Multidisciplinary Reviews

REVIEW ARTICLE
Published Online: September 1, 2025
https://doi.org/10.31893/multirev.2026140

Teaching mathematics in rural schools: A systematic review of classroom implementations

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Abstract This study aims to characterize the scientific production of classroom implementations in mathematics education within rural schools. A systematic literature review was conducted via the Scopus and WoS databases, following the PRISMA statement guidelines. The search equations incorporated keywords from UNESCO's thesaurus: rural education, mathematics, mathematics education, statistics education, statistics, primary education, and primary schools. The initial search yielded 1,926 documents, 13 of which were selected for detailed analysis after applying the inclusion and exclusion criteria. The results were categorized into three dimensions: (1) bibliometric analysis, (2) methodological analysis, and (3) impact analysis. The findings highlight the international interest in implementing strategies to improve mathematics education in rural settings. Pretest and posttest quasiexperimental designs, with control and experimental groups, were predominant. Additionally, mathematics teaching is often integrated with other disciplines, enhancing its applicability across various contexts. Most studies also explore the use of digital tools to support student learning, reflecting the growing integration of technology in education. While positive outcomes are generally reported, some studies mention challenges that may have influenced their findings. Finally, the diversity of pedagogical strategies employed underscores an adaptive and varied approach to teaching mathematics in rural environments.

Keywords: rural context, PRISMA statement, mathematics education, primary education, disadvantaged schools

1. Introduction

Mathematics plays a fundamental role in our culture, as it is a science that aids in understanding the universe, serves as a model of thought, fosters creativity, acts as an instrument for intervening in real-world structures, and functions as a recreational activity (Guzmán, 1997). Owing to this significance, mathematics is included in all countries' core knowledge outlined by curricular guidelines (Zapata-Cardona, 2018). Through educational systems, schools are responsible for developing students' ability to apply mathematical concepts, representations, and procedures to interpret real-world contexts in social, professional, and academic settings (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2009). However, despite continuous efforts to improve students' mathematical learning, significant challenges persist, as evidenced by international assessments (Organization for Economic Cooperation and Development [OECD], 2017, 2023).

Within the educational system, rural schools face distinct challenges. Owing to low student enrollment, these schools often combine multiple educational levels in a single classroom (Leones & Bonilla, 2024), which becomes a determining factor in identifying lower learning outcomes (De la Vega, 2020) than urban schools do (Cano, 2020; Juárez & Rodríguez, 2016). Importantly, the concept of rurality is not without controversy (Boix & Domingo, 2018; Hardwick, 2018; Sanuy et al., 2018), as its definition has evolved in response to social changes, leading to a more diverse understanding of rurality (Santamaría-Cárdaba & Sampedro, 2020; Santos, 2014). Additionally, there is an evident lack of research on rural education, compounded by the ongoing struggle against depopulation in these areas (Santamaría-Cárdaba & Sampedro, 2020). Morales-Romo (2019) highlights the undeniable symbolic value of rural schools for municipalities and their strong appeal to young families settling in these regions. Therefore, research in this context is essential (Harmon, 2017; Morales-Romo, 2017; Sorensen, 2018), particularly to enhance students' learning experiences at these schools.

Given the interest in gathering information on existing research related to mathematics education in rural schools and considering the scarcity of studies in this field—especially concerning reflection on scientific production (Santamaría-Cárdaba & Sampedro, 2020)—this study proposes conducting a systematic review using two well-established databases that store a significant number of scientific documents in the field of mathematics education. The review followed the guidelines of the PRISMA Statement (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) (Moher & Liberati, 2009). This methodological tool is essential for research (Sánchez-Meca, 2010), enabling systematic, rigorous, and replicable analysis of reported studies.

The literature contains various systematic reviews related to rural education. For instance, Biddle and Pricle (2016) analyzed research on rural schools in the United States, focusing on teacher recruitment and training issues. Their findings

 Received: May 10, 2025 | Accepted: June 18, 2025

indicate that, in the mid-20th century, efforts were made to modernize rural education, but interest declined as modernization was perceived to have been achieved. However, by the late 20th century, the precarious conditions in rural areas had reignited interest in studying the issue. Pérez et al. (2018) examined studies conducted primarily in the Andalusia region to illustrate the characteristics of schools in that area. They reported that rural schools prioritize community and proximity over a strong academic focus. Carrete-Marín and Domingo-Peñafiel (2022) analyzed scientific production related to the textbooks and materials used in rural schools, highlighting the need to develop educational resources tailored to rural contexts. Barreira et al. (2023) systematically reviewed science and mathematics teacher training in rural schools. These findings reveal the challenges teachers face, such as a lack of motivation to participate in research-based training programs and concerns about meeting curricular demands, given the limited connection between national curricular guidelines and the realities of rural communities.

Based on the reviewed literature and the issues outlined in the previous paragraphs, this study aims to characterize the scientific production of classroom implementation in mathematics education within rural schools.

2. Methodology

This research is a systematic review conducted following the PRISMA Statement (Moher & Liberati, 2009). To achieve this goal, the study adheres to the flowchart and inclusion-exclusion criteria to select the most relevant documents for the research objective. The analysis is divided into three dimensions: a) bibliometric indicators, b) methodological aspects, and c) study impact.

2.1. Sample and selection procedure for data extraction

The literature review was conducted in January 2025 via the Scopus and Web of Science (WoS) databases, which are considered the most relevant owing to their extensive scientific output and inclusion of educational research (Aravena-Díaz et al., 2024; Ferrada et al., 2020). The search equations used in this study were generated from keywords derived from the United Nations Educational, Scientific, and Cultural Organization (UNESCO): rural education, mathematics, mathematics education, statistics education, statistics, primary education, and primary schools. These keywords were chosen for their relevance to the research scope. The search equations used are presented in Table 1.

Table 1 Equations generated for the database search.

Database	Equation
Scopus	(TITLE-ABS-KEY (rural OR "rural education") AND TITLE-ABS-KEY (math* OR “math* education” OR "Statistic* education" OR statistic*) AND TITLE-ABS-KEY ("primary education" OR "primary schools"))
WoS	ALL=(rural OR “rural education”) AND ALL=(math* OR “math* education” OR statistic* OR “statistic* education”) AND ALL = ("primary education" OR "primary school")

Initially, the search yielded 1,926 documents, of which 1,350 were from Scopus and 576 from WoS. Duplicate documents (380) were subsequently identified and removed, leaving 1,546. From these 1,546 studies, the inclusion and exclusion criteria were applied. The exclusion criteria were as follows: publication year (only studies published between 2014 and 2024 were included), document type (only scientific articles were considered, while books, book chapters, and conference proceedings were excluded), language (articles in English, Spanish, and Portuguese were included), discipline (only studies related to the teaching of mathematics or statistics were considered), participants (only studies involving primary education students were included, while studies focused on early childhood, secondary education, or teachers were excluded), school type (only studies conducted in rural schools were included, excluding those focused on urban schools), and article type (only classroom implementation studies were considered, excluding theoretical articles, systematic reviews, and studies based on questionnaire applications). After applying these criteria, 13 articles were selected for detailed analysis in this study. A flowchart summarizing this process is presented in Figure 1.

3. Results

3.1. Articles for review

Table 2 presents the 13 articles selected for this systematic review. It specifies the assigned code for their identification in this study, the authors, the year of publication, and the titles of the respective studies. The number of authors ranges from one to nine, with an average of 3.8 and a mode of 3 (23.1%). Concerning the years of publication, the articles span from 2015 to 2024, with 2016, 2020, 2022, and 2024 being the years with the highest number of publications (15.4%). Concerning the language of the articles, the majority were written in English (84.6%), whereas a significantly lower proportion were written in Spanish (15.4%). No articles in Portuguese were identified.

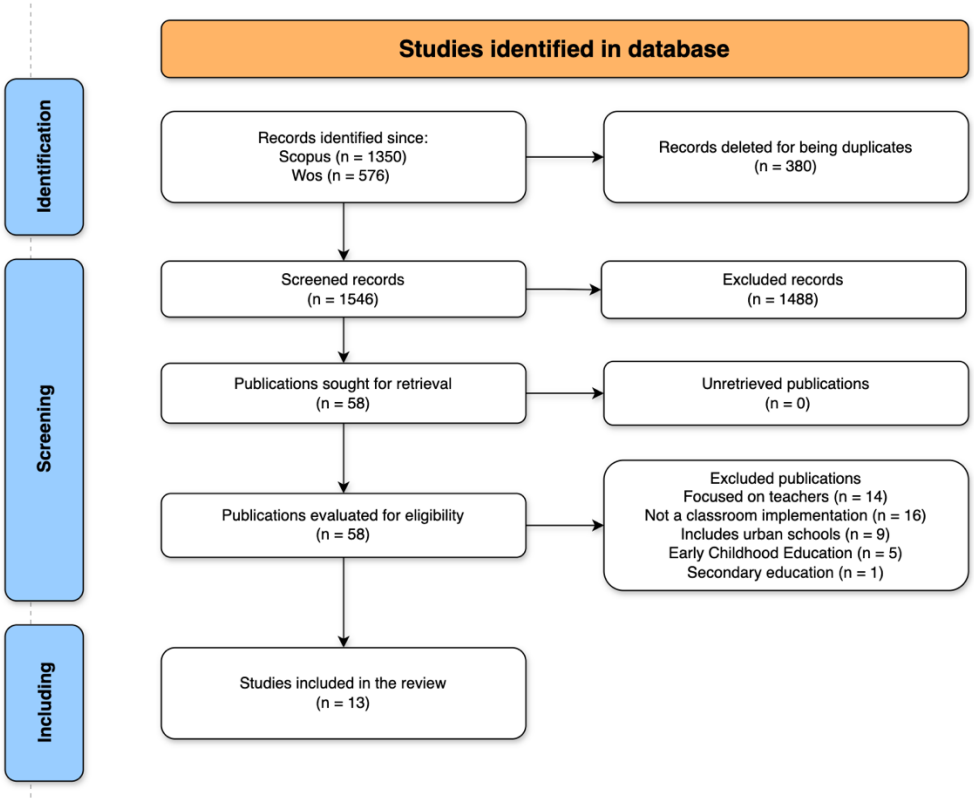

Figure 1 Systematic review flowchart.

Table 2 Coding and basic data of the articles.

Code	Authors	Year	Title
A1	Mo, Huang, Shi, Zhang, Boswell y Rozelle	2015	Computer Technology in Education: Evidence from a Pooled Study of Computer Assisted Learning Programs among Rural Students in China
A2	Lai, Zhang, Bai, Liu, Shi, Chang y Rozelle	2016	More is not always better: evidence from a randomized experiment of computer-assisted learning in rural minority schools in Qinghai
A3	Kyriakides, Meletiou-Mavrotheris y Prodromou	2016	Mobile technologies in the service of students' learning of mathematics: the example of game application A.L.E.X. in the context of a primary school in Cyprus
A4	Halloluwa, Vyas, Usoof y Hewagamage	2017	Gamification for development: a case of collaborative learning in Sri Lankan primary schools
A5	Ibrahim, Ayub, Yunus, Mahmud y Bakar	2019	Effects of Higher Order Thinking Module Approach on Pupils Performance at Primary Rural School
A6	Lee y Choi	2020	Enhancing early numeracy skills with a tablet-based math game intervention: a study in Tanzania
A7	Simweleba y Serpell	2020	Parental involvement and learners performance in rural basic schools of Zambia
A8	Fazzio, Eble, Lumsdaine, Boone, Bouy, Hsieh, Jayanty, Johnson y Silva	2021	Large learning gains in pockets of extreme poverty: Experimental evidence from Guinea Bissau
A9	Carpintero	2022	Matehuerto: El huerto escolar ecosostenible como recurso educativo en matemáticas [GardenMath: The eco-sustainable school garden as an educational resource in mathematics]
A10	Ramli, Maat y Khalid	2022	Digital Game-based Learning and Learning analytics in Mathematics
A11	Trejo	2023	La enseñanza de la adición con números naturales en la escuela primaria multi-grado [Teaching natural number sums in multi-grade primary school]
A12	Arrieta-Cohen, Torres-Arizal y Gómez-Yepes	2024	Evaluating the Impact of an Educational Intervention UsingProject-Based Learning on Postpandemic Recovery in Rural Colombia
A13	De Hoop, Rong, Siwach, Dias, Tembo, Rothbard y Toungui	2024	Impact of Technology-Aided Activity-Based Learning Approaches on Learning Outcomes Experimental Evidence from Community Schools in Rural Zambia

3.2. Bibliometric analysis

Table 3 provides bibliometric information on the articles analyzed in this review. The authors are affiliated with institutions from 14 countries, with the United States having the highest representation, appearing in four articles (A1, A2, A8, and A13), followed by Australia (A3 and A4), Belgium (A1 and A2), China (A1 and A2), Malaysia (A5 and A10), and Zambia (A7 and A13), each contributing two articles. Additionally, three articles feature authors from three countries (A1, A2, and A8). Concerning the journals in which these articles were published, 13 different journals were identified, meaning that each study was published in a different journal. For the indexing databases of these journals, four belong solely to Scopus (A2, A3, A5, and A11), one exclusively to WoS (A9), and eight are indexed in both Scopus and WoS (A1, A4, A6, A7, A8, A10, A12, and A13). The number of references included in the articles ranged from 23 (A9) to 79 (A4), with an average of 44.5 and a median of 45. With respect to citations, Google Scholar was used to gather this information, as it is a widely used search engine across databases. The search was conducted in January 2025, revealing a citation range from 0 (A11 and A12) to 101 (A3), with an average of 29.2 and a median of 24. Finally, the keywords per document vary from 3 (A5) to 10 (A12), totaling 71. The most frequent ones are education (A1, A2, and A8) and randomized controlled trials (A6, A8, and A13), followed by China (A1 and A2), computer-assisted learning (A1 and A2), literacy (A8 and A13), mathematics (A9 and A13), and primary education (A9 and A12).

3.3 Methodological analysis

Table 4 summarizes the methodological aspects of the articles included in this systematic review. First, the most frequently reported methodological design is quasiexperimental (A5, A7, and A10), specifically pretest and posttest designs (A1, A2, A4, A5, A6, A7, A10, and A12), with experimental and control groups (A1, A2, A4, A5, A6, A7, A8, A10, and A13). In some cases, these designs are supported by interviews (A1, A2, A4, and A7), field studies (A4), recordings (A4), and informal observations (A7). Other studies report the use of case studies (A3) and qualitative studies (A11), whereas one article does not define the methodology used (A9). Second, the studies reported sample sizes ranging from 10 to 15,421 primary education students, primarily focusing on the third grade (A2, A4, A11, and A12). Third, the majority of studies focus on arithmetic development (A4, A6, A8, A10, A11, and A13), followed by those aiming to teach all mathematical domains in primary education (A1, A2, A7, A9, and A12). Additionally, some studies address geometry (A3 and A5) and measurement (A5). Connections with other subjects are also reported, with language and literacy education being the most frequently integrated content area (A1, A2, A7, A8, A9, A12, and A13), followed by natural sciences (A9, A12), social sciences, and arts (A9). Fourth, regarding contextual data, the duration of the implementations varies from two weeks to four years. Some studies offer extracurricular classes to reinforce and supplement the content taught in regular school sessions (A1, A2, and A7). In contrast, others simulate mathematical situations (A3, A4), provide lesson plans to enhance student learning (A8 and A13) or apply project-based learning (PBL) methodologies (A8 and A13). Finally, concerning the materials used, software-assisted learning is predominant (A1, A2, A3, A4, A6, A10, and A13), whereas concrete materials are used less frequently (A9 and A11). Some articles do not specify the materials used (A5, A7, A8, and A12).

3.4 Analysis of the results

The following is a detailed summary of the impact reported in each of the studies analysed, highlighting their contribution to the field of study:

A1. The *Computer Assisted Learning* (CAL) program has positive effects on students' academic performance in Mathematics and Chinese. The additional exercises provided by the CAL software, new technologies, and the fast interaction of computers may have contributed to the positive impact on student learning. Furthermore, the programs are more effective when applied outside school hours, preventing the replacement of regular classes when interventions are conducted during school time. In terms of students' self-efficacy, it improved with the CAL Mathematics program. However, no effects were observed on self-efficacy when receiving CAL sessions in Chinese. This is explained by the fact that mathematics exercises may involve multiple problem-solving processes, which can enhance students' self-efficacy. In contrast, language exercises reinforce vocabulary memorization, grammar, and comprehension of phrases or paragraphs, making self-evaluation less likely. Boys benefited more than girls from the CAL Chinese program.

A2. Interventions with *Computer Assisted Learning* (CAL) software had positive effects on the academic results of 3rd-grade primary school students, as the CAL program improved students' scores in Mandarin and Mathematics exams. However, due to the doubling of instructional hours when adding the Mathematics CAL program, some schools were forced to use regular school hours instead of the planned initial extracurricular time. As a result, no significant improvements were observed in students' scores in Mandarin or the Mathematics CAL tests. One possible interpretation of these results is that replacing regular classroom teaching may have counteracted the positive effects of the CAL intervention. Additionally, in the second phase of the CAL program, where Mathematics was included, the instruction was in Mandarin, which may have created learning difficulties for students who use it as a second language.

Table 3 Bibliometric data of the analyzed articles.

Code	Countries	Journal	Database	References	Citations	Keywords
A1	Belgium, United States, China	China Economic Review	Scopus y WoS	35	50	Education, Computer assisted learning, Pooled study, China
A2	Belgium, United States, China	Journal of Development Effectiveness	Scopus	26	24	Education, development, computer-assisted learning, random assignment, test scores, China, rural minorities
A3	Cyprus, Australia	Mathematics Education Research Journal	Scopus	61	101	Mobile technologies, Gameapps, Primary school, Mathematics learning
A4	Australia, Sri Lanka	Personal and Ubiquitous Computing	Scopus y WoS	79	66	Collaboration learning, Gamification, Human computer interaction, ICT4D, Interaction design for children
A5	Malaysia	Malaysian Journal of Mathematical Sciences	Scopus	51	37	Conventional approach, HOTS-based module approach, Rural school
A6	Republic of Korea	Educational Technology Research and Development	Scopus y WoS	68	39	Early mathematics education, Randomized controlled trial, Tablet game-based learning
A7	Zambia	South African journal of childhood education	Scopus y WoS	31	21	Academic performance, Home learning resources, Homework, Home–school communication, Parental involvement, Parent–child interaction, Rural communities
A8	United Kingdom, United States, Netherlands	Journal of Public Economics	Scopus y Wos	53	33	Bundled intervention, Education, Literacy, Numeracy, Randomized controlled trial (RCT), State capacity
A9	Spain	Edma 0-6: Educación Matematica en la Infancia	WoS	23	7	Methodology, mathematics, primary education, eco-sustainable school garden, meaningful learning
A10	Malaysia	Pegem Egitim ve Ogretim Dergisi	Scopus y Wos	45	1	21st-century abilities, Data science application in education, Games, Improving classroom teaching, Teaching/learning strategies
A11	Mexico	Educación Matemática	Scopus	29	0	Cooperative learning, multigrade, number, teaching
A12	Colombia	Education Sciences	Scopus y Wos	31	0	21st-century skills, depth of knowledge, evidence-centered design, language skills, math skills, primary education, program evaluation, project-based learning, rural education, science skills
A13	United States, Zambia	Journal of Research on Educational Effectiveness	Scopus y Wos	46	1	E-learning, Learning outcomes, literacy, mathematics, randomized controlled trial, structured pedagogy, sub-Saharan Africa, Zambia

A3. Using digital games in teaching and learning mathematics improved student engagement and learning, including for low-performing students. In this sense, students understood the applicability of mathematics in various contexts, leading them to change the belief that mathematics is only for computational and arithmetic purposes. Moreover, students recognized the pedagogical value of using tablets with educational applications, such as the A.L.E.X. software. However, it is essential to note that the results are not generalizable due to the small sample size and the qualitative nature of the research.

A4. The study found that the use of technology, particularly tablets and applications specifically designed for developing countries, has the potential to provide a better learning experience. This implies that applications should not be created based on assumptions from developed countries, as contexts and practices differ. Researchers are therefore encouraged to consider

these implications and not rely solely on results from the developed world. The primary usability difficulties were related to interaction design, although students collaborated more freely. A novel aspect of this study is that it represents one of the first interventions exploring how gamified digital educational applications influence the teaching/learning experience in a primary classroom in a developing country in South Asia. Ultimately, the findings contribute to existing empirical evidence in the field of Human-Computer Interaction (HCI) through the design, implementation, and evaluation of primary school children's learning/teaching experience incorporating technology into their classroom activities.

Table 4 Methodological analysis of the collected articles.

Code	Methodology	Sample	Content	Context	Material
A1	Pretest and posttest with control and treatment groups and interviews	15,421 primary school students Control group: 8,502 Experimental group: 6,919	Mathematics and Chinese (General)	Two 40-minute extracurricular sessions per week supporting content covered in classes	Computer Assisted Learning (CAL) software for computers
A2	Pretest and posttest with control and treatment groups and interviews	3,701 third-grade primary school students	Mathematics and Chinese (General)	Two 40-minute extracurricular sessions per week supporting content covered in classes	Computer Assisted Learning (CAL) software for computers
A3	Exploratory case study	15 fifth-grade primary school students (8 boys and 7 girls) aged 10–11	Geometry	The class is organized into three groups of five students, each with access to an iPad to use the A.L.E.X. app	A.L.E.X. software for iPad or Android tablets
A4	Pretest and posttest with treatment and control groups, field study, recording, and follow-up interview	130 third-grade primary school students	Arithmetic	Over two weeks, sessions were divided into monetary use as a buyer and seller	Gamification software for tablets
A5	Quasiexperimental with control and experimental groups, pretest and posttest	127 students (5 years old) Treatment group: 66 Control group: 61	Measurement and Geometry	Over 12 weeks, the development of HOTS (Higher Order Thinking Skills) in problem-solving for Measurement and Geometry is encouraged	Not defined
A6	Experimental and control groups with pretest and posttest	122 students (6 to 10 years old) Treatment group: 60 Control group: 62	Arithmetic	One daily session for 46 days focused on identifying quantity discrimination, addition, subtraction, and missing numbers	Math game software for tablets
A7	Quasiexperimental with control and experimental groups, pretest and posttest, informal observations, and interviews	168 participants: 84 fourth-grade primary school students and 84 parents	Mathematics and Chitonga	Ten-week awareness program on how to help children with homework	Not defined
A8	Control and experimental groups	2,112 primary school students	Arithmetic and literacy	Included daily lesson plans, teacher manuals, student workbooks, and other educational materials specific to each grade level over four years	Not defined
A9	Not defined	First and second-grade primary school students	Mathematics, Language, Natural Sciences, Social Sciences, Arts	School garden used through Project-Based Learning (PBL), conducted 2 to 3 times per week for 45 to 50 minutes	Eco-sustainable school garden

A10	Quasiexperimental with control and experimental groups, pretest and posttest	64 primary school students	Arithmetic	Two hours per week for ten weeks	Math game software
A11	Qualitative experimental study, participant observation	10 multigrade students from first to third grade of primary school	Arithmetic	Playground games organized into eight sessions over eight weeks, one session per week	Seed bags and target throwing
A12	Pretest and posttest with a single group	287 third-grade primary school students	Mathematics, Language, and Science	Project-Based Learning (PBL)	Not defined
A13	Control and experimental groups	1,865 students Experimental group: 888 Control group: 977 (6 to 9 years old)	Arithmetic, preliteracy, and literacy	Lesson plans and teacher training, with structured guides to improve student learning	The e-School 360 software for tablets and projectors

A5. Implementing the HOTS-based module proves to be an excellent alternative for enhancing learning, as developing HOTS is crucial for equipping a generation with critical thinking abilities. The results of this study contribute to evaluating students' HOTS in relation to mathematical learning in rural areas with empirical evidence. However, the results obtained for students in the treatment group were not significant in mathematics. Therefore, like teachers, implementing HOTS in mathematics teaching requires a paradigm shift to achieve national education objectives. Finally, it is reported that these changes should be made cautiously so that students have the opportunity and necessary support to master mathematics from the early years of schooling.

A6. This study reveals the possibility of improving arithmetic learning using tablets, even when students lack experience with digital devices, which was the study's primary concern. Students quickly adapted to the digital application due to its simple interface. After the intervention, children could recognize and name numbers below 100 and distinguish between two numbers within that range. Additionally, they could add two single-digit numbers when the sum was less than 10 and complete forward counting tasks when the missing number was the last in the sequence. However, after 46 days of intervention, most students struggled with single-digit addition with regrouping, subtraction with regrouping, and sequential addition following patterns. From this perspective, the study highlights specific developmental needs and provides valuable didactic information for researchers, teachers, and curriculum designers. The application's incomplete curriculum may explain the lack of significant learning gains, as it lacks games covering all test objectives.

A7. This study reveals that properly sensitized parents can play a decisive role in their children's education. The results show an increase in the quality of parent-child interactions regarding schoolwork. Additionally, the use of household resources for teaching Mathematics and Chitonga increased, improving students' performance in both subjects. Furthermore, it is noted that many rural parents lack sufficient knowledge to support their children with school tasks, making it essential to identify strategies to maximize their potential in assisting with homework.

A8. This intervention yielded positive results in students' literacy and numeracy skills compared to those who did not receive the treatment. It demonstrates that providing this nearly free intervention is beneficial for parents and children in disadvantaged areas with high assimilation rates. Additionally, the results suggest that donors or educational agencies can achieve similar learning benefits by implementing such interventions in contexts with irregular or low-quality education. This study offers the opportunity to conduct follow-up assessments of students to examine education's long-term economic and social benefits, particularly in literacy and arithmetic.

A9. The school garden has proven to be an element that enhances mathematics learning and its real-life applications. Thanks to the flexibility of the environment, students have understood complex processes more quickly and have solved problems by integrating mistakes as part of the learning process. One of the most important aspects is that it has been possible to verify improvements in students' analytical, reasoning, and reflection skills, strengthening critical thinking across various subjects through *Project-Based Learning* (PBL).

A10. The results of this study demonstrate that the application of mathematical games in the teaching and learning process has successfully improved students' academic performance. The applications used are highly applicable and align with post-pandemic Covid-19 regulations. Additionally, they allow teachers to monitor students' learning and develop effective strategies to ensure that their academic progress is not negatively affected by COVID-19-related disruptions.

A11. Positive results were reported from using the target-throwing game to help students understand the metric system. Students showed motivation in using numbers to record scores and in performing arithmetic operations to calculate cumulative points and determine the winner. The importance of primary school students' communication processes was recognized, as interaction was the main element that facilitated the construction of new knowledge. The activity design

adapted students' learning paces, making it particularly effective for multigrade classrooms. Most students expressed enthusiasm when playing with peers, although some experienced greater difficulties understanding instructions.

A12. This study demonstrates the effectiveness of a *Project-Based Learning* (PBL) intervention that integrates Mathematics, Language, and Science, as well as 21st-century skills, for students in rural multigrade schools. This intervention helped students recover lost learning and enabled them to excel in more advanced cognitive and practical tasks. The positive impact on 21st-century skills highlights the value of integrating these competencies into the curriculum to better prepare students for future educational challenges. However, this study also identified areas where student performance declined, particularly creativity, suggesting the need for an additional focus within these types of interventions.

A13. The results indicate that integrated, technology-based teaching programs can improve learning outcomes in impoverished areas of Africa. This improvement was evident even among students without prior experience with basic technology. Specifically, students in the treatment group showed substantial improvements in Language, Arithmetic, and Oral Vocabulary skills.

Considering the above, most studies highlight improvements in mathematical learning through digital applications (A1, A2, A3, A4, A6, A10, and A13), even when students have no prior technology experience (A3, A6, and A13). However, these studies also reported challenges that affected their results. For example, in some cases, teachers replaced regular school classes with those that were supposed to be conducted outside of school hours (A1 and A2), the application interface was complex for students to understand due to language barriers (A2), and the mathematical topics covered in the application were insufficient to address the curriculum (A6) fully. Also, successful implementations were reported, particularly those that involved parents as supporters in the educational process (A7), incorporated games with tangible materials such as target throwing (A11), or integrated mathematics into interdisciplinary learning approaches (A9 and A12). On the other hand, positive learning outcomes were observed in nonmathematical subjects, such as Chinese (A1 and A2), Chitonga (A7), Language (A8, A9, A12, and A13), Natural Sciences (A9 and A12), Social Sciences, and Arts (A9). Finally, one study reported unsatisfactory results in mathematical learning (A5), attributing this outcome to the need for paradigm shifts in teaching HOTS among teachers and students.

4. Conclusions

Based on the results obtained in this study, mathematics education in multigrade rural schools is a research area of global interest. This is demonstrated by the diversity of countries to which the authors of the systematic review articles belong and the variety of journals in which these studies have been published. English-language articles predominated, whereas no articles in Portuguese were found. With respect to research methodology, quasi-experimental designs with pretests and posttests, including control and experimental groups, are the most common. Additionally, the number of participants in these studies ranged from 10 to 15,421, allowing most investigations to derive conclusions from large student samples.

Furthermore, most implementations integrate mathematical content with other subject areas, enabling students to connect concepts across different contexts and fostering the development of critical, analytical, and creative skills. In addition, the widespread use of digital applications for these interventions highlights the increasing integration of technology into the educational process. This approach promotes active student participation and the development of essential digital competencies, key elements in preparing students for an increasingly dynamic and technology-driven world. Regarding the impact of these implementations, most studies report positive results in mathematics learning and other disciplines. However, some challenges have been identified, such as using applications with interfaces in languages that are not easily understandable for students or replacing practical regular classes with extracurricular support sessions due to time constraints. Moreover, digital applications did not fully cover the curriculum evaluated in standardized tests. These findings suggest optimizing and adapting technological tools to make them more accessible and aligned with curricular guidelines. Developers of these applications must collaborate closely with educators and experts in didactics, incorporating features that address students' actual needs. Similarly, institutions must establish clear guidelines for implementing new technologies to ensure that the established quality of teaching is not compromised. Successful implementations using nontechnological materials, such as the eco-sustainable garden and the target-throwing game, are reported. These experiences demonstrate the versatility of strategies incorporating tangible resources into the teaching process and highlight the importance of diversifying pedagogical methodologies.

This study is limited by the search being conducted exclusively in the WoS and Scopus databases, which restricts the number of available articles for analysis. With respect to future directions, this research provides guidelines for future systematic reviews aimed at gathering information on interventions that seek to improve mathematics learning in students attending rural schools and replicating the use of interventions identified in the reviewed articles. Moreover, expanding the review by incorporating additional databases to include a broader range of specialized journals is suggested. This would allow for a more targeted search on topics related to mathematics education, such as the teaching of statistics.

Acknowledgment

All the authors would like to thank the Universidad Católica del Maule for their support in developing this research.

Ethical Considerations

Not applicable.

Conflict of Interest

The authors declare that they have no conflicts of interest.

Funding

This research did not receive any financial support.

References

Aravena-Díaz, M. D., Cárcamo-Mansilla, N., Díaz-Levicoy, D., Vergara-Gómez, A., & Rodríguez, M. (2024). Desarrollo de habilidades STEM mediante el uso de prototipos tecnológicos en educación secundaria: Una revisión sistemática. *Interciencia, 49*(8), 481–489.

Barreira, J. S., Júnior, J. E. L., Gonçalves, T., Moura-Silva, M. G., & Gonçalves, T. O. (2023). Desafíos para la formación de profesores deficiencias y matemática en escuelas rurales: Una revisión sistemática de la investigación. *Revista Electrónica de Enseñanza de las Ciencias, 22*(2), 260–281.

Biddle, C., & Pricle, A. P. (2016). Constructing and reconstructing the "rural school problem": A century of rural education research. *Review of Research in Education, 40*(1), 298–325. https://doi.org/10.3102/0091732X16667700

Boix, R., & Domingo, L. (2018). La escuela rural, una mirada intercontinental. *Aula de Innovación Educativa, 270*, 14–17.

Cano, A. (2020). Análisis de dificultades en la enseñanza y aprendizaje del español y las matemáticas en escuelas primarias multigrado de Veracruz-México. *Tendencias Pedagógicas, 37*, 57–74. https://doi.org/10.15366/tp2021.37.006

Carrete-Marín, N., & Domingo-Peñafiel, L. (2022). Textbooks and teaching materials in rural schools: A systematic review. *Center for Educational Policy Studies Journal, 12*(2), 67–94. https://doi.org/10.26529/cepsj.1288

De la Vega, L. F. (2020). Docencia en aulas multigrado: Claves para la calidad educativa y el desarrollo profesional docente. *Revista Latinoamericana de Educación Inclusiva, 14*(2), 153–175. http://dx.doi.org/10.4067/S0718-73782020000200153

Ferrada, C., Carrillo-Rosúa, J., Díaz-Levicoy, D., & Silva-Díaz, F. (2020). La robótica desde las áreas STEM en Educación Primaria: Una revisión sistemática. *Education in the Knowledge Society, 21*(22), 1–17. https://doi.org/10.14201/eks.22036

Guzmán, M. (1997). Matemáticas y sociedad: Acortando distancias. *Números: Revista de Didáctica de las Matemáticas, 32*, 3–11.

Hardwick, K. (2018). Rural school principals: Professional development and getting the 3Rs correct. *Australian Quarterly, 89*(3), 21–27.

Harmon, H. L. (2017). Collaboration: A partnership solution in rural education. *The Rural Educator, 38*(1), 1–5. https://doi.org/10.35608/ruraled.v38i1.230

Juárez, D., & Rodríguez, C. (2016). Factores que afectan a la equidad educativa en escuelas rurales de México. *Pensamiento Educativo, 53*(2), 1–15. https://doi.org/10.7764/PEL.53.2.2016.8

Leones, S., & Bonilla, O. (2024). Revisión bibliográfica sistemática de la investigación en educación multigrado. *Ciencia Latina Revista Científica Multidisciplinar, 8*(1), 9333–9355. https://doi.org/10.37811/cl_rcm.v8i1.10253

Moher, D., & Liberati, A. (2009). Revisiones sistemáticas y meta-análisis: La responsabilidad de los autores, revisores, editores y patrocinadores. *Medicina Clínica, 135*(11), 505–506. https://doi.org/10.1016/j.medcli.2010.02.016

Morales-Romo, N. (2017). The Spanish rural school from the New Rural paradigm: Evolution and challenges for the future. *Revista Colombiana de Ciencias Sociales, 8*(2), 412–438. https://doi.org/10.21501/22161201.2090

Morales-Romo, N. (2019). Cierre de las escuelas en entornos rurales: ¿Por o para el despoblamiento? *Revista PH, 98*, 20–23. https://doi.org/10.33349/2019.98.4388

OECD. (2017). *Informe nacional: TIMMS 2015*. Agencia de la Calidad de la Educación.

OECD. (2023). *PISA 2022 results (Volume I): The state of learning and equity in education*. OECD Publishing. https://doi.org/10.1787/53f23881-en

Pérez, M., García, I., & Quijano, R. (2018). Una aproximación a la realidad de los centros públicos rurales en Andalucía. *Tendencias Pedagógicas, 32*, 147–160. https://doi.org/10.15366/tp2018.32.011

Sánchez-Meca, J. (2010). Cómo realizar una revisión sistemática y un meta-análisis. *Aula Abierta, 38*(2), 53–64.

Santamaría-Cárdaba, N., & Sampedro, R. (2020). La escuela rural: Una revisión de la literatura científica. *Revista de Estudios sobre Despoblación y Desarrollo Rural, 30*, 147–176. https://doi.org/10.4422/ager.2020.12

Santos, L. (2014). Programa único o diferenciado: Especificidad curricular de la escuela rural uruguaya. *Historia da Educação, 18*(43), 33–48. https://doi.org/10.1590/S2236-34592014000200003

Sanuy, J., Llevot, N., Coiduras, J., & Soldevila, J. (2018). El Programa de Coordinación de los Estudios y la Innovación de la Escuela Rural de Cataluña. *EHQUIDAD. Revista Internacional de Políticas de Bienestar y Trabajo Social, 9*, 125–144. https://doi.org/10.15257/ehquidad.2018.0005

Sorensen, J. F. (2018). The importance of place-based, internal resources for the population development in small rural communities. *Journal of Rural Studies, 59*, 78–87. https://doi.org/10.1016/j.jrurstud.2018.01.011

UNESCO. (2009). *SERCE: Aportes para la enseñanza de las matemáticas*. UNESCO-OREALC.

Zapata-Cardona, L. (2018). Enseñanza de la estadística desde una perspectiva crítica. *Yupana, 10*, 30–41. https://doi.org/10.14409/yu.v0i10.7695