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Didactic Pedagogical Application and Logical-Mathematical Reasoning in High School Students

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Abstract---This research aimed to analyze the relationship between pedagogical teaching methods and the development of logical-mathematical reasoning in first-year high school students at the San Cayetano Educational Unit, located in the Chone canton. The learning challenges are primarily linked to the predominance of traditional and repetitive methodologies in the classroom, as well as insufficient pedagogical training for teachers, factors that limit the development of logical-mathematical skills in students. Within this framework, a classification of content related to didactics, pedagogy, and logical-mathematical reasoning was developed, considering teaching practices based on teachers' knowledge and professional experience. The study employed a mixed-methods approach, integrating qualitative, quantitative, and documentary methods, with an exploratory-descriptive design. Data analysis was conducted using descriptive statistics, allowing for an objective and precise interpretation of the results, complemented by the application of inductive and deductive reasoning. Data collection techniques included observation checklists and surveys. The results show that the application of pedagogical teaching strategies has a positive influence on the development of logical-mathematical reasoning, observing that only a small percentage of students present a poorly developed level, in contrast to the majority, who reach developed and highly developed levels

Keywords---pedagogical didactics, logical mathematical reasoning, didactic strategies, high school.

Introduction

This research contributes to enhancing the development of cognitive skills such as analysis, reflection, and problem-solving, promoting meaningful learning in decision-making and concept comprehension. It transforms students into active, critical, and reflective participants in their learning, enabling them to connect ideas, organize their thinking, and apply knowledge in diverse contexts. This is important because it strengthens students' logical and critical thinking, allowing them to analyze, reason, and solve mathematical problems autonomously and reflectively.

The ICFES (2025) general report on the results of the diagnostic mathematics exam administered to 25 high school students highlights this need. The overall average score was 74/100, with a performance distribution of 35% at the outstanding level, 40% at the satisfactory level, and 25% at the low level. While acceptable performance was observed in basic algebraic operations and solving contextualized problems, weaknesses were identified in content related to functions, solving equations, trigonometry, and probability statistics, reinforcing the urgent need to strengthen pedagogical teaching strategies that enhance logical-mathematical reasoning (Niroo et al., 2012).

Logical-mathematical reasoning is a fundamental pillar in the comprehensive education of first-year high school students, due to its direct impact on understanding, analyzing, and solving problems in both academic and everyday life contexts. In an educational landscape characterized by constant scientific and technological advancements, the implementation of innovative teaching and pedagogical strategies that promote meaningful learning, critical thinking, and student autonomy is essential. However, difficulties in learning mathematics persist in educational practice, manifesting as low levels of academic performance and limitations in applying mathematical concepts logically and reflectively (Mohedo et al., 2014).

The problem lies in the limited application of innovative teaching strategies, which hinders the development of logical reasoning and critical thinking, as well as in the limited pedagogical training of teachers focused on memorization, low student motivation, and the limited incorporation of innovative teaching resources in the classroom. In this regard, several authors agree that the development of logical thinking and scientific and technological competencies is not the domain of an isolated discipline, but rather the result of a comprehensive and high-quality education that integrates diverse knowledge and learning experiences (Rincón-Rojas, 2020). Furthermore, strengthening competencies involves acquiring skills, abilities, and capacities that foster the construction of meaningful learning and the student's academic growth (Gómez et al., 2021).

The objective of this article is to analyze the relationship between the pedagogical application of teaching methods and the development of logical-mathematical reasoning in first-year high school students at the San Cayetano Educational Unit in the Chone canton. From this perspective, logical-mathematical reasoning acquires special relevance, as it contributes to the development of cognitive, social, and adaptive skills necessary to face problematic situations that demand analysis, reflection, and a change of perspective. Furthermore, it enables the understanding of abstract concepts and the relationships between them, strengthening cognitive, motor, and social dimensions that influence academic performance and the student's personal success (Alonso et al., 2016).

In accordance with the above, the application of pedagogical teaching strategies aimed at strengthening logical-mathematical reasoning emerges as a relevant alternative for improving teaching and learning processes at the high school level. In particular, the incorporation of appropriately designed didactic situations, based on reflective pedagogical practice and the Theory of Didactic Situations, allows for a redefinition of the teaching role and fosters mathematical learning aligned with the stated educational objectives (Jiménez-Espinosa, 2002; Godino, 2003).

Methodology

The research was conducted using a mixed-methods approach, integrating qualitative, quantitative, and documentary methods, with an exploratory-descriptive design. The documentary component allowed for a comprehensive review of theoretical sources and previous studies by various authors who have addressed the issue from didactic, methodological, and pedagogical perspectives in mathematics education, which facilitated the conceptual foundation of the study.

The fieldwork was conducted at the Unidad Educativa Cinco San Cayetano school, located in the canton of Chone, Ecuador. The population consisted of 280 high school students of both sexes, aged between 15 and 18 years. From this population, the first-year high school class, consisting of 42 students, was selected as the focus group, in addition to the Mathematics teacher. According to Sánchez et al. (2022), the sample represents a subgroup of the population; therefore, a non-probabilistic sampling was chosen, taking into account the characteristics and objectives of the study.

The descriptive statistical method was used to analyze the data, allowing for the objective and precise organization, interpretation, and presentation of the results. Inductive and deductive methods were also applied, as patterns related to the development of logical-mathematical reasoning in students were identified from the information gathered through the observation checklist. These patterns were then compared with existing theoretical frameworks.

Regarding data collection techniques, direct classroom observation was used, supported by a pre-structured observation sheet, as well as a survey administered through a questionnaire with closed-ended questions directed at the students. From a quantitative perspective, the data obtained were subjected to mathematical analysis, allowing the results to be expressed through numerical values. The non-experimental design facilitated the collection of information within the natural study context, in order to describe the behavior of the variables and the relevant characteristics of the group under investigation.

Finally, the application of the observation instrument was systematically planned, defining the most appropriate time and class session, and prioritizing a playful and participatory approach that fostered student interaction. Likewise, the necessary materials were organized and prepared to ensure the proper execution of the process. In accordance with [Peña's & Naranjo \(2015\)](#) methodological proposal, the observation sheet constitutes a fundamental instrument for objectively measuring, analyzing, and evaluating data related to the object of study

Development

Pedagogical didactic application

The pedagogical didactic application integrates pedagogical theory with didactic practice to design, implement, and evaluate effective teaching and learning processes. It utilizes strategies and tools, including technologies, that optimize the acquisition of knowledge, skills, and values, focusing on motivation, active participation, and the student's holistic development. This approach is based on a theoretical framework and adapted to classroom needs to make education more meaningful and relevant to the context. The strategies for teaching and learning processes in mathematics that teachers value most highly are the development of workshops ([García, 2018](#)).

Pedagogical practice is the daily activity that teachers carry out in and out of their classrooms, guided by the curriculum, and to educate their students. These activities are permeated by didactic and pedagogical components, guided in some way by the aims and principles of holistic education established by the curriculum, but also by their beliefs and conceptions ([Hidalgo et al., 2018](#)).

According to [Allauca et al. \(2017\)](#), pedagogical practice is defined as the “intentional actions carried out by the teacher based on their knowledge, experiences and academic training, referring to before, during and after the class, and are considered a cyclical work, since they include the planning, execution and evaluation of this.”

Pedagogical practice is a catalyst for possibilities, autonomous, an intellectual attentive to the demands of the reality in which it intervenes, an investigator of its own practice, willing to transform its actions based on decision-making resulting from reflection on what it does, or rather, on what it fails to do ([Alvis-Fuentes et al., 2019](#)). Educational practice is a dynamic, reflective activity that includes all the events that occur in the interaction between the teacher and their students ([García et al., 2008](#)). This practice is not restricted solely to the educational processes that take place within the classroom, but also includes all types of pedagogical intervention that occur outside the classroom and the actions that the teacher carries out before and after classes.

The application of didactic strategies is contrasted with the positive effects it produces on student learning compared to a competitive or individualistic methodology ([Guerra Santana et al., 2019](#)). The use of new strategies in the classroom develops sensitivity, flexibility, imagination, and commitment to action, which are part of the development of creativity, a fundamental element in education, facilitated by the environment, resources, and discernment ([Villota Zambrano, 2023](#)). Didactic games are a participatory technique aimed at developing in students methods of leadership and appropriate behavior, thus stimulating discipline with an adequate level of decision-making and self-determination ([Herrera, 2017](#)).

Logical-mathematical reasoning

The lack of interest shown by students in learning, especially in mathematics, is increasingly worrying. Therefore, it is necessary to establish the parameters required to develop students' logical-mathematical thinking. This involves implementing activities that motivate and engage students ([Cruz & Chicaiza, 2017](#)). Logical-mathematical reasoning, in particular, is assessed through contextualized tests with rich and evocative materials. These tests encompass a broad range of domains and more open-ended activities than those used in psychometric evaluations.

Furthermore, they are less prescriptive (Bueno et al., 2024). In addition, this type of assessment allows educators to get to know their students better, recognizing the wide range of abilities present in young children, valuing diverse learning styles, and accepting differences in talents, abilities, skills, attitudes, and work habits.

The importance of logical-mathematical reasoning in students lies in its development of social interaction skills and the ability to adapt to situations that require a change of perspective, leading to problem-solving. The development of logical-mathematical reasoning is fundamental for students to understand abstract concepts and relationships, and it also contributes to cognitive, motor, and social development, thus contributing to personal success (Alonso et al., 2016; Loja-Deleg et al., 2024).

For learning to be more meaningful, collaborative activities must be carried out; for this reason, collaborative learning, which constitutes an interactive learning model, invites students to build together, which demands combining efforts, talents, and skills, through a series of transactions that allow them to achieve the established and agreed goals (Revelo-Sánchez et al., 2018).

Teachers must have a vocation in the area of mathematics in order not to create deficiencies in the development of logical reasoning; likewise, they must implement active methodologies that allow the student to be dynamic and the main actor in the construction of their knowledge in order to achieve meaningful learning (Tubon, 2025). From the above, to build learning in students, the teacher must be continuously and permanently trained on the different existing active methodologies, thus creating a dynamic and motivating environment, enhancing the development of logical mathematical thinking that helps in decision-making for the resolution of a problem or exercise (Velez et al., 2020).

Results

This section presents the results obtained from the classroom observation checklist and the student survey. These instruments allowed for the collection of relevant information on the application of pedagogical teaching strategies and their impact on the development of logical-mathematical reasoning. The data analysis, expressed through frequencies and percentages, made it possible to identify performance levels (underdeveloped, developed, and highly developed), as well as to highlight trends and areas requiring improvement in the mathematics teaching and learning process. The first question on the observation sheet was related to the pedagogical didactic application, showing the results in Table 1.

Table 1
The teacher applies varied pedagogical teaching strategies

Alternatives	Frequency	Percentage (%)
Underdeveloped	6	14,3
Developed	26	61,9
Highly developed	10	23,8

Table 1 shows that 61.9% of students perceive the application of pedagogical teaching strategies as being at a developed level, followed by 23.8% at a highly developed level. However, 14.3% indicate a poorly developed level, highlighting the need to strengthen and innovate pedagogical practices to improve the teaching and learning process. In the case of the question related to analysis and reflection during problem solving, the answers are shown in Table 2.

Table 2
Analysis and reflection are encouraged during problem-solving

Alternatives	Frequency	Percentage (%)
A. Underdeveloped	10	23,8
B. Developed	20	47,6
C. Highly developed	12	28,6

The results in Table 2 show that 47.6% of students consider analysis and reflection during problem-solving to be fostered at a developed level, while 28.6% identify a highly developed level. However, 23.8% indicate a poorly developed level, demonstrating that there is still a group of students who require further encouragement in the development of reflective thinking. Overall, a positive trend is observed, although it is necessary to strengthen

pedagogical strategies focused on logical analysis. The students' answers were investigated logically, and the results can be seen in Table 3.

Table 3
Students logically justify their answers

Alternatives	Frequency	Percentage (%)
A. Underdeveloped	6	14,3
B. Developed	19	45,2
C. Highly developed	17	40,5

As can be seen in the table, 45.2% of the students demonstrate a developed level of logical argumentation in their responses, followed by 40.5% with a highly developed level. However, 14.3% are at a poorly developed level, highlighting the need to continue strengthening teaching strategies that enhance logical argumentation in the classroom.

Table 4 shows the frequencies and percentages of students who solve problems by applying logical reasoning.

Table 4
Students solve problems by applying logical reasoning

Alternatives	Frequency	Percentage (%)
A. Underdeveloped	10	23,8
B. Developed	20	47,6
C. Highly developed	12	28,6

Table 4 shows that 47.6% of students solve problems using logical reasoning at a developed level, followed by 28.6% at a highly developed level. However, 23.8% demonstrate a poorly developed level, indicating a need to reinforce pedagogical strategies that strengthen logical-mathematical reasoning in the classroom. The results obtained from the survey administered to students, using a structured questionnaire, are presented. The following results were obtained from this instrument. In the case of the question related to the activities carried out in class to help reason in mathematical problems, the proposed answers are shown in Table 5.

Table 5
The activities carried out in class help me to reason and analyze mathematical problems

Alternatives	Frequency	Percentage (%)
A. Underdeveloped	8	19
B. Developed	22	52,4
C. Highly developed	12	28,6

As can be seen, 52.4% of students believe that the activities carried out in class promote reasoning and analysis of mathematical problems at a developed level, while 28.6% perceive them at a highly developed level. However, 19% indicate a poorly developed level, suggesting the need to strengthen teaching strategies that enhance logical-mathematical reasoning. First-year high school students were asked if classroom activities help them reason and analyze mathematical problems, and the results are shown in Table 6.

Table 6
The activities carried out in class help me to reason and analyze mathematical problems

Alternatives	Frequency	Percentage (%)
A. Underdeveloped	7	16,7
B. Developed	20	47,6
C. Highly developed	15	35,7

Table 6 shows that 47.6% of students perceive that the activities carried out in class promote reasoning and analysis of mathematical problems at a developed level, followed by 35.7% at a highly developed level. However, 16.7%

indicate a poorly developed level, which suggests the need to continue strengthening the teaching strategies applied in the classroom. In the case of the mathematical logical reasoning question, the answers are shown in Table 7.

Table 7

Pedro follows a daily routine in which he travels 90 km on his bicycle in 3 hours. If today Pedro extended his daily time by two more hours, how many kilometers did Pedro travel today?

Alternatives (km)	Frequency	Percentage (%)
A. 100	4	9,5
B. 150	26	61,9
C. 120	12	28,6

As shown in Table 7, 61.9% of the students selected the correct answer (150 km), demonstrating a developed level in the application of logical-mathematical reasoning. However, the remaining 38.1% chose incorrect alternatives (120 km and 100 km), indicating that there is still a group of students with difficulties in understanding and solving proportionality problems, and therefore, this type of exercise needs to be reinforced in the classroom. We inquired about probability permutations; the results of the answers given by the students can be seen in Table 8.

Table 8

Eight cars compete in a race where only the first, second, and third places are awarded. In how many ways can the first three places be chosen in this race?

Alternatives	Frequency	Percentage (%)
A. 330	12	28,6
B. 230	8	19,0
C. 336	22	52,4

As can be seen in Table 8, 52.4% of the students selected the correct answer (336), reflecting a developed level of combinatorial logical reasoning. However, 47.6% chose incorrect alternatives (330 and 230), indicating that a significant proportion of students still have difficulties understanding counting and permutation problems, making it necessary to reinforce these concepts through specific teaching strategies.

Discussion

The results obtained from the observation checklist and the survey administered to the students demonstrate a significant relationship between the application of pedagogical teaching strategies and the development of logical-mathematical reasoning in first-year high school students, thus fulfilling the research objective. In general, it was observed that the majority of students are at the developed and highly developed levels, both in their perception of teaching practices and in solving mathematical problems, although a small minority group continues to experience difficulties requiring specific pedagogical support (Tudor, 2012).

Based on the observation form, the results show that the application of pedagogical teaching strategies is perceived as predominantly well-developed, which aligns with the findings of García (2018) and Guerra Santana et al. (2019), who maintain that the use of active and varied strategies fosters participation, motivation, and meaningful learning. Furthermore, the promotion of analysis, reflection, and logical argumentation during problem-solving reflects a teaching practice aimed at developing higher-order cognitive skills, consistent with Allauca et al. (2017) and Alvis-Fuentes et al. (2019), who highlight reflective pedagogical practice as a driving force for learning.

However, the presence of percentages close to 20% at the underdeveloped level in some indicators demonstrates that limitations still exist in the systematic implementation of pedagogical strategies that promote logical reasoning in all students. This finding supports the observations of Cruz & Chicaiza (2017), who warn that the persistence of traditional and unmotivating methodologies negatively impacts students' interest in and performance on mathematics.

The results of the student survey complement the observation findings, showing that most students perceive the classroom activities as contributing to their reasoning and analysis of mathematical problems. However, specific exercises on proportionality and combinatorial reasoning reveal that, although more than 50% of students achieve correct answers, a significant proportion still struggle with conceptual understanding. This situation aligns with the

findings of the ICFES report (2025), which identifies weaknesses in content areas such as functions, proportionality, statistics, and probability, reinforcing the need to strengthen targeted teaching strategies.

In this sense, the results confirm that logical-mathematical reasoning does not develop spontaneously, but rather requires intentional, contextualized, and participatory didactic situations, as proposed by Jiménez-Espinosa (2002) and Godino (2003) from the Theory of Didactic Situations. Furthermore, the importance of collaborative learning and active methodologies as mediators of logical thinking is reinforced, in accordance with Revelo-Sánchez et al. (2018) and Tubon et al. (2025).

In summary, the discussion suggests that the application of pedagogical teaching strategies has a positive impact on the development of logical-mathematical reasoning, although it highlights the need for ongoing teacher training, diversification of strategies, and strengthening of activities focused on argumentation, problem-solving, and combinatorial thinking. These results confirm that reflective and innovative pedagogical practices are key to improving mathematical performance and the holistic development of high school students. Despite the progress observed, a minority group of students with an underdeveloped level was identified, which highlights the need to strengthen and innovate teaching strategies, especially in content that requires greater logical reasoning.

Conclusions

The research showed that the application of pedagogical teaching strategies has a positive impact on the development of logical-mathematical reasoning in first-year high school students, with a predominance of developed and highly developed levels. The results of the observation sheet and the survey show that active, reflective, and participatory pedagogical practices favor logical argumentation, analysis, and the resolution of mathematical problems. It is concluded that continuous teacher training and the incorporation of active methodologies are essential elements to improve the teaching and learning processes of Mathematics and promote meaningful learning in High School.

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