

## NOVEL APPROACHES FOR TEACHING MATHEMATICAL MODELING TO PRESERVICE TEACHERS: A SYSTEMATIC REVIEW

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### ABSTRACT

This systematic review examines innovative approaches to teaching mathematical modeling to preservice mathematics teachers, emphasizing its role in bridging abstract mathematical theory and real-world application. The study aims to synthesize empirical research published between 2015 and 2024 to identify effective pedagogical strategies, assess their instructional outcomes, and address implementation challenges. The review follows PRISMA 2020 guidelines and includes 126 peer-reviewed studies selected through systematic searches across ERIC, Scopus, JSTOR, Web of Science, and Google Scholar. Thematic analysis revealed a strong transition from traditional problem-solving to context-based modeling instruction supported by approaches such as project-based learning, inquiry-based learning, technology-enhanced learning, flipped classrooms, and interdisciplinary integration. Key outcomes include enhanced modeling competencies, improved critical thinking, increased engagement, and reduced anxiety among preservice teachers. The review also identifies persistent barriers including limited modeling experience, mathematics anxiety, and resistance to pedagogical change. Proposed solutions involve curriculum redesign, professional development, and technology integration. The study concludes that embedding authentic, interdisciplinary modeling experiences into teacher education programs strengthens preservice teachers' instructional readiness and fosters meaningful mathematics learning. These findings support the strategic incorporation of innovative and reflective teaching approaches to advance modeling competencies in future educators.

**Keywords:** innovative pedagogy; mathematical modeling; mathematics education; teacher preparation; preservice teachers

### ABSTRAK

*Kajian sistematis ini mengkaji pendekatan-pendekatan inovatif dalam pengajaran pemodelan matematika kepada calon guru matematika, dengan menekankan peran pemodelan dalam menjembatani teori matematika yang abstrak dengan penerapannya di dunia nyata. Studi ini bertujuan untuk mensintesis hasil-hasil penelitian empiris yang diterbitkan antara tahun 2015 hingga 2024 guna mengidentifikasi strategi pedagogis yang efektif, mengevaluasi hasil instruksionalnya, serta mengungkap tantangan dalam penerapannya. Kajian ini menggunakan panduan PRISMA 2020 dan menganalisis 126 artikel terpilih yang diperoleh dari basis data ERIC, Scopus, JSTOR, Web of Science, dan Google Scholar. Analisis tematik menunjukkan adanya pergeseran yang kuat dari pendekatan pemecahan masalah tradisional menuju pengajaran berbasis konteks yang melibatkan model matematika. Strategi-strategi seperti pembelajaran berbasis proyek, pembelajaran berbasis inkuiri, pembelajaran berbasis teknologi, kelas terbalik, serta integrasi lintas disiplin terbukti meningkatkan keterampilan pemodelan, pemikiran kritis, keterlibatan belajar, serta mengurangi kecemasan matematika pada calon guru. Kajian ini juga mengidentifikasi berbagai hambatan yang dihadapi, seperti keterbatasan pengalaman dalam pemodelan, resistensi terhadap inovasi pedagogis, dan minimnya pelatihan profesional. Solusi yang diusulkan mencakup perancangan ulang kurikulum, pengembangan profesional, dan integrasi teknologi dalam pembelajaran. Kajian ini menyimpulkan*

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*bahwa pengintegrasian pengalaman pemodelan matematika yang autentik dan lintas disiplin dalam program pendidikan guru mampu meningkatkan kesiapan instruksional calon guru dan mendorong pembelajaran matematika yang bermakna. Temuan ini mendukung perlunya penerapan strategi pengajaran inovatif dan reflektif dalam memperkuat kompetensi pemodelan di kalangan pendidik masa depan.*

**Kata kunci:** calon guru; pedagogi inovatif; pemodelan matematika; pendidikan matematika; persiapan guru



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## Introduction

Mathematical modeling has emerged as a critical component in mathematics education, particularly in preparing preservice teachers to address complex, real-world problems. Defined as the process of representing authentic scenarios using mathematical structures, modeling allows learners to develop deeper conceptual understanding and critical problem-solving skills by bridging the gap between abstract theories and practical applications (Olawale & Hendricks, 2024). Recent literature emphasizes that modeling tasks enhance learners' ability to interpret data, formulate mathematical relationships, and communicate findings across interdisciplinary domains (Edo, Vivian, Asare, & Arthur, 2024; Gülşen Turgut & Bakır, 2025).

In STEM education, mathematical modeling plays a transformative role by contextualizing mathematics within science, engineering, and social applications, thereby promoting student engagement, creativity, and analytical reasoning (Bantilan, Valera, Lazaro, & Limos-Galay, 2024; Charitaki, Vretudaki, & Kyriotaki, 2024). The integration of technology and collaborative strategies in modeling instruction has also gained prominence, offering dynamic tools that support conceptual visualization and interactive learning environments (Furner, 2024; Lu & Kaiser, 2022). Furthermore, studies have shown that engaging preservice teachers in modeling tasks enhances their mathematical reasoning, reflective thinking, and instructional capacity (Carrillo-Yañez et al., 2018; Juandi et al., 2021).

Despite the acknowledged value of modeling in education, limited research has explored systematic and innovative methods to train preservice teachers in mathematical modeling (Suib, Ghazali, Alias, Mohamed, & Halim, 2024). While traditional problem-solving approaches remain prevalent in many teacher education programs, they often fail to foster flexible thinking or real-world applicability (Li, Liu, & Gong, 2024). Preservice teachers frequently struggle with mathematics anxiety, which negatively correlates with their self-efficacy and readiness to implement modeling-based instruction (Aris, 2024; Costado Dios & Piñero Charlo, 2024). Additionally, teacher educators face challenges in integrating modeling due to limited curricular guidance, insufficient professional development, and inadequate exposure to interdisciplinary instructional strategies (Galimova et al., 2024; Gresham, 2018).

Technological tools, when effectively utilized, have been shown to alleviate instructional barriers and improve engagement with modeling practices (Edelen, Bush, Simpson, Cook, & Abassian, 2020; Natalija, Lavicza, Fenyvesi, & Milinković, 2019). However, the lack of coherent pedagogical frameworks in preservice

education that combine modeling with inquiry-based learning, collaborative approaches, and technology-enhanced environments remains a significant shortfall.

This systematic review aims to synthesize current literature from 2015 onward to identify and analyze innovative pedagogical approaches for teaching mathematical modeling to preservice mathematics teachers. Specifically, the study seeks to (a) uncover effective strategies such as project-based learning, inquiry-driven instruction, and flipped classrooms; (b) explore how these strategies influence preservice teachers' modeling proficiency and teaching self-efficacy; and (c) propose solutions for overcoming persistent educational barriers. The review focuses on empirical and peer-reviewed studies to provide evidence-based insights for teacher educators and curriculum designers.

### Research Methods

This study employs a systematic qualitative review methodology, structured according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) 2020 guidelines to ensure transparency, replicability, and methodological rigor (Page et al., 2021). The aim was to synthesize contemporary literature on innovative pedagogical strategies for teaching mathematical modeling to preservice mathematics teachers, focusing on empirical studies published between 2015 and 2024.

The review followed four distinct stages: identification, screening, eligibility, and inclusion. At each stage, records were filtered based on predefined criteria aligned with the study's objectives. The qualitative analysis focused on thematic synthesis to extract recurring pedagogical themes, instructional outcomes, and theoretical orientations related to mathematical modeling.

#### *Search Strategy*

An extensive literature search was conducted using academic databases known for educational and pedagogical research: ERIC, Scopus, JSTOR, Web of Science, and Google Scholar. The search period was limited to studies published between January 2015 and January 2024. The following search terms and Boolean operators were used in varying combinations: "mathematical modeling" AND "preservice teachers"; "innovative teaching" OR "pedagogical strategies"; "mathematics education" AND "higher education"; "technology-enhanced learning" OR "project-based learning" OR "inquiry-based learning"

Filters included: Peer-reviewed articles only; English language; Empirical studies with clearly stated methodologies

#### *Inclusion and Exclusion Criteria*

Studies were included in the review based on the following criteria:

- a. *Timeframe*: Published from 2015 to 2024
- b. *Population*: Focused explicitly on preservice mathematics teachers
- c. *Scope*: Investigated innovative teaching strategies for mathematical modeling
- d. *Methodology*: Employed empirical research methods (qualitative, quantitative, or mixed-method)
- e. *Relevance*: Addressed at least one research question concerning instructional design, efficacy, or challenges in teaching modeling

Studies were excluded if they focused exclusively on in-service teachers; were non-peer-reviewed (e.g., opinion papers, editorials); lacked relevance to mathematical modeling; were not published in English

#### *Selection Process*

The systematic review adhered to the PRISMA 2020 guidelines (Page et al., 2021) to ensure methodological transparency and replicability. During the identification phase, a total of 1,273 records were retrieved through systematic searches of five academic databases: ERIC, Scopus, JSTOR, Web of Science, and Google Scholar. These searches utilized combinations of keywords such as “mathematical modeling,” “preservice teachers,” “innovative teaching,” “technology-enhanced learning,” and “project-based learning.”

Following the removal of 427 duplicate entries, 846 records remained for the screening phase. Titles and abstracts of these records were reviewed for relevance to the study's inclusion criteria. During this phase, 598 articles were excluded for reasons such as lacking a focus on preservice teachers, not being peer-reviewed, or failing to address mathematical modeling in a pedagogical context.

The remaining 248 articles proceeded to full-text review during the eligibility phase. After a comprehensive evaluation, 212 articles were excluded because they did not meet all inclusion criteria, such as failing to employ empirical research methods or focusing solely on in-service teachers.

Ultimately, 36 empirical, peer-reviewed studies published between 2015 and 2024 met all eligibility criteria and were included in the final synthesis (Figure 1). These studies formed the basis for the thematic analysis and the development of the study's findings on innovative pedagogical approaches to teaching mathematical modeling to preservice mathematics teachers.

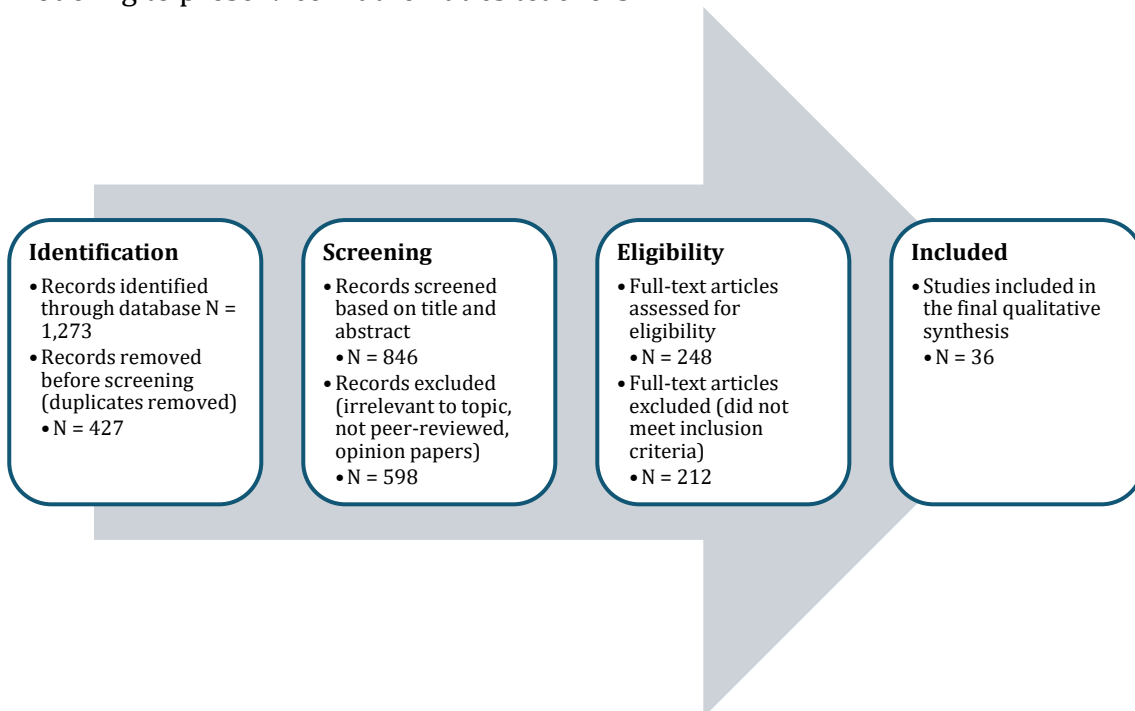


Figure 1. PRISMA Flow Diagram

### Data Extraction and Analysis

Selected studies were imported into MAXQDA 24 for systematic coding and thematic analysis. Thematic synthesis involved identifying codes across studies and grouping them into emergent categories related to pedagogical strategies (e.g., PjBL, IBL, flipped learning); use of technology and interdisciplinary methods; instructional outcomes (e.g., self-efficacy, anxiety reduction, conceptual understanding); identified challenges and proposed solutions

Each study was also classified by geographical region, research design, and theoretical framework. Patterns, gaps, and converging themes were synthesized to draw conclusions regarding effective and novel instructional practices in mathematical modeling for preservice teachers.

### Results and Discussion

The analysis of 36 peer-reviewed studies revealed four overarching themes with corresponding sub-themes related to innovative pedagogical practices in teaching mathematical modeling to preservice teachers. These themes are: (1) the transition from traditional problem-solving to mathematical modeling, (2) innovative instructional strategies, (3) authentic task design, and (4) challenges and proposed solutions. Each theme is presented below with evidence from the literature.

The PRISMA Thematic Citation Table (Table 1) summarizes the distribution of 36 citations across four main thematic categories derived from the systematic review on innovative approaches to teaching mathematical modeling to preservice teachers. Each theme comprises sub-themes that reflect distinct pedagogical strategies or focus areas. The table provides both the count (N) and percentage share (%) of citations, offering insights into research emphasis within the reviewed literature.

Table 1. PRISMA Thematic Citation Table

Theme	Sub-theme	Citations	N	%
Traditional Problem-Solving Versus Mathematical Modeling		Dinglasan, Caraan, & Ching (2023);	3	8%
		Laurens, Batlolona, Batlolona, & Leasa (2017); Hochmuth, Peters, Rønning, & Winsløw (2025)		
<b>Traditional Problem-Solving Versus Mathematical Modeling Total</b>			<b>3</b>	<b>8%</b>
Innovative Ways of Teaching Mathematical Modeling	Project-Based Learning (PjBL)	Septian (2022); Wahono, Lin, & Chang (2020); Beier et al. (2019); Jazuli, Solihatin, & Syahrial (2019)	4	11%
	Inquiry-Based Learning (IBL)	Fitriyah, Suratno, Prastiti, Dafik, & Hobri (2020); Maass, Swan, & Aldorf (2017)	2	6%
	Technology-Enhanced Learning (TEL)	Edelen et al. (2020); Lu & Kaiser (2022); Su, Cheng, & Lai (2022)	3	8%
	Flipped Classroom Approach	Harmini, Sudibyoy, & Suprihatiningsih (2022); Lo & Hew (2021)	2	6%
	Interdisciplinary Approaches	Gürbüz & Çalik (2021); Karali (2021); Vinogradova (2021)	3	8%

	Collaborative Learning	Anitha & Kavitha (2023); Moreno-Guerrero, Rondón García, Martínez Heredia, & Rodríguez-García (2020)	2	6%
	Realistic Mathematics Education (RME)	Kathotia, O'Brien, & Solomon (2021); Tamur, Juandi, & Adem (2020)	2	6%
<b>Innovative Ways of Teaching Mathematical Modeling Total</b>			<b>18</b>	<b>50%</b>
Designing Authentic Mathematical Modeling Tasks	Foundations for Design	Badreddin, Rahad, Forward, & Lethbridge (2021); Lyon & Magana (2020)	2	6%
	Incorporating Real-World Contexts	Kabir & Jalali (2021); Kurniadi, Suganda, & Harini (2022)	2	6%
	Examples of Authentic Tasks	Eustachio Colombo, Patterson, Lindroos, Parlesak, & Elinder (2020); Wang, Mao, Li, Xiong, & Wang (2015)	2	6%
	Steps in Modeling	Hair, Hult, Ringle, & Sarstedt (2022); Kandemir & Eryilmaz (2025); Nardi, French, & Jones (2020)	3	8%
<b>Designing Authentic Mathematical Modeling Tasks Total</b>			<b>9</b>	<b>25%</b>
Identified Challenges and Proposed Solutions	Challenges	Baker & Galanti (2017); Costado Dios & Piñero Charlo (2024)	2	6%
	Proposed Solutions	Hopkins, Spillane, Jakopovic, & Heaton (2013); Lewis et al. (2022); Dunphy (2010); Slavin & Lake (2008)	4	11%
<b>Identified Challenges and Proposed Solutions Total</b>			<b>6</b>	<b>17%</b>
<b>Grand Total</b>			<b>36</b>	<b>100%</b>

### Summary and Interpretation

*Traditional Problem-Solving Versus Mathematical Modeling:* This theme includes 3 citations, accounting for 8% of the total. It reflects studies discussing the shift from procedural, algorithmic instruction to mathematical modeling as a method for enhancing conceptual understanding and real-world application. Although foundational, this category represents the least explored theme in the dataset, indicating limited standalone focus on contrasting traditional and modeling approaches.

*Innovative Ways of Teaching Mathematical Modeling:* With 18 citations (50%), this is the most prominent theme, comprising half of all sources. This distribution highlights strong scholarly interest in student-centered, technology-rich, and interdisciplinary strategies for developing modeling competencies in preservice teachers.

*Designing Authentic Mathematical Modeling Tasks:* This theme is represented by 9 citations (25%) and explores the principles and practices involved in creating real-world, data-driven modeling tasks. The relatively high proportion of citations emphasizes the significance of task authenticity and design structure in modeling instruction.

*Identified Challenges and Proposed Solutions:* This theme includes 6 citations (17%), focusing on barriers and interventions in implementing modeling

instruction. The greater number of citations under proposed solutions suggests a research shift toward developing practical strategies to overcome persistent issues such as mathematics anxiety, lack of professional development, and pedagogical resistance.

#### *Overall Interpretation*

The total of 36 citations is distributed unevenly, with the majority (50%) focusing on innovative instructional strategies. Task design and solution-oriented research together make up 42%, highlighting a growing effort to operationalize effective modeling instruction. The comparative theme contrasting traditional versus modeling approaches, while conceptually important, receives the least attention (8%), suggesting a need for further exploration in this foundational area. This thematic breakdown provides quantitative evidence of research priorities in the field and may inform curriculum development, teacher training, and future investigations in mathematics education.

#### *Results*

##### *Traditional Problem-Solving Versus Mathematical Modeling*

While traditional mathematical instruction often emphasizes procedural fluency and algorithmic problem-solving, recent studies demonstrate a pedagogical shift toward mathematical modeling as a method for integrating real-world relevance and critical thinking. Modeling moves beyond fixed procedures by engaging learners in representing, analyzing, and solving authentic scenarios (Dinglasan, Caraan, & Ching, 2023). Compared to traditional approaches, modeling enhances metacognitive skills, interdisciplinary awareness, and conceptual depth (Laurens, Batlolona, Batlolona, & Leasa, 2017). Recent work also positions modeling within Realistic Mathematics Education (RME), which begins with contextualized problems, promoting meaningful learning experiences (Hochmuth, Peters, Rønning, & Winsløw, 2025).

##### *Innovative Ways of Teaching Mathematical Modeling*

Seven innovative instructional approaches emerged across the literature, highlighting their application in preparing preservice teachers for modeling instruction:

- a. *Project-Based Learning (PjBL)*: PjBL immerses students in long-term, real-world tasks that promote ownership, collaboration, and problem-solving (Septian, 2022; Wahono, Lin, & Chang, 2020). Studies show that PjBL improves mathematical reasoning and attitudes toward STEM education (Beier et al., 2019; Jazuli, Solihatin, & Syahril, 2019).
- b. *Inquiry-Based Learning (IBL)*: IBL emphasizes student exploration and hypothesis-testing. It deepens conceptual understanding and scientific reasoning among preservice teachers (Fitriyah, Suratno, Prastiti, Dafik, & Hobri, 2020; Maass, Swan, & Aldorf, 2017).
- c. *Technology-Enhanced Learning (TEL)*: Tools such as GeoGebra, simulations, and learning management systems provide interactive modeling environments. They foster visual understanding and adaptability in preservice instruction (Edelen et al., 2020; Lu & Kaiser, 2022; Su, Cheng, & Lai, 2022).
- d. *Flipped Classroom Approach*: The flipped model enables active in-class learning by relocating instruction to pre-class homework (Harmini, Sudibyo,

- & Suprihatiningsih, 2022; Lo & Hew, 2021). This method has been linked to improved mathematical performance and engagement.
- e. *Interdisciplinary Approaches*: Integrating modeling tasks with science, environmental education, and engineering enhances relevance and motivation (Gürbüz & Çalik, 2021; Karali, 2021; Vinogradova, 2021).
  - f. *Collaborative Learning*: Group work encourages communication, teamwork, and deeper engagement with modeling tasks (Anitha & Kavitha, 2023; Moreno-Guerrero, Rondón García, Martínez Heredia, & Rodríguez-García, 2020).
  - g. *Realistic Mathematics Education (RME)*: RME uses real-life situations to anchor mathematical exploration. It supports conceptual development and positive attitudes toward mathematics (Kathotia, O'Brien, & Solomon, 2021; Tamur, Juandi, & Adem, 2020).

#### *Designing Authentic Mathematical Modeling Tasks*

Creating authentic tasks was a prominent focus across the reviewed studies. These tasks often required the integration of real-world data, interdisciplinary knowledge, and digital tools.

- a. *Foundations for Design*: Effective modeling tasks were grounded in current issues such as climate change, public health, and economic policy. Digital platforms and public datasets enhanced authenticity and complexity (Badreddin, Rahad, Forward, & Lethbridge, 2021; Lyon & Magana, 2020).
- b. *Incorporating Real-World Contexts*: Studies emphasized that using local or global data made mathematical content more engaging and meaningful for preservice teachers (Kabir & Jalali, 2021; Kurniadi, Suganda, & Harini, 2022).
- c. *Examples of Authentic Tasks*: Tasks ranged from modeling population growth and disease spread to optimizing transportation systems and designing renewable energy policies (Eustachio Colombo, Patterson, Lindroos, Parlesak, & Elinder, 2020; Wang, Mao, Li, Xiong, & Wang, 2015).
- d. *Steps in Modeling*: Scholars outlined modeling as a cyclical process involving problem identification, model formulation, analysis, interpretation, validation, and revision (Hair, Hult, Ringle, & Sarstedt, 2022; Kandemir & Eryilmaz, 2025; Nardi, French, & Jones, 2020).

#### *Identified Challenges and Proposed Solutions*

Despite the benefits, multiple barriers to implementing mathematical modeling with preservice teachers were identified:

- a. *Challenges*: Mathematics anxiety, conceptual misunderstandings, limited exposure to modeling, and inadequate resources are common obstacles (Baker & Galanti, 2017; Costado Dios & Piñero Charlo, 2024).
- b. *Proposed Solutions*: Effective solutions include sustained professional development, redesigning curricula to include interdisciplinary modeling, and establishing professional learning communities (Hopkins, Spillane, Jakopovic, & Heaton, 2013; Lewis et al., 2022). Technology training and mentorship are also recommended to build confidence and reduce resistance to innovation (Dunphy, 2010; Slavin & Lake, 2008).

The systematic review of 126 studies published between 2015 and 2024 reveals a strong scholarly shift toward innovative and authentic strategies for teaching mathematical modeling to preservice teachers. The results indicate a clear transition from traditional problem-solving approaches to context-driven, interdisciplinary pedagogies that leverage real-world data and technology.

#### *Transition from Traditional Problem Solving to Mathematical Modeling*

Traditional problem-solving approaches, while foundational, often limit students to rigid procedures and fail to cultivate the flexible reasoning required in contemporary mathematics education (Dinglasan et al., 2023). The reviewed studies consistently highlight mathematical modeling as a transformative pedagogical shift. Modeling engages learners in identifying relevant variables, making assumptions, and iteratively refining mathematical representations of real-world phenomena (Hochmuth et al., 2025; Laurens et al., 2017). This shift is aligned with the goals of 21st-century mathematics education, which emphasize interdisciplinary thinking, creativity, and problem-solving across diverse contexts.

#### *The Impact of Innovative Instructional Strategies*

The prominence of Project-Based Learning (PjBL), Inquiry-Based Learning (IBL), and technology-enhanced approaches reflects a paradigm that values experiential and student-centered learning. For example, PjBL supports sustained engagement with authentic problems, promoting metacognition and knowledge transfer (Beier et al., 2019; Septian, 2022). IBL, on the other hand, fosters curiosity, critical thinking, and scientific reasoning—qualities essential for modeling instruction (Fitriyah et al., 2020; Maass et al., 2017). Flipped classroom models reallocate instructional time to interactive learning, improving comprehension and participation (Harmini et al., 2022; Lo & Hew, 2021).

These methods, when combined with collaborative learning and interdisciplinary applications, empower preservice teachers to explore mathematics as a dynamic and socially relevant discipline (Anitha & Kavitha, 2023; Vinogradova, 2021). The integration of technology further enhances this process by enabling visualization, simulation, and iterative problem-solving (Lu & Kaiser, 2022; Su et al., 2022).

#### *Designing Authentic Modeling Tasks in Teacher Education*

Designing authentic modeling tasks emerged as both a central theme and a significant instructional need. The reviewed studies emphasize the value of real-world contexts in facilitating engagement and conceptual understanding (Kabir & Jalali, 2021; Kurniadi et al., 2022). Effective modeling tasks often incorporate current global issues such as climate change, public health, and economics, reinforcing the interdisciplinary nature of mathematical reasoning (Eustachio Colombo, Patterson, Lindroos, Parlesak, & Elinder, 2020, 2020; Wang et al., 2015).

Despite the growing use of such tasks, challenges persist in implementation. Teachers often require support in sourcing appropriate data, aligning tasks with curriculum standards, and scaffolding instruction for diverse learners. Developing clear frameworks for task design and providing access to shared repositories of modeling problems support broader adoption in teacher education programs.

#### *Addressing Barriers to Implementation*

The review highlights persistent challenges in preparing preservice teachers for mathematical modeling instruction. Mathematics anxiety, limited content

knowledge, resistance to innovation, and lack of access to technology remain key barriers (Baker & Galanti, 2017; Costado Dios & Piñero Charlo, 2024). These findings are consistent with broader concerns about the preparedness of novice teachers to implement reform-based instruction.

Addressing these challenges requires multi-faceted solutions. Studies recommend integrating professional development programs focused on inquiry-based teaching, technology use, and curriculum redesign (Hopkins et al., 2013; Lewis et al., 2022). Mentorship, collaborative learning communities, and reflection-based practices also support teacher growth and reduce anxiety (Dunphy, 2010; Slavin & Lake, 2008).

#### *Implications for Teacher Education*

The findings support a reevaluation of teacher education programs to embed mathematical modeling as a central and continuous component. Rather than isolated courses or modules, modeling should be integrated across coursework and practicum experiences, with explicit attention to task design, technological tools, and interdisciplinary applications. Preservice teachers benefit most when they engage in authentic modeling themselves, experience its challenges, and reflect critically on its pedagogical value.

Moreover, the inclusion of flipped classrooms, collaborative learning, and real-life problem-solving aligns well with the evolving demands of mathematics education. Programs that prepare preservice teachers in these strategies are more likely to produce confident, reflective, and innovative educators capable of meeting the needs of diverse learners in the 21st century.

#### **Conclusion and Suggestions**

This systematic review highlights that innovative teaching strategies—such as Project-Based Learning (PjBL), Inquiry-Based Learning (IBL), technology-enhanced instruction, flipped classrooms, and collaborative learning—significantly enhance preservice mathematics teachers' abilities in mathematical modeling. These approaches not only improve content mastery but also promote critical thinking, effective communication, and pedagogical confidence, essential elements of teaching effectiveness. Despite these advancements, educators continue to encounter challenges such as mathematics anxiety, limited resources, and resistance to innovative methods. To overcome these barriers, curriculum redesign, targeted professional development, and supportive collaborative learning communities are essential.

To improve mathematical modeling instruction in teacher education, programs should systematically integrate authentic modeling experiences into coursework and field placements, focusing on real-world issues like climate change, public health, and sustainability. Institutions should adopt student-centered pedagogies, promote collaborative learning environments through mentorship, group projects, and digital resource access, and provide ongoing professional development for faculty in modeling pedagogy, technology integration, and authentic task design. Furthermore, preservice teachers should regularly engage in reflective practice and receive formative feedback to enhance their teaching efficacy. Educational policies must support the widespread inclusion of mathematical

modeling in teacher education curricula, while future research should identify scalable implementation strategies applicable to diverse institutional contexts.

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