

Systematic Review in Solving Mathematical Problems

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Abstract

The ongoing challenges faced by mathematics students are highlighted through an analysis of the effectiveness of different teaching styles used worldwide. A systematic review of the literature selected nine articles from a total of 598 relevant articles using rigorous inclusion criteria and quantitative techniques. The results suggest that incorporating problem-solving skills into educational programs can significantly improve students' critical thinking and academic performance. Constructivist and sociocultural approaches, which promote collaboration, introspective practice, and participation, have been shown to be highly effective. The conclusion is that to foster a fruitful and meaningful learning environment and to enhance students' critical thinking and academic achievement in mathematics, a balanced teaching approach that combines direct instruction and independent learning is essential. This can be achieved through the use of technology and collaborative resources.

Keywords: Solving Mathematical Problems, Teaching Strategies, Mathematical Education.

INTRODUCTION

The purpose of this article is to examine and analyze the effectiveness of various teaching strategies for solving mathematical problems in educational environments worldwide. Teaching mathematics has been a persistent challenge in education, affecting both students' academic performance and their confidence and attitude toward the subject (Krause, 2023; Newton et al., 2022; Register et al., 2021; Rosillo & Montes, 2021). Despite advances in pedagogy and technology, many students continue to face significant difficulties when solving mathematical problems (Bharaj et al., 2023; Taylor & Dobie, 2024; Battey & Coleman, 2021; Ariza Muñoz et al., 2023; Becker & Hall, 2024). These difficulties not only affect their academic performance but also have a lasting impact on their confidence and attitude towards mathematics (Ärlebäck & Albarracín, 2024; Richit et al., 2024; Solin, 2021).

This article is based on a systematic review of the existing literature on mathematical problem-solving in education. Keywords such as "mathematics," "school," and "education" were used to conduct comprehensive searches in academic databases: Scopus, Scielo, and Web of Science. Studies that cover a wide range of pedagogical approaches and educational contexts from around the world were selected (Rodríguez Muñoz et al., 2022). The inclusion criteria focused on the relevance, methodological rigor, and geographical diversity of the studies (Herrero et al., 2023; Willingham et al., 2021). The information collected was analyzed and synthesized to identify common patterns and trends (Cavanaugh et al., 2023).

LITERATURE REVIEW

According to constructivism, students must build their own knowledge through experience and interaction with the environment (Luczak & Erwin, 2023). In the context of mathematical problem-solving, this implies that students must actively participate in the learning process, developing strategies and solutions through practice and reflection (Campos et al., 2024). From a sociocultural perspective, learning is considered a social and contextual process (Rubin & van Es, 2023). Mathematical problem-solving not only depends on

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individual ability but also on interactions with teachers, peers, and the educational context in general (Byerley et al., 2024). This approach highlights the importance of creating a collaborative learning environment and providing adequate support to students (Esperanza et al., 2023).

This evolution has been influenced by theorists such as Jean Piaget and Lev Vygotsky, who promoted the importance of active and social learning (Morán-Soto & González Peña, 2022; Tárrega-Mínguez et al., 2021). These approaches have led to the implementation of methodologies that encourage critical thinking, collaboration, and problem-solving in real-world contexts (Akyuz & Stephan, 2022).

Various countries have adopted standards and curricula that seek to balance direct instruction with opportunities for exploration and autonomous learning, reflecting contemporary trends in mathematics education (Luque-Sánchez & Montejo-Gómez, 2023). International organizations such as UNESCO and the OECD have emphasized the importance of quality mathematics education for sustainable development and effective participation in the global knowledge economy (McGraw et al., 2023). Educational policies such as the Common Core in the United States and the Program for International Student Assessment (PISA) have established frameworks for the teaching and assessment of mathematical competencies with a focus on problem-solving and analytical thinking (Marbán et al., 2021).

The justification for this study lies in the importance of solving mathematical problems as a fundamental skill that transcends the academic field and is applied in multiple aspects of daily and professional life (Schanke, 2023). Understanding and improving the teaching of this skill is crucial to preparing students to face the challenges of the 21st century, especially in a globalized context that requires coherent educational standards adaptable to different cultural and economic contexts (de la Cruz & Goldman, 2023).

This article seeks to contribute to the global understanding of best practices and offer evidence-based recommendations to improve mathematics teaching in various educational contexts (Miller & Suaray, 2023). The findings of this review are expected to highlight the importance of a balanced approach that combines direct instruction with opportunities for exploration and autonomous learning (Morán-Soto et al., 2022).

METHODOLOGY

This study employs a systematic review using a quantitative approach to evaluate the impact of interventions on problem-solving skills. Additionally, a descriptive non-experimental design was used (Hernández et al., 2014; Gonzales & Covino's, 2021), with the PRISMA statement guiding the selection and analysis of studies (Page et al., 2021).

Sample

The population and sample included relevant research on mathematical problem-solving in educational settings, ranging from primary education to the university level, conducted worldwide between 2020 and 2024 (Bernardo et al., 2015; Mucha-Hospinal et al., 2021). Only studies that met specific inclusion and exclusion criteria were examined to ensure the validity and reliability of the findings. This was achieved by strictly applying the PRISMA criteria (Moher et al., 2014; Hutton et al., 2016; Urrutia & Bonfill, 2010).

A comprehensive search was carried out in academic databases such as Scopus, SciELO and Web of Science using keywords in Spanish, English and Portuguese.

Regarding the criteria used for the selection of articles, the following were considered: (a) educational subject, (b) year of publication between 2020 and 2024, (c) type of publication (articles located in scientific and open access databases in everyone), (d) developed in the initial to university educational context and (e) with quantitative, qualitative or mixed methodological approaches. The exclusion criteria were: (a) categories not related to the educational subject, (b) articles published outside the range of years 2020 to 2024, (c) restricted access, (d) articles developed in contexts of special educational needs and (f) studies without a methodological approach such as books, essays, letters and conferences.

For data analysis, Atlas.ti 24 was used, analyzing and grouping the different variables related to solving mathematical problems. The systematic review identified 598 articles, of which 09 were selected for detailed

analysis (Page et al., 2021). The findings suggest that the implementation of educational programs that integrate problem-solving skills can significantly improve students' academic performance and critical ability (Lou et al., 2023). The search was carried out in July 2024, according to the following equations.

Equation 1:

"matemáticas" AND ("escuela" OR "educación")

Equation 2:

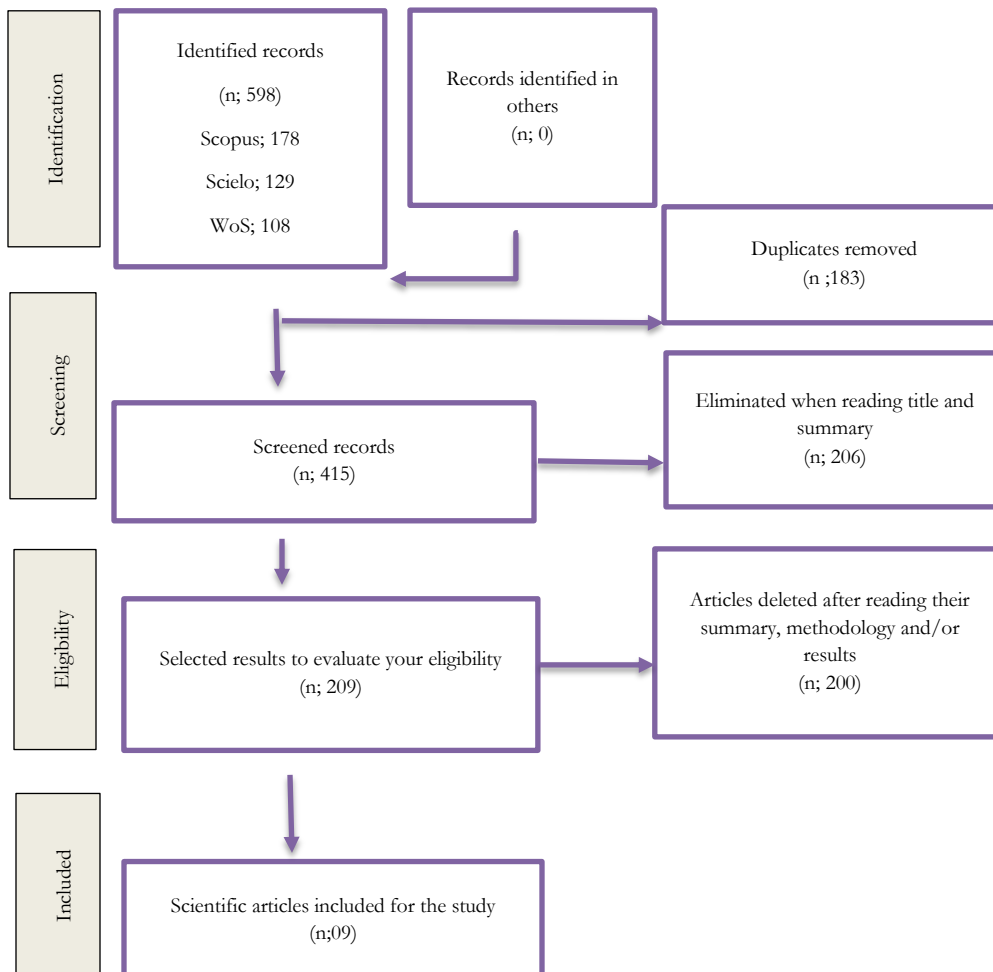
"mathematics" AND ("school" OR "education")

Table 1: Number Of Items, included – Excluded.

Database	Included articles	Excluded articles		Total
		First review	Second review	
Scopus	2	91	90	183
Scielo	6	70	54	130
Web of Science	1	228	56	285
Total	9	389	200	598

Note: Own elaboration.

Figure 1: Diagram, study eligibility procedure (PRISMA).



Ethical Aspects

Ethical aspects were duly respected, stating that the included studies complied with ethical research regulations, and the data were analyzed confidentially and incognito (Ali, 2023).

RESULT AND FINDINGS

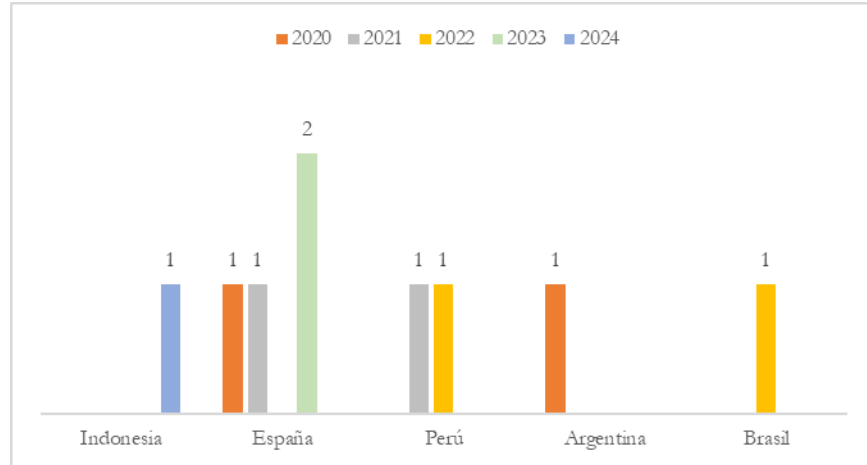


Figure 2: Number of articles included per country

Spain is the country with the largest number of articles included, with a total of three articles distributed across two different years. The other countries each have a single article published in different years. This indicates that the systematic review covered articles from several countries over different years, with a greater contribution from Spain in 2023.

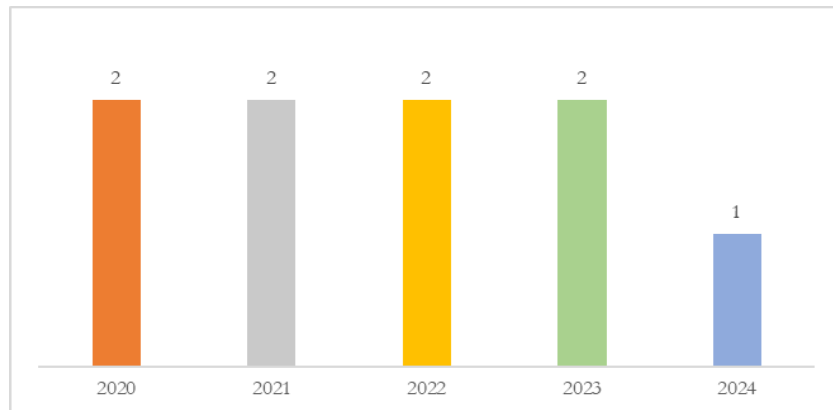


Figure 3: Number of articles included per year

This figure indicates that the systematic review has maintained a constant rate of inclusion of articles during the years 2020 to 2023, but in 2024 a decrease in the number of articles included is observed. This could be due to a lower availability of relevant articles or changes in the criteria for inclusion in the review.

Table 2: Scientific Articles Included

Author	Qualification	Sample	Methodology	Results
Suherman, S., & Vidakovich, T. (2024)	'Mathematical creative thinking - test based on ethnomathematics: role of attitude towards mathematics, creative style, ethnic identity and educational level of parents'	896 high school students randomly selected from five public and private schools in Indonesia.	Quantitative, descriptive	The study investigates the relationship between attitude towards mathematics, creative style, ethnic identity and parental educational level on mathematical creative

				thinking, showing how these factors influence academic performance.
Costado Dios, MT (2024)	'A training experience for future primary school teachers: implementation of a geometry and measurement activity'	199 students of the Primary Education Teacher Degree at the University of Cádiz.	The workshop methodology included the creation of a three-dimensional object using geometric figures and various materials.	This article describes an educational experience at the University of Cádiz where future teachers carried out a workshop combining knowledge and skills of geometry and measurement to develop professional skills.
Berrocal Ordaya, C., & Palomino Rivera, AA (2024)	'Ability to solve mathematical problems and its relationship with teaching strategies in first grade secondary school students'	60 first grade high school students in Peru.	A quantitative, descriptive and correlational approach was used.	The study determined a significant positive and low association between the perception of teaching strategies and the ability to solve mathematical problems.
Proença, MC, Pereira, AL, Mendes, LOR, & Travassos, WB (2024)	'Teacher professional development: reflections on pedagogical and mathematical knowledge'	A case study of a mathematics teacher in Brazil.	Qualitative research was used with a case study approach.	The article analyzes the professional development of a mathematics teacher, identifying four axes: initial knowledge, professional development, applied knowledge and challenges.
Blanco, TF, González-Roel, V., Diego-Mantecón, JM, & Ortiz-Laso, Z. (2024)	'Analysis of the art-mathematics connection in Primary Education textbooks'	24 Mathematics and 24 Plastic Education textbooks from four publishers. Spain.	descriptive quantitative analysis and qualitative analysis	The article analyzes the art-mathematics connection in primary education textbooks in Spain, highlighting that the ornamental connection is the most frequent.
Nieto-Isidro, S., & Moro Domínguez, MA (2024)	'Interdisciplinary reinforcement of basic numerical combinations in Primary Education'	49 first-year Primary Education students participated, distributed in two groups: 25 in the experimental group and 24 in the control group.	It was quasi-experimental research with an experimental group and a control group.	Evaluation of an interdisciplinary program in the Physical Education Classroom that showed a significant improvement in the participants' elementary calculation skills.
Sancha, I., & Broitman, C. (2024)	'The transformation of mathematical knowledge into writing situations linked to the institutionalization process'	A 5th year Primary Level classroom in Argentina.	Qualitative research was used with a case study design and some contributions from Didactic Engineering.	The article shows that writing situations contributed significantly to students' mathematical conceptualization. During problem solving in pairs, students developed new understandings by having to explain and justify their thinking processes in writing.
Gamarra Salinas, R., Yon Delgado, JC, & Yon Delgado, MR (2024)	'Ontosemiotic Approach in the development of Mathematical Capacities: Yarinacocha Intercultural School, Amazonia'	Students of the fourth grade of Basic Education of the IE Intercultural Bilingual Application Yarinacocha.	Used a qualitative case study approach	The article showed high effectiveness in the use of teaching materials to improve students' mathematical abilities. It was observed that the majority of students achieved or were in the process of achieving the abilities to mathematize, communicate and represent mathematical ideas, develop and use strategies, and reason and argue generating mathematical ideas.
Álvarez-Rey, I., & Muñoz-Rodríguez, L. (2024)	'Playful resources to improve the attitude of Primary Education students towards learning geometry'	10 students in the third year of Primary Education.	used a quasi-experimental approach to evaluate the impact of recreational resources	The study presents a didactic intervention with recreational resources, improving the attitude and

				motivation of students towards geometry, highlighting the importance of constructivist methodologies.
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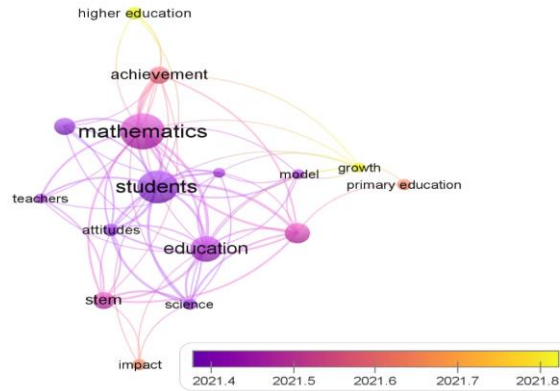


Figure 4: Co-Occurrence Of Keywords Obtained from The Web of Science Database for Publications Approved in The Years 2020-2024.



Figure 5: Summary: Scopus between the years 2020-2024 for equation 2.

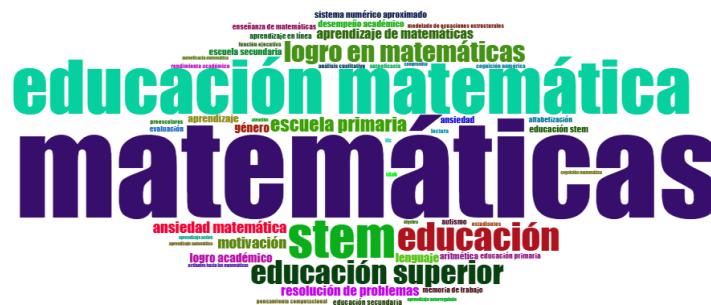


Figure 6: Cloud Of Keywords Obtained: Scielo Based On The Keywords Of Research Published In The Years 2020-2024.

Figure 4 models the co-occurrence of keywords associated with the study variable "mathematical problem solving." The terms "students," "mathematics," and "education" are prominently observed. Additionally, recent research has focused on the variables "higher education" and "growth" in the Web of Science database.

Figure 5 provides a general summary of publications in the Scopus database, obtained for the review of Equation 2. A total of 400 articles were found, associating 987 keywords related to this review. Furthermore, Figure 6 shows a visual representation of the 987 related keywords mentioned above.

CONCLUSION

The systematic review shows that the combination of educational strategies for solving mathematical problems positively impacts the academic progress and critical skills of students. These strategies promote

cooperation, reflective practice, and active engagement, creating a more productive learning environment. Suherman and Vidákovich (2024) highlight the importance of mathematical creative thinking and its positive relationship with mathematics, creative style, and ethnic identity, underscoring the need for inclusive pedagogical strategies.

The results indicate that effective mathematics instruction requires adapting the curriculum to balance independent learning and direct instruction. This approach allows students to acquire mathematical skills applicable in everyday life and work. Costado Dios's (2024) research demonstrates that specific workshops in geometry and measurement improve the professional skills of future teachers, suggesting that practical and contextualized training programs can increase the effectiveness of mathematics teaching in primary education.

The review of nine publications selected from different studies indicates that integrating problem-solving skills into educational programs improves critical thinking and academic performance. To promote meaningful learning, institutions must combine direct instruction with independent inquiry, relying on technology and collaborative resources. Berrocal Ordaya and Palomino Rivera (2024) found a positive relationship between the strategies applied to teaching and students' ability to solve problems, highlighting the importance of designing pedagogical strategies that develop critical thinking.

The analysis by Blanco et al. (2024) on the connection between art and mathematics in primary education textbooks highlights the usefulness of the ornamental connection as a pedagogical tool. Integrating artistic elements into mathematics teaching improves students' motivation and conceptual understanding, supporting an interdisciplinary approach that reinforces learning from multiple perspectives. These findings underscore the importance of pedagogical approaches that not only teach mathematical content but also cultivate creative and critical skills essential for academic success in mathematics.

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