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Article

Mathematical Modeling and Attitudes Toward Learning It in Elementary Education: A Literature Review

Modelación matemática y actitudes hacia su aprendizaje en educación básica: una revisión bibliográfica

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Abstract

This article presents an exhaustive review of how conventional mathematics instruction creates emotional barriers, such as apathy and stress. The objective of this study is to analyze, through a review of the scientific literature, the impact of mathematical modeling on students' attitudes in general basic education. A representative sample of 15 scientific articles published between 2015 and 2026 was selected. Data were collected from high-impact databases such as SciELO, Redalyc, Dialnet, and Google Scholar using structured search strings and recorded in a matrix for data extraction based on specific inclusion criteria. The findings show that mathematical modeling reduces emotional barriers, promotes collaborative work, and stimulates the development of mathematical communication—provided that the activities are based on real-world contexts relevant to the students— . It is also emphasized that teacher guidance is important for the implementation of the proposed activities. The conclusion reached is that mathematical modeling is more than a

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teaching technique; it is a pedagogical approach that transforms the relationship with this discipline and the prejudices held about it by making students the protagonists of their own learning.

Keywords: mathematical modeling, attitudes toward mathematics, elementary education, meaningful learning, affective dimension.

Resumen

En este artículo se realizó una búsqueda exhaustiva sobre como la enseñanza convencional de las matemáticas genera barreras emocionales, como la apatía y el estrés. El presente estudio tiene como objetivo analizar a través de la revisión de la literatura científica, el impacto que tiene la modelación matemática en las actitudes de los estudiantes en el nivel de educación general básica. Se eligió una muestra representativa de 15 artículos científicos publicados entre 2015 y 2026. La recolección de la información se realizó mediante bases de datos de alto impacto como SciELO, Redalyc, Dialnet y Google Académico, mediante el uso de cadenas de búsquedas estructuradas y se registró en una matriz para la extracción de datos bajo criterios de inclusión específicos. Los hallazgos muestran que la modelación matemática disminuye las barreras emocionales, favorece el trabajo colaborativo y estimula el desarrollo de la comunicación matemática, en caso de que las actividades se basen en contextos reales y cercanos al estudiante, también se destaca que el acompañamiento del docente es importante para el desarrollo de las actividades propuestas. Se llega a la conclusión de que la modelación matemática es más que una técnica de enseñanza, es un enfoque pedagógico que transforma la relación de esta disciplina y el prejuicio que se tiene sobre esta al convertir a los estudiantes en protagonistas de su propio aprendizaje.

Palabras clave: modelación matemática, actitudes hacia las matemáticas, educación básica, aprendizaje significativo, dimensión afectiva.

Introduction

Currently, mathematics faces a major challenge: the development of students with negative attitudes, apathy, and anxiety toward the subject. The literature warns that this systematic rejection arises at a very early age. Thus, children are raised under the false premise that this discipline is a purely abstract, complicated burden reserved for a select few.

One possible cause lies in the fact that teaching practices focus on traditional instruction rather than a constructivist model, placing greater emphasis on the memorization of procedures and the presentation of contexts that are meaningless to the student (Mancilla et al. 2026) .

Attitudes toward mathematics can be understood as affective and cognitive dispositions that determine how students relate to the discipline, including their level of confidence, motivation, and interest in mathematical tasks. Savaşlı & Serin (2025) , through the application of the Attitudes Toward Mathematics Scale (ATMS), demonstrated that these dispositions are measurable and modifiable: fourth-grade students who participated in mathematical modeling activities showed a statistically significant improvement in their attitudes compared to those who received traditional instruction, demonstrating that the affective dimension of mathematics learning responds directly to the type of pedagogical experience offered to them.

From this perspective, mathematical modeling emerges as a solid teaching strategy for general basic education. This methodology is understood as a process in which students use mathematical tools to understand, represent, and propose solutions to real-world problems in their environment. In this regard, Donnet et al. (2024) explain that modeling serves as a bridge to real life and enables students to respond to everyday challenges.

From a didactic perspective, a strategy is understood as an organized set of pedagogical actions aimed at facilitating learning by connecting mathematical content to real-life situations. In this regard, Moreno Reyes et al. (2016) structure the modeling process into five sequential stages: understanding the problem, simplifying it, mathematizing it, applying the model, and interpreting the results.

This cycle demonstrates that modeling is not a spontaneous activity, but rather a pedagogical process that, when properly guided, fosters critical thinking, autonomy, and a greater interest in mathematics.

Similarly, Asempapa (2017) notes that “mathematical modeling facilitates students’ problem-solving efforts and collaboration, in addition to fostering their mathematical thinking and learning” (p. 25).

Although various authors highlight the benefits of mathematical modeling, the literature analyzing how this methodology impacts affective and attitudinal dimensions in elementary education is

scattered. Part of the literature focuses on evaluating academic performance or the conceptions of pre-service teachers (Rivera & Gallegos, 2009) .

In this context, there is a need to investigate alternatives for transforming the teaching–learning process in mathematics and promoting an active role for students that allows them to apply problem-solving to real-world contexts.

This narrative review seeks to bridge that gap by offering an organized synthesis of the existing evidence on the impact of mathematical modeling on the attitudes of elementary school students. Most of the available studies focus on measuring academic performance or teachers' conceptions, leaving the students' affective dimension in the background.

The objective of this narrative review is to analyze the existing scientific literature on the impact of mathematical modeling on the attitudes of students in general elementary education. To guide this search and help bridge that gap, three main questions were proposed: What are the most common attitudes students exhibit when participating in mathematical modeling activities? Which elements specific to this methodology directly influence these attitudes? And which teaching strategies or innovations are most effective when implementing modeling to foster a positive attitude toward learning?

Systematizing these findings is innovative and important for Ecuadorian education. Applying mathematical modeling starting in elementary school helps build a positive relationship between students and the subject, thereby reversing stress, apathy, and demotivation toward mathematics.

Materials and Methods

This research was conducted using a narrative review design in mathematics education. This methodological approach allows for the comprehensive identification, analysis, and organization of scientific knowledge; this design was chosen for its ability to integrate studies employing diverse methodologies.

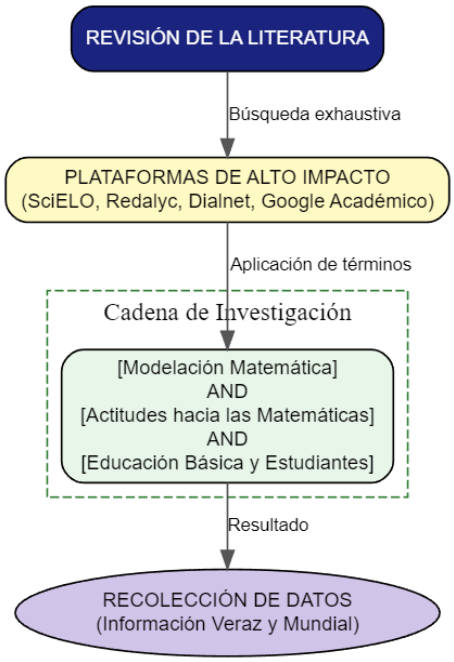
The review included qualitative, quantitative, and mixed-methods articles to provide a broader perspective on the study. This approach is ideal for addressing dimensions such as the affective and attitudinal, which are not always quantifiable; therefore, a narrative approach allows for the capture of classroom experiences.

To collect the information, an exhaustive search was conducted using academic databases. Priority was given to high-impact, open-access platforms to ensure the reliability of the sources. The main databases consulted were SciELO, Redalyc, Dialnet, and the Google Scholar search engine. These search engines were chosen due to their ease of access and extensive scientific information at both the global and Latin American levels (see Figure 1).

The literature review was conducted using the following search string: “mathematical modeling” OR “ ” “mathematical modeling” OR “mathematical modeling” AND “positive attitudes” OR “attitudes toward mathematics” OR “positive attitudes toward mathematics” OR “mathematical attitudes” AND “basic education” OR “students” OR “elementary students” OR “educación básica” (see Figure 1).

Figure 1.

Data Collection Process



This search string allowed for the interrelation between the main variable—mathematical modeling—and the affective dimension of students in basic education. Additionally, a filter was applied to ensure that the collected information was up-to-date; priority was given to scientific articles and book chapters published between

2015 and 2026 to ensure that the review presents the most recent information and innovations.

In order to select literature related to the topic, inclusion criteria were established. The search was limited to studies conducted in basic education that analyzed how mathematical modeling influenced the development of students' attitudes, such as stress, interest, and motivation. Furthermore, the decision was made to exclude from the sample those studies focused on college students, pre-service teachers, or those that measured only students' numerical performance.

In the first phase, search engines yielded a large number of articles that were discarded after reviewing their titles and abstracts. The relevant studies proceeded to a full-text review, during which articles that did not meet the established criteria were definitively excluded.

Through this process, it was possible to identify recurring patterns related to students' attitudes toward mathematical modeling activities, as well as the pedagogical factors that influence those attitudes. To finalize the literature review, the selected articles were organized into a matrix to facilitate data extraction.

This design aimed not only to organize information but also to construct a robust explanatory framework, thereby establishing a connection between theories of mathematical modeling and how these theories relate to the attitudes students develop toward mathematics.

Similarly, the matrix made it possible to identify various teaching strategies used by teachers to implement modeling in the classroom and promote more active and meaningful student participation in mathematics learning.

Results

The results of the narrative review were organized around three research questions. Table 1 presents a synthesis of the selected studies, followed by an analysis of the findings for each question.

Table 1. *Summary of selected studies on mathematical modeling and attitudes in elementary education.*

Title and Author(s)	Year	Method	Participants	Country
Interactions and Contributions. Form of Participation... (Parra-Zapata and Villa-Ochoa)	2016	Qualitative (Observation and interviews)	27 fifth-grade students	Colombia
Fermi Problems and Modeling Eliciting Activities... (Toalongo et al.)	2024	Mixed (Case study)	24 sixth-grade students	Ecuador
Modeling for the Development of Mathematical Competence... (Miñarro Fernández and Montejo-Gámez)	2023	Qualitative (Classroom experience)	24 sixth-grade students	Spain
Solving multiplication problems through modeling... (Tambaco Quintero et al.)	2025	Mixed (Descriptive-exploratory)	15 elementary school teachers	Ecuador
A Mathematical Modeling Activity in Elementary School... (Trelles et al.)	2022	Qualitative (Multiple case study)	7 sixth-grade students	Spain
Standardizing the practice of modeling-... (Olarte García)	2020	Qualitative (Descriptive study)	30 fifth-grade elementary school students	Colombia

Modeling as a learning strategy for solving... (Malusín Carabajo et al.)	2025	Mixed (Pre-experimental)	35 fourth-grade elementary students	Ecuador
Contributions to reflection on reality... (Martínez-Novoa)	2025	Qualitative (Case studies)	38 eighth-grade students	Colombia
The Effect of Mathematical Modeling Activities... (Savaşlı and Serin)	2025	Quantitative (Quasi-experimental)	Fourth-grade elementary students	Turkey
Dengue as a Context: Working on Statistical Concepts... (Ocampo-Arenas and Gaviria-Quintana)	2022	Qualitative (Classroom experience)	Fifth-grade elementary students	Colombia
Learning Mathematics Through Modeling... (Hitt and Quiroz Rivera)	2017	Qualitative (Case Study)	60 high school students	Canada
Energy expenditure during physical activities... (Parra-Zapata et al.)	2017	Qualitative (Classroom experience)	42 seventh-grade students	Colombia
The development of modeling skills... (Carrasco Mancilla et al.)	2026	Qualitative (Case studies)	Two fifth-grade teachers	Chile
Mathematical Modeling as a Bridge Between the	2024	Qualitative (Case study)	High school students	Argentina

Classroom... (Donnet et al.)				
Stop Swallowing Lies: Modeling a Study... (Jiménez Echavarría)	2022	Qualitative (Classroom experience)	Third-grade elementary students	Colombia

Impact of Mathematical Modeling on the Affective Dimension

The reviewed articles show that in traditional educational settings, children develop emotional barriers toward mathematics, thereby creating feelings of insecurity, stress, and boredom, as they perceive the subject as merely abstract content. Along these same lines, indicates that when students were asked about the topics covered in class, they struggled to explain them and stated that this subject was boring for them and only for gifted individuals.

This apathy toward mathematics often leads to what Villa-Ochoa (2015) refers to as "shortcut" attitudes stemming from factors such as students' reactions to highly structured problems, resulting in teachers lowering the quality of their texts and failing to take full advantage of the resources that modeling can provide.

However, when working with this methodology—by providing the necessary scaffolding and a well-structured instructional sequence—an immediate emotional shift occurs: students' passivity gives way to a willingness to work. In this regard, Parra-Zapata & Villa Ochoa (2016) demonstrate that mathematical modeling provides spaces that foster dialogue and reflective participation, thereby leading students to reflect on their own reality.

Martínez Novoa (2025) points out that when students are engaged in real-world contexts, they internalize knowledge, strengthen collaborative work, and even begin to develop a more technical language, making them feel more confident in what they are learning without feeling misled.

Parra-Zapata et al. (2017) demonstrate that connecting mathematics to students' interests transforms their attitude toward the subject. By engaging in a modeling activity—such as calculating the energy expenditure of cycling—the students were able to mathematically understand their own routine. This confirms that using a personal

context is not secondary but rather the indispensable driving force for achieving a change in attitude.

The literature highlights that students are able to understand mathematical modeling activities, even if they have no prior experience. In this regard, Toalongo et al. (2024) point out students' ability to adapt to this methodology, as well as the ease with which they interact with one another, exchange ideas, and relate their prior knowledge to the problem at hand.

Similarly, Miñarro & Montejo (2023) highlight that one of the competencies students developed most during the application of modeling was mathematical communication, which is of utmost importance for understanding the assigned task and for peer collaboration.

In this regard, the quasi-experimental study by Savaşlı & Serin (2025) provides concrete evidence by using psychometric scales to measure changes in students' attitudes. They found a clear improvement in the group that worked with modeling, compared to those who received traditional instruction. These results suggest that applying this approach helps transform the classroom environment and enables students to take on a more confident and active role in their own learning.

In conclusion, the literature confirms that the implementation of mathematical modeling in elementary and middle school classrooms across different countries and grade levels transforms the educational environment, in which students become active agents of their own learning, reinforcing positive attitudes and the ability to collaborate with their peers.

Instructional Design and Teacher Mediation

A review of the literature makes it clear that what truly motivates students is the connection between mathematics and real-world problems. However, these approaches are not always implemented in the classroom, as noted by Asempapa (2017) : "Teachers fear that students will be unable to solve modeling tasks due to the high cognitive demands."

For this reason, it is essential to emphasize the teacher's role in this process. Mancilla et al. (2026) assert that close guidance and just-in-time support prevent students from becoming frustrated by challenging mathematical situations, ensuring that young people do not lose confidence in their abilities.

Breaking down this barrier is necessary if we want to change the classroom environment. Olarte (2020) highlights in his research that students perceive mathematics as “difficult and only for geniuses”; however, when problems are related to everyday situations, motivation increases.

In fact, the emotional benefits of applying mathematical modeling are evident. Quintero et al. (2025) state that approaching multiplication through modeling completely changes students’ perspective, as they lose their fear of making mistakes and become actively engaged with the problem.

Consequently, students’ attitudes can be reinforced over the long term if modeling is introduced from the earliest stages of education. In this regard, Malusín Carabajo et al. (2025) agree that presenting modeling as a learning strategy in elementary education sparks a participatory interest that prevents future aversion to mathematics.

In conclusion, the way in which mathematical modeling is implemented directly contributes to the development of students’ attitudes, especially when the teacher promotes active communication during the activities. Similarly, it fosters confidence in expressing ideas, thereby strengthening participation during the learning process, as noted by Miñarro & Montejo (2023) .

Innovative Strategies for Building Mathematical Confidence

To foster a positive attitude toward mathematical modeling, the literature emphasizes that the key innovation lies in how activities are designed. Olarte (2020) suggests that replacing traditional textbooks with materials featuring real-life problems is an effective strategy and can serve as the most beneficial starting point for students.

Along the same lines, notes that the activities implemented must be realistic or applied to real-life situations so that students can develop a “ e sense of reality”; this is why the implementation of mathematical modeling activities is an innovative strategy and must be carried out in a realistic context.

In a study conducted by Jiménez (2022) with third-grade students, the students analyzed the sugar content in the items in their lunchboxes. The students examined labels, organized statistical data, and interviewed a nutritionist. The process culminated in the creation of a television commercial in which they communicated their findings and proposed healthy alternatives. Beyond the mathematical content, the students developed a critical perspective

on what they consumed. This demonstrates that when mathematics addresses something real and relevant to their lives, students take on an active role without the need for external explanations.

One strategy that ties into modeling is the incorporation of public health topics. In a study conducted by Ocampo et al. (2022) , the researchers found that using the spread of dengue fever to teach statistical concepts was highly effective. Because it was a situation affecting their community, the students understood the real-world value of the data they were analyzing.

Similarly, Trelles et al. (2022) implemented a mathematical modeling activity using real COVID-19 data, in which students had to predict the number of infected people based on a data table; the activity demonstrated that students were able to express their predictions even without prior experience. This suggests that strategies linked to students' real-world experiences strengthen the development of confidence and engagement in their learning.

Table 2.

Innovative Strategies for Applying Mathematical Modeling in the Classroom

Innovative Strategy	Context of Application	Author(s)	Observed Impact
Public Health	Dengue Transmission	Ocampo et al. (2022)	Understanding the true value of data.
Current Data	COVID-19 Predictions	Trelles et al. (2022)	Developing predictions without prior experience.
Text Substitution	Everyday Problems vs. Books	Olarte (2020)	Greater sense of reality and motivation.

Discussion

After analyzing the findings, we can confirm that modeling positively transforms the classroom, regardless of the country or grade level. However, a reasonable question arises: almost all studies involve brief experiences limited to a single instructional unit. This leads us to wonder whether this enthusiasm is fleeting or whether we are truly fostering a lasting change in children's relationship with mathematics.

To resolve this uncertainty, the way forward is through longitudinal studies. We need to understand whether continued exposure to this method succeeds in consolidating these positive attitudes over the years. Only then will we know if modeling can be the definitive

antidote to math anxiety, which often persists throughout a student's entire academic career.

Another vital point is the role of the teacher, who acts as the primary driver of attitudinal change. However, the current literature does not clearly show how to prepare teachers for this challenge in our Latin American context. As suggested by Mancilla et al. (2026) , there are severe gaps in initial teacher training that we must address so that this methodology becomes a regular practice and not just an isolated experiment.

On the other hand, we need to broaden our perspective. While the information we have from Ecuador, Colombia, and Spain provides an excellent foundation, we still need to discover what is happening in the rest of the region. It would be ideal to have much larger and more rigorous studies, similar to the work by Savaşlı and Serin (2025) , to help us measure this emotional change in completely diverse classrooms.

Finally, we cannot ignore the fact that every classroom is a world of its own, shaped by its environment. Factors such as gender, socioeconomic status, or the gap between rural and urban contexts could completely alter a student's response. Including these variables in the future research agenda will allow us to design strategies that are far more inclusive and attuned to the human reality of our students.

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