https://doi.org/10.1007/s11858-025-01650-x

Dede, E., & Ozdemir, E. (2022). Mapping and performance evaluation of mathematics education research in Turkey: A bibliometric analysis from 2005 to 2021. *Journal of Pedagogical Research*, *6*(4), 1–19. https://doi.org/10.33902/JPR.202216829

Diana, Surjono, H. D., & Mahmudi, A. (2023). The effect of flipped classroom learning model on students' understanding of mathematical concepts and higher-order thinking skills. *International Journal of Information and Education Technology*, *13*(12), 2014–2022. https://doi.org/10.18178/ijiet.2023.13.12.2016

Fajri, H. M., Marini, A., & Suyono. (2025). A bibliometric study on mathematical modelling in elementary schools in the Scopus database between 1990-2024. *Eurasia Journal of Mathematics, Science and Technology Education*, *21*(2). https://doi.org/10.29333/ejmste/15916

Fasinu, V. G., Govender, N., & Kumar, P. (2023). An empirically-based practical-realistic pedagogic mathematical model for teaching and learning of an antenna theory and design course. *Eurasia Journal of Mathematics, Science and Technology Education*, *19*(1). https://doi.org/10.29333/ejmste/12769

Govender, R., & Machingura, D. (2023). Ascertaining Grade 10 learners' levels of mathematical modelling competency through solving simultaneous equations word problems. *Pythagoras*, *44*(1), 1–18. https://doi.org/10.4102/PYTHAGORAS.V44I1.728

Greefrath, G., Siller, H. S., Vorhölter, K., & Kaiser, G. (2022). Mathematical modelling and discrete mathematics: opportunities for modern mathematics teaching. *ZDM - Mathematics Education*, *54*(4), 865–879. https://doi.org/10.1007/s11858-022-01339-5

Haas, B., Lavicza, Z., & Kreis, Y. (2023). Parent's experience in remote learning during COVID-19 with digital and physical mathematical modelling. *Research and Practice in Technology Enhanced Learning* (Vol. 18). https://doi.org/10.58459/rptel.2023.18013

Hidayat, R., Mohd Ayub, A. F., Abd Hamid, H. S., & Nasir, N. (2025). Difficulties in instructing mathematical modeling: Case study in Malaysia. *International Electronic Journal of Mathematics Education*, *20*(2), em0811. https://doi.org/10.29333/iejme/15815

Jablonski, S., Barlovits, S., & Ludwig, M. (2023). How digital tools support the validation of outdoor modelling results. *Frontiers in Education*, *8*(July), 1–15. https://doi.org/10.3389/feduc.2023.1145588

Junger, M. S., & Lipovec, A. (2025). The integration of mathematical modeling tasks into primary education: A comparative study of Croatia and Slovenia. *International Journal of Education and Practice*, *13*(2), 723–738. https://doi.org/10.18488/61.v13i2.4129

Kandemir, M. A., & Eryilmaz, N. (2025). Innovative approaches in mathematical modeling: Harnessing technology for teaching second degree equations to future mathematics educators in Türkiye. *Social Sciences and Humanities Open*, *11*. https://doi.org/10.1016/j.ssaho.2025.101281

Kontorovich, I. (2023). "Find the area enclosed by.." Parceling an especially robust model of reasoning among first-year students. *International Journal of Research in Undergraduate Mathematics Education*, *9*(1), 149–172. https://doi.org/10.1007/s40753-023-00213-3

Koyunkaya, M. Y., & Dede, A. T. (2024). Using different digital tools in designing and solving mathematical modelling problems. *Education and Information Technologies* (Vol. 29, Issue 14). Springer US. 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*(2), 337–359. https://doi.org/10.1007/s10649-021-10058-9

Krawitz, J., Schukajlow, S., Yang, X., & Geiger, V. (2025). A systematic review of international perspectives on mathematical modelling: modelling goals and task characteristics. *ZDM - Mathematics Education*, *57*(2), 193–212. https://doi.org/10.1007/s11858-025-01683-2

Ledezma, C., Sol, T., Sánchez, A., & Font, V. (2026). Practical arguments of prospective primary education teachers in mathematical modelling problems. *Education Sciences*, *16*(1), 118. https://doi.org/10.3390/educsci16010118

Lindl, A., Durandt, R., & Blum, W. (2025). Fostering mathematical modelling competency in different learning environments and educational contexts – an exploratory comparative analysis of four intervention studies. *ZDM - Mathematics Education*, *57*(2), 351–364. https://doi.org/10.1007/s11858-025-01680-5

Lu, X., Chen, X., Chen, Y., & Kaiser, G. (2026). Motivation and epistemic emotions in mathematical modelling. *ZDM- Mathematics Education*. https://doi.org/10.1007/s11858-026-01770-y

Lu, X., & Kaiser, G. (2022). Creativity in students' modelling competencies: conceptualisation and measurement. *Educational Studies in Mathematics*, *109*(2), 287–311. https://doi.org/10.1007/s10649-021-10055-y

Maass, K., Zehetmeier, S., Weihberger, A., & Flößer, K. (2023). Analysing mathematical modelling tasks in light of citizenship education using the COVID-19 pandemic as a case study. *ZDM - Mathematics Education*, *55*(1), 133–145. https://doi.org/10.1007/s11858-022-01440-9

Marzi, G., Balzano, M., & Pellegrini, M. M. (2025). *Guidelines for bibliometric-systematic literature reviews : 10 steps to combine analysis , synthesis and theory development*. *December 2022*, 81–103. https://doi.org/10.1111/ijmr.12381

Schukajlow, S., Krawitz, J., Kanefke, J., Blum, W., & Rakoczy, K. (2023). Open modelling problems: cognitive barriers and instructional prompts. *Educational Studies in Mathematics*, *114*(3), 417–438. https://doi.org/10.1007/s10649-023-10265-6

Siller, H. S., Elschenbroich, H. J., Greefrath, G., & Vorhölter, K. (2023). Mathematical modelling of exponential growth as a rich learning environment for mathematics classrooms. *ZDM - Mathematics Education*, *55*(1), 17–33. https://doi.org/10.1007/s11858-022-01433-8

Siller, H. S., Nitzan-Tamar, O., & Kohen, Z. (2023). Scaffolding practices for modelling instruction in STEM-related contexts: insights from expert and novice teachers. *ZDM - Mathematics Education*, *55*(7), 1351–1364. https://doi.org/10.1007/s11858-023-01529-9

Zbiek, R. M., Peters, S. A., Galluzzo, B., & White, S. J. (2024). Secondary mathematics teachers learning to do and teach mathematical modeling: a trajectory. *Journal of Mathematics Teacher Education*, *27*(1), 55–83. https://doi.org/10.1007/s10857-022-09550-7

Zhang, Q., Fang, H., & Tang, X. (2025). Modeling mathematical well-being among undergraduates: An exploratory study in Mainland China. *International Journal of Educational Research*, *9*(July), 100507. https://doi.org/10.1016/j.ijedro.2025.100507