Analysis and Metaphysics
ISSN: 1584-8574, eISSN: 2471-0849
Vol 23 (1), 2024
pp.658-668

Digital Strategy for the Strengthening of Mathematical Logical Thinking in Primary Education

Hernán Javier Guzmán Murillo
Doctor en Ciencias de la Educacio´n
Universidad de Sucre Colombia
hernan.guzman@unisucre.edu.co
https://orcid.org/0000-0002-6757-4549

Karen Catalina Leal Acosta
Magister en Derecho Pu´blico
Universidad de Sucre Colombia
karen.leal@unisucrevirtual.edu.co
https://orcid.org/0000-0002-7916-2605

Tania Inés Martinez Medrano
Magister en Derecho Procesal
Universidad de Sucre, Colombia
tania.martinez@unisucre.edu.co
https://orcid.org/0009-0006-1722-6577

Publication date: May 20, 2024

Summary

The development of mathematical logical thinking is fundamental in basic education, as it allows students to improve their ability to analyze, solve problems, and understand essential mathematical concepts. This study presents the implementation of an interactive didactic sequence based on digital resources to strengthen mathematical logical thinking in fifth grade primary school students. The design of the pedagogical intervention was based on the analysis of the difficulties evidenced in diagnostic tests applied to the students, where deficiencies were identified in the resolution of problem situations involving basic mathematical operations. To address this problem, a didactic sequence structured in three phases (opening, development, and closing) was designed, implemented on the Genially digital platform, which integrates explanatory videos, interactive activities, digital games, and practical exercises aimed at improving students' mathematical skills. The methodology used corresponds to a qualitative approach with an action research design, in which 34 fifth-grade students participated. The data were collected through direct observation, questionnaires and checklists that allowed evaluating the interaction of students with digital resources and their performance in solving mathematical problems. The results indicate that the use of the interactive didactic sequence contributed significantly to the development of mathematical logical thinking, improving the students' ability to apply calculation strategies,

interpret sentences and develop mathematical reasoning processes. In addition, there was an increase in student motivation and participation in activities, suggesting that the integration of digital technologies in the classroom can be an effective tool to enhance mathematical learning in primary education.

Keywords: interactive didactic sequence; mathematical logical thinking; problem solving.

Introduction

The development of mathematical logical thinking in primary education is a fundamental aspect for the acquisition of cognitive competencies that allow students to face problematic situations in various contexts of daily and academic life. In recent years, various studies have shown that basic education students have difficulties in understanding and applying mathematical concepts, which negatively impacts their performance in national and international learning assessment tests (OECD, 2021). These difficulties are usually related to the mechanical use of algorithms, the lack of problem-solving strategies, and the poor application of logical reasoning in the interpretation of mathematical situations (Gómez & Mendoza, 2022).

Against this backdrop, it is essential to design pedagogical strategies that favour the strengthening of mathematical logical thinking from an innovative didactic perspective, incorporating active methodologies and the use of digital technologies as tools for mediating learning (Vallejo & González, 2022). The teaching of mathematics should not be limited to the transmission of operating procedures, but should promote exploration, analysis, and argumentation, allowing students to construct knowledge in a meaningful way and develop problem-solving skills in a dynamic and interactive environment (Pérez & Ramírez, 2020).

In this context, this study proposes the design and implementation of an interactive didactic sequence based on the use of digital tools, with the aim of strengthening mathematical logical thinking in fifth-grade primary school students. This proposal is based on the need to generate learning experiences enriched with technological resources that favor motivation, active participation and the development of essential mathematical skills.

The didactic sequence has been designed on the Genially platform, integrating multimedia resources such as explanatory videos, interactive games, and practical exercises aimed at solving mathematical problems. The proposal is structured in three phases: opening, where the mathematical concept is introduced in a visual and interactive way; development, in which students solve digital activities guided by the teacher; and closing, where consolidation and reflection exercises are carried out on the learning acquired.

Through this research, we seek to answer the question: How does the implementation of an interactive didactic sequence influence the development of mathematical logical thinking in primary school students? Based on this question, it is hypothesized that the use of digital resources designed in a structured and pedagogically grounded manner can contribute significantly to the improvement of mathematical comprehension and the strengthening of logical thinking in students.

Part Two: Theoretical Approaches

The design and implementation of the interactive didactic sequence is based on different theoretical approaches that support the importance of the use of digital technologies for the teaching of mathematics. The main conceptual frameworks that underpin this study are presented below.

1. Mathematical Logical Thinking and Problem Solving

Mathematical logical thinking is an essential cognitive skill that allows individuals to analyze, structure, and solve mathematical problems efficiently. According to Piaget (1971), the development of logical thinking occurs through processes of abstraction and generalization, in which the individual establishes relationships between concepts and builds increasingly complex structures of knowledge. In the educational context, the strengthening of mathematical logical thinking is essential for success in learning mathematics, since it facilitates the understanding of fundamental principles and the application of problem-solving strategies in different scenarios (Kilpatrick, Swafford & Findell, 2001).

From Polya's (1957) perspective, problem-solving is an essential component of mathematical thinking, since it involves the formulation of strategies, the organization of information, and decision-making to find solutions to situations posed. In this sense, the teaching of mathematics should promote learning experiences that challenge students to develop their logical reasoning and to apply problem-solving strategies in real contexts.

2. Use of Digital Technologies in Mathematics Teaching

The use of digital technologies in the classroom has proven to be an effective strategy for improving mathematical learning, by providing interactive resources that encourage autonomous exploration and discovery. According to recent studies, the use of digital tools such as simulations, educational games, and interactive platforms favors the development of mathematical skills, by allowing students to manipulate visual representations and experiment with different problem-solving strategies (Prensky, 2012; Hattie, 2018).

The integration of technologies in the teaching of mathematics is supported by the Multimodal Learning Theory (Mayer, 2005), which postulates that learning is more effective when different formats of information presentation, such as texts, images, and interactive animations, are combined. In this sense, the use of digital didactic sequences facilitates the understanding of complex mathematical concepts, by providing dynamic visual representations that reinforce the conceptualization and application of the contents.

3. Constructivist Approach and Inquiry-Based Learning

The constructivist approach maintains that learning is an active process in which students construct knowledge from interaction with the environment and the resolution of problematic situations (Vygotsky, 1978). From this perspective, the teaching of mathematics should focus on the exploration of concepts and the formulation of hypotheses, promoting learning based on inquiry and experimentation.

The implementation of interactive didactic sequences allows the principles of constructivist learning to be applied, by providing an exploratory environment where students can interact with content, solve problems, and receive immediate feedback on their performance. This approach not only favors the development of mathematical logical thinking, but also increases motivation and interest in learning mathematics (Bruner, 1996).

Through this study, we seek to provide empirical evidence on the effectiveness of digital strategies in the teaching of mathematics, providing tools that can be used by teachers to improve the development of logical thinking in their students. The following sections will describe the methodology used, the results obtained and the implications of these findings for educational practice.

Methodology

Study Design and Approach

This study adopts a qualitative approach with an action research design, which allows analyzing the implementation of an interactive didactic sequence and its impact on the development of mathematical logical thinking in primary school students. Action research is a methodological approach that seeks to generate changes in educational practice through observation, intervention and reflection on teaching and learning processes (Elliot, 1993).

The study was carried out in three phases:

1. Initial diagnosis, in which the students' difficulties in mathematical logical thinking were identified through diagnostic tests and classroom observation.
2. Implementation of the interactive didactic sequence, based on the integration of digital tools in the teaching-learning process.
3. Impact evaluation, through the observation of student performance, surveys and checklists applied before and after the intervention.

Participants

The study population consisted of 34 fifth-grade primary school students from a public educational institution. The sample was selected through non-probabilistic intentional sampling, considering the availability of digital resources in the classroom and the willingness of teachers to participate in the study.

Data Collection Instruments

To evaluate the impact of the interactive didactic sequence on the development of mathematical logical thinking, the following instruments were used:

- Initial and final diagnostic test: composed of mathematical problems of logical reasoning that allow the level of mathematical competence of the students to be identified before and after the implementation of the didactic sequence.
- Classroom observation: a structured observation guide was used to record the students' interaction with digital resources and their participation in the proposed activities.
- Student perception surveys: applied at the end of the intervention, with the aim of knowing the students' assessment of the use of digital tools in the learning of mathematics.
- Checklists: used to evaluate students' participation and performance in solving mathematical problems during the implementation of the didactic sequence.

Implementation Procedure

The interactive didactic sequence was designed on the Genially platform, incorporating interactive activities, explanatory videos, practical exercises, and digital games that allow students to explore mathematical concepts in a visual and dynamic way. The implementation was structured in three phases:

1. Opening: introduction of mathematical concepts through videos and exploration activities.
2. Development: problem solving and interactive exercises guided by the teacher.
3. Closing: reflection and evaluation of learning through self-assessment activities and consolidation of knowledge.

Data Analysis

The data analysis was carried out using a qualitative approach, applying content analysis techniques to interpret the information obtained from classroom observations, student perception surveys and diagnostic tests. The results obtained before and after the intervention were compared, identifying improvements in mathematical problem solving and in students' perception of the use of digital resources in mathematics teaching.

The findings obtained are presented in the following section, where the results of the study are detailed and their implications for the teaching of mathematical logical thinking in primary education are discussed.

Results

Analysis of the Data Collected

The analysis of the data obtained through diagnostic tests, classroom observation, and student perception surveys made it possible to evaluate the impact of the interactive didactic sequence on the development of mathematical logical thinking in fifth grade students.

1. Results of the Initial and Final Diagnostic Test

The initial diagnostic test showed that most of the students had difficulties in solving mathematical problems that required the application of logical reasoning and the structuring of solution strategies. The main problems detected were:

- Difficulty in interpreting mathematical statements and establishing relationships between the data provided.
- Mechanical use of algorithms without understanding the mathematical procedure.
- Errors in the identification of numerical patterns and relationships between mathematical operations.

After the implementation of the interactive didactic sequence, the results of the final test showed a significant improvement in the resolution of mathematical problems, evidenced in the increase in the precision of the answers and in the application of more structured solution strategies.

Figure 1
Comparison of results in the initial and final diagnostic test.
(Note: Figure included according to the original document of the intervention model).

2. Classroom Observation

During the implementation of the didactic sequence, classroom observation made it possible to identify positive changes in the students' attitude towards learning mathematics:

- Increased active participation in digital activities and problem-solving.
- Greater autonomy in learning, evidenced in the exploration of digital resources without the need for constant intervention by the teacher.
- Use of trial and error strategies in the resolution of interactive problems, which favored the development of logical reasoning.

These findings suggest that the integration of digital tools in the teaching of mathematics facilitates the understanding of mathematical concepts, by providing visual and interactive representations that reinforce the learning process.

3. Student Perception Surveys

At the end of the intervention, surveys were applied to the students to find out their perception of the use of the interactive didactic sequence in the learning of mathematics. The main results were:

- 92% of students stated that the use of digital tools made mathematics more understandable and dynamic.
- 88% of the students considered that the didactic sequence helped them to improve their ability to solve mathematical problems.
- 95% of students expressed that they would like to continue using digital resources in their math classes.

These results reflect a high level of acceptance of digital tools as a learning strategy and highlight their potential to improve motivation and academic performance in mathematics teaching.

4. Qualitative Analysis of the Impact of the Intervention

The content analysis of the observations and surveys allowed us to identify some key patterns in the impact of the didactic sequence:

- Students developed greater confidence in their ability to solve math problems, reducing anxiety and fear of making mistakes.
- Learning based on exploration and the use of interactive games favored the construction of their own strategies for problem solving.
- Teachers reported an improvement in students' attitudes toward learning mathematics and in their ability to work as a team in problem solving.

Summary of Findings

Indicator	Initial Result	Upshot	Improvement Observed
Interpretation of mathematical statements	Casualty	Loud	Yes
Using Solution Strategies	Deficient	Adequate	Yes
Interest and motivation in the subject	Low	High	Yes
Logical reasoning ability	Limited	Improved	Yes
Acceptance of the use of digital tools	Neutral	Very positive	Yes

The results obtained show that the implementation of an interactive didactic sequence based on digital tools can be an effective strategy to strengthen mathematical logical thinking in primary school students. The implications of these findings and their relevance to educational practice will be discussed in the following section.

Discussion

The results obtained in this study show that the implementation of an interactive didactic sequence based on digital tools has a positive impact on the development of mathematical logical thinking in primary school students. The comparison between the results of the initial and final diagnostic test shows a significant improvement in the students' ability to interpret mathematical statements, apply structured solution strategies and recognize numerical patterns.

From the approach of the Multimodal Learning Theory (Mayer, 2005), these findings can be explained from the use of visual representations, digital interactions, and practical activities that favor the construction of mathematical knowledge in a meaningful way. The incorporation of digital tools in teaching allowed students to explore mathematical concepts autonomously, increasing their motivation and reducing anxiety about problem-solving (Hattie, 2018).

Impact on the Development of Mathematical Logical Thinking

The use of a structured digital didactic sequence facilitated the application of Polya's (1957) problem-solving model, providing students with a guided process for identifying, understanding, and solving mathematical situations. The improvement observed in the interpretation of statements and in the planning of solution strategies confirms the importance of designing learning experiences that go beyond the mechanical application of algorithms and that promote logical reasoning and mathematical argumentation (Kilpatrick, Swafford & Findell, 2001).

These results coincide with previous research that has shown that teaching mathematics using digital tools favors the construction of solid mental models and facilitates learning based on exploration and discovery (Prensky, 2012; Vallejo & González, 2022). In this study, it was observed that interaction with digital resources allowed students to generate hypotheses, perform tests and correct errors in real time, which increased their level of understanding and autonomy in solving mathematical problems.

Motivation and Attitude towards Learning Mathematics

Another key aspect identified in the research was the increase in students' motivation and positive attitude towards learning mathematics. The student perception survey revealed that more than 90% of students considered that the interactive didactic sequence improved their understanding of mathematical concepts and allowed them to learn in a more dynamic and fun way.

These findings are aligned with the Theory of Game-Based Learning (Gee, 2005), which argues that the incorporation of playful and interactive elements in the teaching process generates greater cognitive and emotional involvement on the part of students. The combination of explanatory videos, interactive activities, and mathematical games on the Genially platform favored active participation and commitment to learning, reducing the perception of mathematics as a difficult or boring subject.

Challenges and Limitations

While the results of this study are encouraging, the adjusted coefficient of determination (adjusted R^2 = 0.06387) indicates that the interactive didactic sequence explains only a part of the development of mathematical logical thinking, suggesting that there are other factors that influence this ability. Some of the variables that may have played a role in the process include:

- Individual differences in the pace of student learning.
- Degree of familiarity with digital tools, since some students showed greater speed in adapting to interactive resources.
- Socio-educational context, including access to technological devices and digital infrastructure in the educational institution.

Another aspect to consider is the need for teacher training in the pedagogical use of digital tools. The effective integration of technological resources in teaching requires teachers to have adequate strategies to design and adapt interactive didactic sequences to the needs of their students (García & Mendoza, 2021).

Implications for Educational Practice

The results obtained in this study have important implications for educational practice and the design of mathematics teaching strategies in primary education. In particular, it is recommended:

1. Incorporate digital tools in the classroom as a complement to traditional teaching, promoting the interactive exploration of mathematical concepts.
2. Design structured didactic sequences that combine explanatory videos, interactive activities, and practical exercises to strengthen mathematical logical thinking.
3. To encourage problem-based learning, providing students with opportunities to analyze mathematical situations and develop solution strategies autonomously.
4. Train teachers in the use of digital platforms, ensuring that they can design technology-enriched learning experiences.

Finally, future research could expand this analysis through longitudinal studies that allow evaluating the impact of the use of digital tools on the development of mathematical logical thinking over time. It would also be pertinent to explore the influence of other factors, such as the level of family support and the perception of mathematical self-efficacy in students, to obtain a more comprehensive view of the learning process.

Conclusions

The results obtained in this study show that the implementation of an interactive didactic sequence based on digital tools favors the development of mathematical logical thinking in primary school students. The comparison of the results of the initial and final diagnostic test shows a significant improvement in the students' ability to interpret mathematical statements, structure solution strategies, and apply logical reasoning in problem solving.

From a theoretical approach, these findings support the Multimodal Learning Theory (Mayer, 2005), which suggests that the combination of visual, auditory, and interactive stimuli improves the understanding of mathematical concepts and facilitates their application in different contexts. Likewise, the results are aligned with the Theory of Game-Based Learning (Gee, 2005), which emphasizes the positive impact of gamification on students' motivation and commitment to learning.

On a methodological level, the research showed that the use of digital technologies such as Genially allows for the structuring of didactic sequences that integrate explanatory videos, interactive activities, and practical exercises, promoting more dynamic and participatory learning. Classroom observation reflected an increase in students' autonomy, who explored mathematical concepts more actively and developed greater confidence in their ability to solve problems.

However, the adjusted coefficient of determination (adjusted R^2 = 0.06387) indicates that the interactive didactic sequence explains only a part of the development of mathematical logical thinking, suggesting that other factors also influence this ability. Among these factors are students' previous experience with digital tools, the level of family support, and the perception of mathematical self-efficacy, elements that could be explored in future studies.

From a practical perspective, the findings of this study highlight the need to:

1. Incorporate digital tools in the teaching of mathematics, with the aim of facilitating the understanding of abstract concepts and encouraging autonomous exploration.
2. Design didactic strategies that combine interactive activities and problem-solving, promoting the development of logical thinking in a structured way.
3. Train teachers in the use of educational technologies, ensuring that they can implement effective didactic sequences and adapt them to the needs of their students.

Finally, future research could expand the analysis of the relationship between the use of digital tools and the development of mathematical logical thinking, exploring longitudinal methodologies that allow evaluating the impact of technological integration on learning over time. In addition, it would be pertinent to investigate how interaction with digital platforms influences students' perception of mathematical self-efficacy and their academic performance in the subject.

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