ESPERGESIA
REVISTA LITERARIA Y DE INVESTIGACIÓN
https://doi.org/10.18050/esp.2014

Universidad César Vallejo

Review article

Virtual Strategies to Develop Logical- Mathematical Thinking in Students: A Rapid Review

Estrategias virtuales para desarrollar el pensamiento lógico-matemático en estudiantes: una revisión rápida

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Fecha de recepción: 19.12.2023
Fecha de revisión: 13.05.2024
Fecha de aprobación: 24.05.2024

Cómo citar: Pazmiño Arcos, A. F., Fonseca Herrera, C. E., Sonia Del Pilar, R. M., & Rodríguez Morales, C. (2024). Estrategias virtuales para desarrollar el pensamiento lógico-matemático en estudiantes: una revisión rápida. Espergesia, 11(1), e110106. https://doi.org/10.18050/rev.espergesia.v11i1.2895

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Abstract

The integration of virtual strategies into mathematics teaching represents a promising practice to optimize the teaching and learning process, driven by advancements in technology and data analysis. **Objective:** To systematize the crucial virtual strategies for fostering the development of logical-mathematical thinking in students, through an exhaustive review of specialized literature. **Methodology:** A bibliographic review was conducted, compiling and describing information from scientific articles. Inclusion and exclusion criteria were established to select relevant literature, focusing on documents about the use of virtual strategies to improve logical-mathematical thinking in the target age group. Results: The adoption of virtual strategies and technological tools in education enriches the learning experience, facilitating the creation of innovative methodological proposals. These strategies promote differentiated learning, moti-vation, interest, and creativity in mathematics, positively transforming the educational landscape. It was observed that the use of virtual strategies is essential for effectively developing logical-mathematical thinking, underscoring the importance of continually adapting and improving these tools. **Conclusions:** The effective integration of virtual strategies is fundamental for the development of logical-mathematical thinking. The study highlights the need for teachers to adopt and expand the use of these strategies, leveraging their potential to foster a more dynamic and motivating learning experience. Furthermore, the importance of continuous teacher training that includes the pedagogical use of ICT to improve educational quality is emphasized.

Key words: Virtual Strategies; Logical-Mathematical Thinking; Early Education; Educational Innovation; Teacher Training.

Resumen

La integración de estrategias virtuales en la enseñanza matemática representa una práctica prometedora para optimizar el proceso de enseñanza y aprendizaje, impulsada por avances en tecnología y análisis de datos. **Objetivo:** sistematizar las estrategias virtuales cruciales para fomentar el desarrollo del pensamiento lógico-matemático en estudiantes, mediante una revisión exhaustiva de la literatura especializada. **Metodología:** Se realizó una revisión bibliográfica, recopilando y describiendo información de artículos científicos. Se establecieron criterios de inclusión y exclusión para seleccionar literatura relevante, centrándose en documentos que tratan sobre el uso de estrategias virtuales para mejorar el pensamiento lógico matemático en el grupo de edad objetivo. Resultados: La adopción de estrategias virtuales y herramientas tecnológicas en la educación enriquece la experiencia de aprendizaje, facilitando la creación de propuestas metodológicas innovadoras. Estas estrategias promueven un aprendizaje diferenciado, la motivación, el interés y la creatividad en las matemáticas, transformando positivamente el panorama educativo. Se observó que el uso de estrategias virtuales es esencial para desarrollar el pensamiento lógico matemático de manera efectiva, subrayando la importancia de adaptar y mejorar continuamente estas herramientas. **Conclusiones:** La integración efectiva de estrategias virtuales es fundamental para el desarrollo del pensamiento lógico matemático. El estudio destaca la necesidad de que los docentes adopten y expandan el uso de estas estrategias, aprovechando su potencial para fomentar un aprendizaje más dinámico y motivador. Además, se enfatiza en la importancia de una formación docente continua que incluya el uso pedagógico de las TIC para mejorar la calidad educativa.

Palabras clave: crecimiento económico, desempleo, Ley de Okun, modelo ARMA, Ecuador.

INTRODUCTION

The present report highlights that mathematics, in addition to being indispensable, is recognized as the queen of all disciplines. This area of knowledge not only favors the acquisition of specialized scientific skills and knowledge, but also presents an evolution parallel to the growth of civilization, contributing significantly to problem solving and cultural development (Lucas & Miraval, 2019). Despite its abstract nature, mathematics teaching promotes scientific thinking among students. Therefore, it is crucial that the mathematics teacher possesses comprehensive and up-to-date knowledge in concepts, methods, and techniques to optimize the teaching and learning process (Das, 2019).

The integration of virtual strategies in mathematics classrooms, according to Monreal Mendoza (2012), represents a promising practice. However, the success of this integration depends on multiple factors, including teachers' expertise and attitudes towards the implementation of virtual strategies. Das (2019) emphasizes that this process is indispensable for children to optimally acquire knowledge in various domains, transcending purely academic skills to foster an integral development of the student. This educational approach is linked to the ability to work and think numerically, as well as the ability to use logical reasoning, which brings significant benefits to student development.

Molero (2021) introduces the idea of a new global evolution driven by advances in technology, data analysis and knowledge expansion, pointing out that the use of virtual strategies through ICTs has become a fundamental pillar to meet the demands of the educational system. These tools not only facilitate the learning process, but also promise to offer innovative solutions to the multiple challenges faced by the education sector, highlighting the multiple benefits and positive factors involved in the integration of ICTs in education.

Today, we face a growing problem that mainly affects students, hindering their learning due to insufficient didactic inputs and limited use by educators of creative virtual strategies. The latter, if used appropriately, have the potential to enrich logical thinking in subjects such as mathematics. Therefore, our study aims to demonstrate that the implementation of virtual strategies in preschool education, specifically to foster the development of logical-mathematical thinking, is beneficial not only for students but also for teachers. In this sense, the effective use of ICT can improve the quality of teaching, optimize learning processes and school management, and contribute to the professional development of educators by making instruction more effective in the development of arithmetic and logical skills.

Pibaque & Vélez (2021) highlight the relevance of implementing virtual technologies in the educational process, since they facilitate the optimization of learning, a practice that is reflected daily in the teaching performance, promoting in turn, the adoption of innovative methodologies in teaching. Thus, it is possible to affirm that virtual learning environments, by integrating didactic strategies, games and interactions, facilitate the construction of knowledge, collaboration and effective learning among students. The incorporation of ICTs in mathematics education not only improves the educational process, but also requires the adoption of appropriate pedagogical approaches and significant methodological changes (Lucas & Miraval, 2019).

In the current context, there is a progressive implementation of virtual strategies that function as valuable resources in the educational environment, thus fostering the development of logical-mathematical thinking. It is important to highlight that ICTs have had a significant impact on the teaching and learning process, a fact that has been consistently manifested over time since technology began to be integrated into the social and educational environment of students (Llumiquinga *et al*., 2022).

The incorporation of technology, in combination with children's innate abilities, has enhanced the development of logical-mathematical thinking. However, with the exception of a few notable cases, this potential did not capture much attention within the educational community until before the COVID-19 pandemic (Baccaglini-Frank & Maracci, 2015).

The growing demand for qualified professionals in programming and new technologies is already becoming evident in our country. Therefore, it is not only a right, but also a necessity that primary education students are trained as critical individuals, equipped with the necessary tools

to generate technology and overcome their role as mere consumers. In this sense, learning programming from childhood is feasible and does not require special preconditions (Cerrón Molina, 2022).

The main purpose of this study was to systematize the crucial virtual strategies to foster the development of logical-mathematical thinking in students, through an exhaustive review of the specialized literature. Within the specific objectives established, we sought to: (1) characterize the performance of teachers specialized in mathematics, (2) identify the main deficiencies in the use and application of virtual strategies by these educators, (3) examine the didactic resources used by teachers to teach mathematics, and (4) develop a training proposal aimed at mathematics teachers to optimize the implementation of virtual strategies.

METHODOLOGY

Type of study and design

This work was based on a literature review methodology, focusing on the analysis and description of information obtained from scientific articles. This approach, combined with the proposed objective, provided a broad perspective on the topic of interest. Since there were limited studies on this subject, detailed information was collected and described, which was subsequently compared with that provided by various authors (Bavaresco, 2013).

Procedures

For the selection of relevant literature, eligibility criteria were defined, which included both inclusion and exclusion criteria, in order to ensure the relevance of the information collected. Renowned databases and information sources, such as Scopus, Web of Science, Scielo, Google Scholar, Redalyc, and Dialnet, among others, were used for the search. The terms used in the search strings included “virtual strategies”, “pre-school education” and “development of mathematical logical thinking”. The data selection process began with the elimination of duplicate entries, followed by a preliminary analysis through the reading of abstracts to assess their relevance. Subsequently, the selected articles were read in their entirety in order to extract significant information. The organization of the data focused on virtual strategies, facilitating a comprehensive understanding and analysis of the results.

Inclusion Criteria

The inclusion criteria for the study encompassed a variety of document types, including essays, original articles, and theses, which focused on the application of virtual strategies by teachers in pre-school education. Only papers published in English and Spanish were considered. In addition, preference was given to articles from high impact journals to ensure the quality and relevance of the information collected. The time period for the selection of papers was limited from January 2014 to December 2022, which allowed the inclusion of a broad spectrum of recent research in this field.

Exclusion criteria

Specific exclusion criteria related to document type and content were established for the study. Web pages that did not contain information on the application of virtual strategies or on the development of mathematical logical thinking were excluded. In addition, documents published before January 2014 and after December 2022 were discarded, thus limiting the search to a specific time frame that excludes non-relevant or outdated information with respect to the research objectives.

RESULTS AND DISCUSSION

Virtual strategies in mathematics teaching are presented as a significant catalyst for the development of logical-mathematical thinking in students. Our review showed that the adoption of technological tools and materials in education not only enriched the learning experience of students and teachers, but also facilitated the creation of novel and creative methodological proposals. It was observed that such strategies not only fostered differentiated learning, adapting to diverse skills, styles and speeds, but also promoted motivation, interest and creativity in the study of mathematics. These findings underscore the positive transformation that virtual strategies can bring to the educational landscape, offering new horizons for approaching and understanding a discipline traditionally considered complex and challenging.

According to Huamaní (2017), the use of technological tools and materials in the teaching of mathematics facilitates students and teachers to develop diverse skills, learning styles and rhythms. This enables the creation of both innovative and creative methodological proposals, contributing significantly to the improvement of cognition and the educational process. This study systematizes the contribution of the virtual strategies identified by the researchers and the participants. In addition, mention is made of an interview with an expert, from which it is deduced that the adoption and implementation of virtual strategies benefits the development of logical-mathematical thinking by stimulating interest, creativity and motivation in the mathematical field. This agrees with what is expressed by Rodríguez & López (2017), who argue that "it is necessary to implement different didactic situations that facilitate an interaction promoting the advancement of logical-mathematical thinking through the resolution of various exercises, supported by creative virtual strategies" (p. 16).

According to Delgado & Solano (2009), learning outcomes based on virtual strategies tend to motivate students more than traditional methods. Students report feeling as protagonists of their own active learning process, as virtual strategies make classrooms more dynamic and include deep planning and applied analysis. The main task of these strategies is to encourage the generation of new and innovative ideas in the classroom. However, negative evaluations are also identified, as some parents consider the use of these tools to be a waste of time.

In Spain, Moreno *et al*. (2021) indicated that the application of virtual strategies as a didactic technique has produced positive results in relation to the games in the classroom. This approach has improved student motivation, evidenced by improvements in academic performance, greater concentration and reinforced self-confidence. During the evaluation of these strategies, teachers rated the results obtained by the students as very good or excellent. In addition, students expressed their wish that these strategies be implemented in all subjects and levels of primary school education.

A study conducted in Mexico by Edel (2010) highlights the importance of motivation in the learning process for students of all ages. According to the findings, the use of virtual strategies increases motivation, teamwork and competitiveness, creating a more pleasant learning environment. This is because students stop acting out of obligation and begin to actively engage in meaningful reasoning and learning, marking a promising future for education.

Similarly, Rodriguez & Lopez (2017) highlight that gaming constitutes an effective learning strategy, adopted by various educational institutions worldwide at all levels: primary, secondary and university. The integration of technological tools in the classroom transforms the educational experience, encouraging students not only to listen but also to participate and interact actively. This methodology not only inspires and entertains, but also promotes unconscious learning by combining technology and games. However, we identified limitations, such as time management and attention span of students, especially those who use mobile devices in class.

In addition, Rincón (2011) highlighted the positive impact of virtual strategies on student performance in mathematics, focusing particularly on gamification. This analysis revealed that this technique significantly increases student learning by offering constant stimuli, presenting challenges that students strive to overcome. In addition, virtual strategies in mathematics teaching and methods for assessing academic performance are often based on quantitative approaches. Initial diagnostic assessments are followed by interventions that, according to the applications of these strategies, result in a marked improvement in academic performance. On the other hand, in Ecuador, Molero (2021) analyzed the results obtained before and after implementing virtual strategies, identifying a substantial improvement after the introduction of gamification. This finding is considered a crucial reference point for evaluating the impact of such strategies in the local educational environment. These findings underscore the effectiveness of virtual strategies, particularly gamification, as powerful tools for fostering improved academic performance in mathematics. The constant search for challenges and the motivation provided by these techniques contribute significantly to the educational process, offering promising prospects for future research and practical applications in the educational field.

It was also identified that Onrubia (2019) in Ecuador proposed a shift from the traditional approach to education to one based on virtual strategies. This new approach focuses

on developing students' creativity, skills, abilities and competencies through games as an innovative strategy. The integration of virtual platforms into the curriculum allows for comprehensive coverage of thematic content. This method makes learning more attractive for students, who become the main actors in the educational process by competing, collaborating and generating knowledge, thus increasing their creativity and curiosity (Onrubia, 2019). It is evident that the use of virtual strategies in the teaching of mathematics in primary-school education facilitates the development of mathematical knowledge.

The researchers emphasize that in order to achieve positive results in early childhood education, it is crucial to use virtual strategies to support learning. The relevance of this research approach lies in its potential to help students achieve significant gains and advance their mathematical reasoning. Currently, both teachers and students are adapting their learning methods to include technological tools, which become allies of educators by enabling effective knowledge development. Virtual strategies represent a significant support in the teaching of exact sciences, offering new opportunities for the promotion of critical reasoning. This transforms the student from being merely a passive receiver of information to become an active generator of knowledge, with more active participation, motivation and academic achievement, which contributes to future research of great importance.

In fact, Mathematics is considered one of the most challenging areas within the educational cycle, requiring constant methodological innovation (Valencia *et al*., 2016). This need for innovation is due to the increasing incidence of student difficulties in this discipline, which are largely attributed to the teaching methodology employed by teachers. The inherent complexity of mathematics requires in-depth knowledge and a willingness to adapt to significant changes in teaching dynamics, suggesting that at advanced educational levels, reinforcements and methodological changes should be implemented to facilitate learning. However, these arguments are easier to formulate than to apply.

Encarnación & Legañoa (2017) emphasize the importance of early knowledge and the development of mathematical skills from preschool education. In the early years, it is crucial that educators identify and apply basic concepts for the development of students' mathematical reasoning, preventing traditional methods from hindering new learning. In later educational stages, the desired performance should be achieved through the adoption of appropriate strategies. This reflects the importance of a pedagogical strategy that evolves with the student, adapting to his or her learning needs and fostering a solid mathematical understanding from an early age.

Likewise, Valencia *et al*. (2016) highlight that mathematics is perceived as one of the most challenging areas of the educational cycle, which underscores the need for constant methodological innovation to address the increasing rate of student difficulties in this discipline. The effectiveness of mathematics teaching, therefore, depends to a large extent on the approach adopted by teachers. Encarnación & Legañoa (2017) argue that, given the complexity of the subject, it is crucial to be prepared to implement significant changes in teaching dynamics, especially at higher levels through mathematical reinforcement and methodological changes. These changes, however, must start from preschool education, where the early development of mathematical skills and the application of methods that encourage logical reasoning without tradition hindering new learning is fundamental.

On the other hand, Das (2019) delves into the nature of learning in virtual environments, describing it as a constructive process where what is learned is not merely a reproduction of the content presented, but a reprocessing mediated by the learner's cognitive structure. This implies that virtual learning should be conceived not as a simple transfer of knowledge, but as a process of personal reconstruction that enriches the student's cognitive structure. Rincón (2011) complements this vision by pointing out that the constructive mental activity of the student, in relation to the content, is the core of learning, where the quality of this activity defines the quality of learning itself. In this line, Pibaque & Vélez (2021) warn that not all learning activities are conducive to effective constructive mental activity, nor are all these activities equally beneficial for high quality learning.

These perspectives underline the importance of adopting innovative and constructive approaches to teaching, especially in challenging areas such as mathematics, and recognize the complexity and diversity of learning processes in virtual

environments. The conscious integration of pedagogical strategies that promote constructive mental activity and skill development from an early age is essential to overcome current and future educational challenges.

The results obtained by Zárate *et al*. (2022) in their study show an in-depth exploration of the teaching strategies and experimental experiences used in the classroom. This research highlights that surveys directed to students and teachers emerge as the main method of data collection. It also reveals that a well-developed logical mind is key to effective mathematical problem solving, provided it is applied correctly. However, a challenge arises when some teachers find it difficult to integrate logical thinking into the solution of mathematical problems, which underlines the need to acquire specific knowledge to find the right solution.

In addition, it is noted that approximately 42% of teachers sporadically resort to virtual strategies in teaching mathematics. In this context, Vera (2022) argues that virtual strategies have the potential to significantly influence student learning and performance, generating interest in the study of mathematics and its integration into educational practice. The effectiveness of these strategies depends critically on their quality and the frequency with which they are used in the classroom. Therefore, Zambrano *et al*. (2021) suggest that educators should strive to innovate and apply new creative virtual strategies in all academic subjects to enhance student learning. Interestingly, the data reveal that 48% of teachers have never used web-based applications as a virtual teaching strategy in mathematics, reflecting that 56% have experienced difficulties in their implementation, perceiving them as of limited usefulness. Despite this, the use of virtual strategies has been shown to increase the interest of 68% of students in the learning process, highlighting the importance of continuously adapting and improving these tools to enrich the educational experience.

Carpio & Arana (2021) highlight the importance of virtual strategies in stimulating students' interest and dedication to learning mathematics, emphasizing how these strategies not only improve the learning process, but also promote the development of interpersonal skills, complement face-to-face teaching, and facilitate the monitoring of educational achievements. This perspective is echoed by Edel (2010), who emphasizes the need for mathematics teachers to adopt an innovative approach, integrating new information and communication tools, such as ICTs, to enrich their teaching methodology.

Furthermore, Muelas (2018) points out that, despite the underutilization of these strategies, they have played a crucial role during the pandemic, contributing significantly to the learning process and offering new ways to motivate and integrate all students. In line with this, Pastora & Fuentes (2020) highlight the value of digital tools in mathematics education, arguing that these can ensure and enhance the learning process. Valencia et al. (2016) go further by suggesting that teachers should align their practices with best practices in mathematics teaching, recommending the integration of ITCs in the school curriculum as a strategy to improve educational quality and student motivation.

Jiménez *et al*. (2022) highlight the importance of modern technologies in education, pointing out that they offer various tools for everyday activities and can be implemented in teaching as didactic strategies to foster the development of logical-mathematical thinking in students. This perspective suggests that, although some teachers continue to resort to traditional methods and use technologies only sporadically in mathematics classes, there is a clear need to adopt and expand the use of virtual strategies. These not only serve as communication mechanisms for follow-up and integration, but also motivate and evaluate, promoting active participation and engagement in the learning process.

The research indicates that the prevalence of repetitive methods and an insufficient use of virtual strategies lead to a moderate development of logical thinking among students. Despite the availability of numerous free virtual applications, the complexity of their use represents a challenge for their effective integration into mathematics teaching. It highlights the need for careful and consistent application of these tools to cultivate logical thinking, allowing students to formulate hypotheses, perform synthesis, and develop explanations and analysis in a sequential manner.

Finally, among the tools recommended to enhance logical thinking in mathematics are virtual applications such as Quizizz, Puzzles, Kahoot, GeoGebra, and Graspable Math. Their proper use can revitalize the educational

process, incorporating interactive virtual games, explanatory videos, and the resolution of exercises, in addition to facilitating communication through instant messaging applications such as WhatsApp. These tools not only improve academic performance, but also increase students' interest in their studies, demonstrating the significant value of integrating virtual strategies and information technologies into the mathematics curriculum.

Contributions to knowledge

This study contributes to the understanding of how virtual strategies can be effectively integrated into mathematics teaching for children in the initial stages of education. It highlights the importance of using virtual technologies and tools to enrich the learning experience, promote motivation, and stimulate the development of logical-mathematical thinking, thus contributing to pedagogical innovation and improving educational quality.

Limitations

One of the main limitations identified in this study is the reliance on existing literature, which may limit the understanding of current dynamics in real classrooms and the practical application of virtual strategies. In addition, the variability in the quality and approaches of the studies reviewed could influence the generalization of the results.

CONCLUSIONS

This research highlights how technological advancement and data analysis enhance the educational process, allowing the creation of innovative methodologies that enrich the learning experience. It highlights the need to continuously adapt and improve these tools to effectively respond to current educational challenges.

The research systematizes key virtual strategies, derived from an exhaustive review of specialized literature, to foster differentiated learning that adapts to the diverse abilities, styles and rhythms of students. These strategies, in addition to fostering interest and motivation towards mathematics, promote a more dynamic and participatory educational environment, where students become active protagonists of their learning process.

It was observed that the implementation of virtual strategies is essential not only for the effective development of logical-mathematical thinking but also for the integral formation of students, preparing them to face future challenges in an increasingly digitalized world. This highlights the importance of continuous teacher training that includes the pedagogical use of ICTs, ensuring that educators are equipped with the necessary skills and knowledge to effectively integrate these technologies into their teaching practice.

Furthermore, the study emphasizes the need for teachers not only to adopt these virtual strategies, but also to expand and adapt them to their specific educational contexts in order to maximize their potential. It suggests the creation of collaborative and interactive learning environments that facilitate the development of critical skills and logical-mathematical thinking, always considering the well-being and interests of students.

Finally, the effective integration of virtual strategies in early education is fundamental for the development of logical-mathematical thinking. This approach not only improves educational quality, but also prepares students for the challenges of the future, highlighting the importance of continuous teacher training and the constant adaptation of technological tools to educational needs.

Recommendations

In order to enrich initial teaching and foster students' integral development, it is imperative to design teacher training programs that prioritize the fusion of ICTs and innovative virtual strategies. Likewise, studies that evaluate the effectiveness of these strategies in various educational environments should be promoted in order to provide concrete guidelines for their effective implementation. Multidisciplinary collaboration among educators, technologists and instructional designers is essential to create virtual resources that respond to the specific needs of learners. In addition, it is vital to establish monitoring and evaluation systems to measure the impact of these initiatives on children's logical-mathematical thinking, thus guaranteeing constant improvement and adjustment of educational processes.

Contribución de los autores

Andrea Fernanda Pazmiño Arcos: Conceptualization, Formal analysis, Research, Methodology, Project management, Supervision, Validation, Writing - original draft, Wording: proofreading and editing.

Carolina Estefania Fonseca Herrera: Conceptualization, Formal analysis, Research, Methodology, Visualization, Writing - original draft, Wording: proofreading and editing.

Sonia Del Pilar Román-Medina: CConceptualization, Research, Methodology, Writing - original draft, Wording: proofreading and editing.

Carolina Rodríguez Morales: Research, Validation, Visualization, Writing - original draft, Wording: proofreading and editing.

Conflictos de interés

The authors declare that there are no conflicts of interest.

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