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Active Strategies to Strengthen Logical Mathematical Thinking

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Abstract---Mathematical logical thinking is fundamental in the cognitive and academic development of students, facilitating problem solving and critical reasoning. This article focused on the analysis of problem-based learning to enhance mathematical performance in eighth-year students. basic of the Educational Unit "San Cayetano" of Chone, a problem that currently arises in this educational institution, the following question arises how to strengthen mathematical logical thinking in these students. Traditional teaching methods are considered obstacles that limit the effectiveness of active strategies to strengthen mathematical logical thinking. An in-depth review of the existing literature on the key aspects of problem-based learning and mathematics teaching was carried out. This article aims to implement problem-based learning as an active strategy to strengthen mathematical logical thinking in 8th grade students. A mixed approach was used, combining qualitative and quantitative methods to evaluate how this strategy can improve mathematical logical thinking. In the students, the results obtained through the observation sheet showed us the lack of implementation of active strategies in terms of solving mathematical problems, in the same way a survey was applied to the students, being satisfactory, highlighting the positive impact of this learning. based on problems in academic results.

Keywords---active strategies, logical mathematical thinking, problem-based learning.

Introduction

Mathematical logical thinking is a crucial skill that allows individuals to reason systematically and solve problems efficiently. In the educational field, fostering these skills is essential to prepare students to combat academic and professional challenges. However, traditional mathematics teaching normally focuses on the memorization of mathematical procedures, which can condition the development of critical thinking and creativity. Such mathematical logical thinking is not only relevant in mathematics, but is also fundamental in disciplines such as science, technology, engineering and mathematics (STEM).

Mathematical logical thinking is an expertise that spreads from the simple memorization of formulas and procedures, which is vital for the development of logical thinking, problem solving and decision making in different aspects of daily life. For this reason, it is considered essential in all educational stages, from childhood to adulthood; as it provides essential cognitive tools. Several studies have shown that a solid foundation in the area of mathematics during childhood is correlated with better academic performance both in mathematics and in other areas.

For Tares Quiridumbai & Fernández Reina (2022), it is essential that learning begins with the acquisition of logical-mathematical skills, since they will allow the establishment of solid mental structures to resolve subsequent daily situations, and that the individual is capable of executing more brain functions. complex. Therefore, a didactic intervention that provides an incentive to the student towards learning the contents taught is intended to enhance the

development of logical mathematical thinking skills and abilities. In such a way, well-developed mathematical skills are linked to a greater capacity for logical reasoning, problem solving and critical thinking, skills that are essential in daily life and work. Therefore, intervening in the development of mathematical thinking at all educational stages not only benefits individuals in their academic career, but also contributes to the socioeconomic development of communities and societies in general.

It is necessary to highlight that logical-mathematical thinking is of utmost importance for the development of students' skills, enabling them to understand and apply fundamental concepts. Therefore, this issue was addressed as a priority, given that the lack of skills in this area can restrict job opportunities in the future. These competencies not only influence the academic field, but also enable individuals to make informed decisions in their personal lives and contribute significantly to social progress. Today, we face a wide range of challenges in education, which have an adverse impact on students. Traditional approaches that focus on memorizing formulas rather than fostering conceptual understanding represent one of these challenges. In addition, the scarcity of resources in many classrooms also exerts a negative influence on the learning process; the lack of teacher training can lead to dependence on traditional methods and a lack of willingness to implement new strategies.

In the last decade, various pedagogical strategies have been explored to improve these skills, with active strategies standing out for their effectiveness and dynamism, such as active strategies that include methods such as problem-based learning (PBL), said learning is cooperative and It is done through the use of educational games, which have shown a significant positive impact on the development of logical-mathematical thinking. According to (Castaño & Montante, 2015), these strategies promote more interactive and participatory learning, where students not only receive information, but apply, analyze and synthesize it in a collaborative and participatory manner.

Starting from the hypothesis that is established as: "Implementing problem-based learning (PBL) as an active strategy to strengthen logical mathematical thinking in eighth-year basic students of the San Cayetano de Chone Educational Unit will result in a significant increase in the development of logical mathematical thinking in comparison with those students who do not participate in the program, how to enhance logical mathematical thinking in students of the 8th year of basic education of the "San Cayetano de Chone" Educational Unit?. The purpose of this research is to provide educators, researchers and professionals in the field of education with an active strategy to promote logical-mathematical thinking among their students, thus contributing to closing the gap in the mastery of this important cognitive skill and improving results. long-term educational. This approach benefits not only the students, but also the institution, since it is expected to improve the quality of teaching as a whole (Gorghiu et al., 2015; Yu et al., 2022; Šafranĵ, 2016; Demirel et al., 2015).

Materials and Methods

A mixed approach was used, combining quantitative and qualitative methods since, for its part, "the quantitative approach is characterized by the systematic collection of information that can be quantified, followed by a rigorous analysis using statistical techniques" (Zúñiga et al., 2023). While for Hernández Sampieri & Mendoza Torres (2018), qualitative research is the essence of understanding phenomena, exploring them from the perspective of the participants in their natural environment and in relation to the context.

With the purpose of studying how active strategies favored the development of logical-mathematical thinking in 8th grade students. The study adopted a quasi-experimental design, in which participants were divided into two groups: an experimental group and a control group. With this design, the effect of the intervention of active strategies could be analyzed by comparing the results of both groups. To obtain the data that supported this research, an initial logical-mathematical thinking test was administered to both groups, with the objective of establishing a comparative basis.

The experimental group received instructions based on active strategies such as problem-based learning, mathematical games, and collaborative problem-solving activities for 8 weeks; while the control group continued during the same period with the traditional teaching method. The study population was made up of eighth-year basic level students from the San Cayetano de Chone School, with a total of 31 students. The sample was divided into two groups: 15 students formed the control group, while 16 students made up the experimental group, with the purpose of comparing both groups and validating the implementation of said strategy.

Analysis and Discussion of the Results

Active strategies in the teaching process are techniques that are used and focused on student learning, in order to achieve training in a specific discipline, these are very different from traditional teaching in which the student It is

only limited to receiving from the teacher a series of proposed contents and instructions. However, when referring to active strategies (Márquez, 2021), it states that the active strategies that are applied in the educational field relate to the group of methodologies and techniques that are implemented to achieve an academic goal and for the student to achieve the necessary learning in the teaching-learning process.

For (Sanango Siguencia, 2023), there is a direct relationship between mathematical didactics and pedagogical processes aimed at developing constructive learning, in this way the student learns by doing, thinking, formulating hypotheses, investigating, solving situations, questioning, as a consequence the teaching of mathematics is complemented by entertainment applications that promote meaningful learning, such as the use of technology and digital games that are increasingly common as tools designed to generate these thought processes.

(Carrera Valiente & Uloa Aroca, 2023), establish that the mathematical didactics that are involved in pedagogical procedures aimed at promoting constructivist learning includes the ability to reason, formulate hypotheses, conduct research, analyze problems and ask questions. (Barcia et al., 2019), affirm that these actions promote meaningful learning; In other words, the use of digital tools manifests new criteria, seeking to awaken the interest of students in any area of knowledge, these pedagogical resources serve as support for the teacher, optimizing the teaching process and the inclusion of content.

For (Álvarez Buscan, 2017), some of the strategies that can be applied to improve mathematics learning are shown in figure 1.

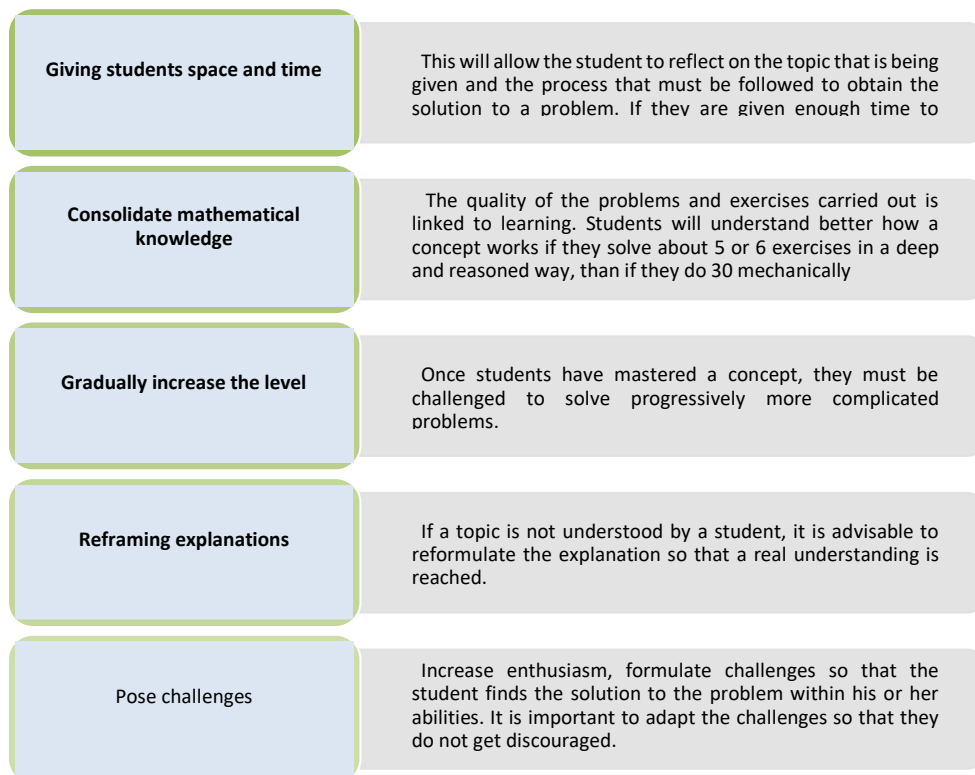


Figure 1. Some of the strategies in learning mathematics

Source: (Álvarez Buscan, 2017)

Others can be mentioned such as:

- Show the real usefulness of the topic taught: It is important that students understand what they do and why they do it, so they will have a more positive attitude towards learning and feel more motivated during lessons.
- Introduce recreational math exercises: The use of puzzles and games can be useful to awaken the class's interest in a subject, as long as these games do not detract from the value of the lesson.

- Address diversity in the classroom: Not all people learn with the same ease or in the same way, so it is necessary to adapt the lessons so that they meet the needs of everyone.
- Take advantage of new technologies for teaching: New technologies are essential during the teaching of mathematics, since they serve to reduce the difficulties posed by this subject and more authentically represent the use of certain advanced concepts.

Active strategies in teaching mathematics

The teaching of mathematics in the educational context can be observed through various skills, which is very useful to solve difficulties that arise in the area of mathematics; Thus, the specific strategies used in the mathematics methodology process are the flipped classroom has to do with activities that students carry out outside the classroom and the objectives of using these strategies so that students can show interest in develop tasks and commitment and be able to fulfill each of them (Gárate Calle, 2021).

In accordance with the teacher in this process is the guide for the students, since he is in charge of developing their strategies to implement in the various activities that he proposes to his class, raising problems, doubts and generating the interest of his students. students for carrying out the activities. Furthermore, intervene in three fundamental aspects for the student, such as self-learning, exercising autonomy for the development of one's own activities, co-learning being developed through group work, and socialization, which is sharing the problems and results that each student has experienced.

On the other hand, problem-based learning is one of the most used and implemented educational strategies today in classrooms. It is a design of tasks that are based on the topic being treated, which takes a specific situation as a starting point for the resolution of the conflict, this helps promote meaningful learning and skill development in the student. , which allows working both individually and in groups, these strategies that allow understanding and learning in a simpler way and that the student can thus obtain skills, mathematical reasoning and educational abilities (Gárate Calle, 2021).

The use of active methodologies in the process of teaching and learning, under PBL, aims to promote collaborative learning in small groups, oriented to the solution of problems that are generally designed from news, where learning is learned by investigating and searching for information. the contents and the experience of working in the classroom. Problem-based learning includes learning activities of: exploration of previous ideas, introduction of variables, synthesis and transfer of content, and revolve around the discussion of a problem (Espinoza Melo & Sánchez Soto, 2014).

Mathematical logical thinking

Logical-mathematical thinking is crucial for academic performance and also has a significant impact on social life. Developing logical-mathematical thinking requires effective mathematical education, which is determined by a series of pedagogical factors. These include innovative teaching approaches, flexible teaching resources, rigorous teacher training and the creation of a stimulating educational environment. These factors play a crucial role in whether students understand and apply mathematical concepts (Arboleda, 2024).

(Medina, 2018), emphasizes, highlighting that logical thinking is crucial for the cognitive development and well-being of children and adolescents since this type of intelligence covers more than numerical skills, it offers significant benefits such as the innate ability to understand concepts, create logical connections in a structured and technical way and associate them with everyday life.

According to Buenaño Albán & Cañar Salas (2017), they mention that logical reasoning is the human capacity that facilitates problem solving, which allows drawing conclusions and lucidly learning those facts through connections between them. When talking about reasoning, it refers to the set of mental activities in order to connect different types of ideas with others, through rules or process study. That is why by promoting logic and critical thinking they will be able to solve different problems, both academically and for making informed decisions, or in everyday life.

Within the same context, Freire Tapia (2023), expresses that logical-mathematical thinking is a capacity that develops in human beings continuously throughout their lives, and that becomes especially relevant during school years. Built on a functional structure that emphasizes reflection, criticality and creativity. The consolidation of these types of reasoning in the individual's mind allows them to solve problems logically, thus achieving a complexity of mental processes that favor logical thinking.

On the other hand (Hidalgo, 2018), states that what must be taken into account for an effective understanding of abstract concepts and the development of reasoning and relationship skills, it is essential to cultivate logical-mathematical thinking. The impact of these skills goes beyond traditional mathematics since logical-mathematical thinking promotes balanced development in different aspects, facilitating the achievement of goals and the achievement of personal success.

Logical-mathematical intelligence contributes to the development of thinking and intelligence; the ability to solve problems in different areas of life, formulating hypotheses and establishing predictions; by promoting the ability to reason about goals and how to plan to achieve them; In addition, it allows establishing relationships between different concepts and reaching a deeper understanding. The importance of mathematical logical reasoning is knowing the ability to start from scratch to solve problems that individuals face before reaching a solution. However, reasoning needs to be practiced daily through the use of various appropriate resources, which allow emphasizing those skills in order to compare and analyze problems, in order to reach different well-founded and solid conclusions, which can then be applied (Vélez et al., 2020).

In teaching, every educator must be familiar with the complete understanding of the evolutionary development of boys and girls. If this knowledge is not available, serious weaknesses could arise in the pedagogical work within educational centers. Among the problems that arise, the teacher's inability to place the child in the corresponding evolutionary stage stands out and, consequently, the decrease in the effectiveness of strategies for the development of logical-mathematical thinking and other areas of learning (Lugo Bustillos et al., 2019). In this line of thought, it is relevant to point out some opinions such as suggested by (López Huamàn, 2018), the teacher as the main axis, acts as an intermediary on the teaching and learning model, positively influencing the child, thus allowing him to manage his activities independently in order to find solutions to problems, promoting cooperation in pedagogical activities.

In most cases, teachers limit themselves to carrying a manual and in this way transcribe educational content in a monotonous way, leaving aside the development of the skills and abilities of each student by stimulating reasoning and the critical capacity for logical thinking. mathematician (Gaviria González, 2022). In this case, the teacher must encourage the student to develop personal knowledge through activities that encourage the development of what they want to learn. That is, when the student uses his reasoning on those problems posed, he exposes his logic which is undoubtedly significant, thus forming the mental constructive use that will not only be applied in pre-established procedures but will also organize various ways of solving problems. a problem, through its ability to understand and lasting learning (Vélez et al., 2020).

On the other hand, in the field of social and business sciences, economics is the science in which the use of mathematics is most common, through ideas or theories, thus leading to pedagogical teaching playing an important role. For (Sánchez & Orihuela, 2013), mathematics shows different economic events by analyzing their reasoning, allowing the economist to show their ideas in a professional way, by formulating hypotheses in relation to mathematical language, maintaining coherence and consistency. relevance when deducing some type of problem carried out within the corporate context.

Data analysis

Was carried out on eighth-year elementary school students with the objective of "Identifying and evaluating the active strategies that are effective in strengthening logical mathematical thinking." In a complementary manner, an observation sheet was carried out to verify if teachers apply games and active methodological strategies in order to contribute to the development of logical-mathematical thinking. Additionally, teachers were interviewed to identify the strategies they are using to improve this area in students.

Through this, the quality and effectiveness of the active strategies in the students was evaluated, which favored the development of skills that prepare them for the academic and professional challenges to come (Constable, 1998; Torday et al., 2023; Vera-Zambrano & Reyes-Meza, 2022; Mahayukti et al., 2017). As for teachers, it will encourage the implementation of appropriate resources and strategies, which will facilitate their adaptation to the curricular framework and guarantee success in the development of logical-mathematical thinking. Below, the results obtained through the survey that was applied to the students are presented in Figure 2. The activities that seem most useful to develop your logical mathematical thinking.

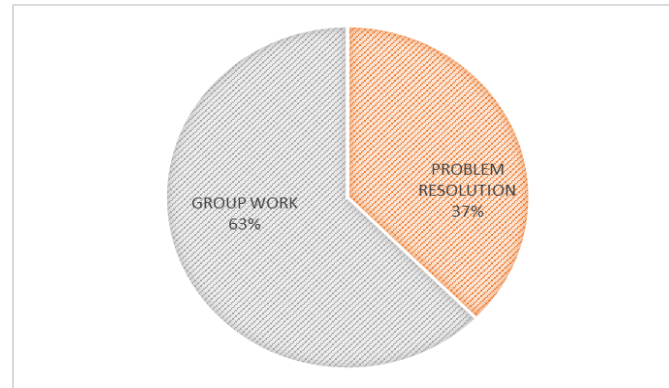


Figure 2. Activities to strengthen mathematical logical thinking

According to the data obtained in Figure 2, it is evident that 63% of students prefer group work, while 37% opt for solving mathematical problems. This suggests that group work can contribute to strengthening students' logical mathematical thinking. Open problem-solving activities (with multiple solutions) were asked if they allow you to develop deeper logical thinking shown in Figure 3.

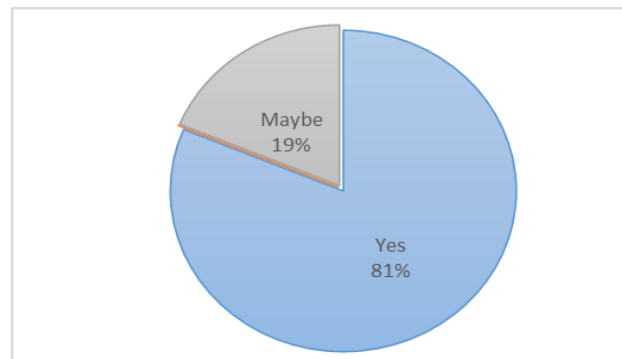


Figure 3. Solving open problems allows the development of logical thinking

The results of this question reflect evidence that 81% consider that open problems strengthen deep mathematical logical thinking, while 19% believe that this could be true, but with certain doubts. This indicates that most students perceive open problems as an effective tool for developing mathematical logical thinking skills. It was taken into account to ask if they consider mathematical challenges in developing their ability to think logically, the results obtained are shown in figure 4.

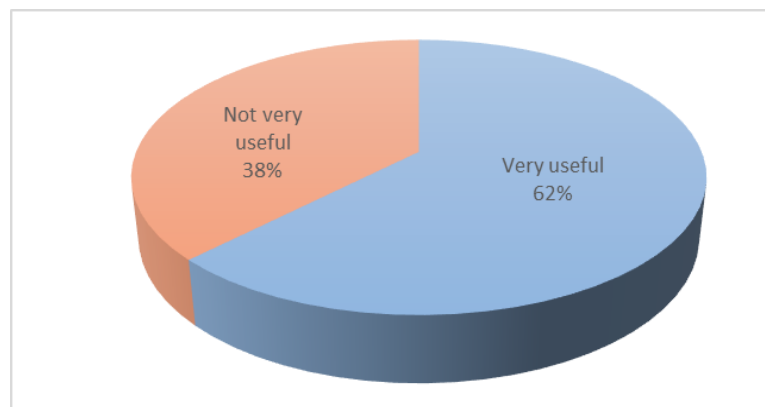


Figure 4. The mathematical challenges

The results obtained from the survey reveal that 62% of students consider that mathematical challenges, such as puzzles, competitions and similar activities, are highly useful for their learning, while 38% perceive them as not very relevant or of less usefulness. This finding suggests that a significant majority of students value these challenges as effective tools to stimulate their interest and enhance their mathematical skills. Figure 5 shows the query referring to whether students consider that repeating a problem with different variations improves your logical reasoning ability.

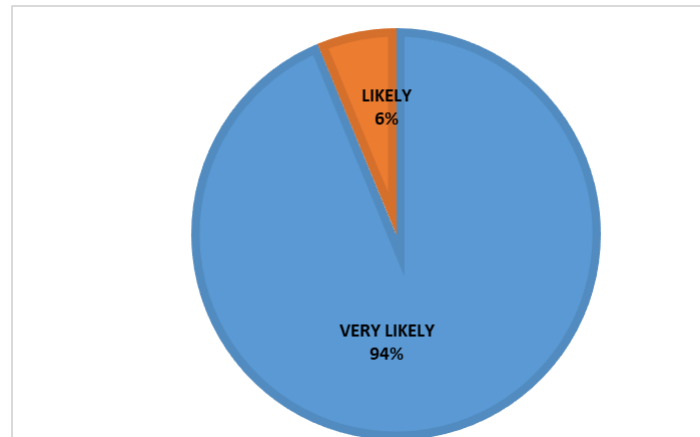


Figure 5. Repetition of a problem with different variations

According to the results obtained, 94% of students consider it very likely that repeating a problem with variations will contribute to improving their mathematical skills, while 6% see it as a rather probable possibility. This data indicates that the majority of students firmly believe in the benefits of repeated practice with modifications, as a strategy to strengthen their mathematical understanding and skills. Figure 6 shows the answers given by respondents related to their consideration of whether learning through competencies helps improve your performance in logical thinking.

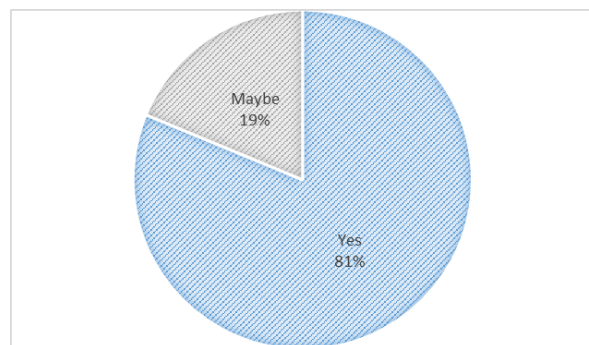


Figure 6. Learning through competencies.

The results of the survey indicate that 81% of students believe that learning through competencies contributes significantly to improving their performance in logical thinking, while 19% consider that it could be useful, but with some uncertainty. This high percentage in favor suggests that the majority of students recognize the value of competencies as an effective tool to stimulate and develop logical reasoning skills. Finally, it was considered appropriate to know the importance that students give to the process of solving a mathematical problem, not only in the final answer, but also in how they arrive at that result.

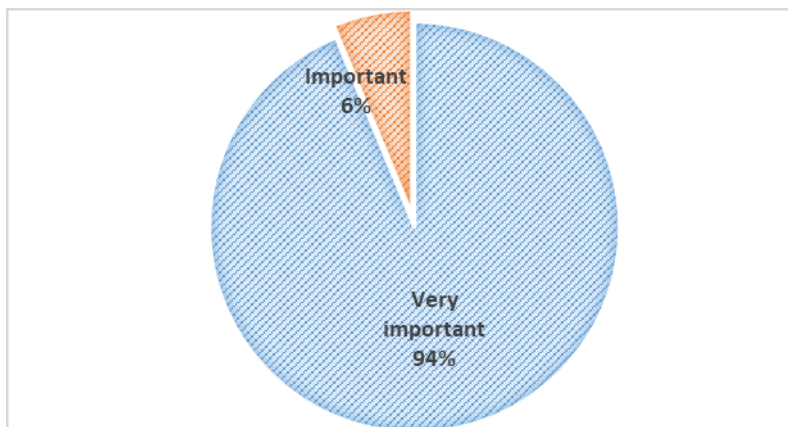


Figure 7. Solving a mathematical problem

The results of the survey show that 94% of students consider it "very important" to reflect on the process of solving a mathematical problem, not only focusing on the final answer, but also on the path taken to get there. On the other hand, 6% think that reflection is "important", but not with the same intensity. This high percentage in favor highlights that most students recognize the relevance of understanding and analyzing the solution process, which suggests a deep understanding that mathematical learning is not only about obtaining correct answers, but also about developing thinking skills, critical and strategic.

The research is based on a solid theoretical framework and presents results that highlight the effectiveness of the approach in the educational context. This article analyzed the implementation of problem-based learning as an active strategy to strengthen logical mathematical thinking in eighth-grade students. The study carried out reveals significant data that demonstrates the positive impact of active strategies on mathematical learning: According to the results obtained in the survey applied, 63% of students prefer group activities to develop their logical skills. These data coincide with what was proposed by [Carrera Valiente & Uloa Aroca \(2023\)](#), who pointed out that collaborative learning encourages interaction and the joint development of knowledge and allows students to construct learning in a more meaningful way.

Of the 16 students surveyed, 81% consider that problems with multiple solutions strengthen their logical reasoning. [Castaño & Montante \(2015\)](#), agree and affirm that open problems not only encourage creativity, but also promote deeper analysis, essential skills in logical-mathematical thinking. 94% of students consider it crucial to reflect on the problem-solving process, beyond focusing solely on the final answer. This finding is supported by [Hidalgo \(2018\)](#), who highlights that reflection in learning allows students to develop critical thinking and understand mathematical concepts more comprehensively.

While challenges, such as riddles or competitions, were valued by 62% of students as useful tools for their learning. This data is reflected in the importance of recreational activities in the development of logical thinking, as argued by [Freire Tapia \(2023\)](#), who highlights that these strategies contribute to consolidating cognitive skills in attractive and practical contexts. On the other hand, [Sanango Siguencia \(2023\)](#), establishes that the use of active strategies in teaching mathematics favors constructivist learning. This approach, based on exploration and problem solving, is reflected in the application of problem-based learning as a central tool in the study. Furthermore, authors such as [Vélez et al. \(2020\)](#), support the idea that PBL promotes autonomy, collaborative work and the development of critical skills, fundamental for mathematical learning.

This article seeks to highlight that these methodologies not only improve academic performance, but also transform the dynamics in the classroom, promoting more interactive and student-centered learning; The importance of personalization in the educational process is also highlighted. While [López Huamán \(2018\)](#), argues that teachers must adapt their strategies to the individual needs of students, in this way their participation will be encouraged and their logical reasoning stimulated. Due to this context, the use of digital tools and educational games, as proposed by [Sanango Siguencia \(2023\)](#), can be key to capturing the interest of students and facilitating learning.

The incorporation of mathematical problems contextualized in daily life situations turned out to be a key factor. The students expressed a favorable response to the practical application of the concepts, which indicates that contextual relevance could be a determining factor to improve learning. In short, the findings indicate that Problem-Based Learning (PBL) can be an effective and positively valued strategy to optimize mathematics teaching in the eighth year of basic general education. The application of innovative pedagogical methods, such as PBL, can have a

considerable impact on improving educational quality and the relevance of mathematical learning (Niroo et al., 2012; Liu & Pásztor, 2022; Altintas & Ozdemir, 2012; Anggoro et al., 2024).

Conclusions

This study focused on the effectiveness of problem-based learning as an active strategy in teaching and strengthening the logical-mathematical competencies of eighth-year basic general education students. The results obtained throughout the study provide valuable information that can guide the design of future pedagogical strategies and improve mathematics teaching. The implementation of PBL demonstrated considerable improvement in students' academic performance. The Posttest results reflected notable progress in problem solving and understanding of mathematical concepts, which highlights the effectiveness of this strategy in strengthening key skills.

Students exhibited a notable increase in their engagement and motivation toward mathematics after implementing PBL. The relationship of mathematical problems with real contexts aroused new interest, transforming the traditional vision of the subject and promoting a more positive attitude towards learning. The teachers, who played a key role in the implementation of PBL, expressed their acceptance of the strategy, noting its flexibility to adjust to the curriculum, its contribution to the development of critical thinking and its ability to motivate students when doing mathematics. more relevant and applicable to real situations.

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