Interactive Learning for the Development of Logical-Mathematical Thinking

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Abstract

Currently, teachers have seen the need to plan teaching strategies supported by technological tools and/or digital educational resources that contribute to the development of cognitive skills. For this reason, this research aimed to determine the impact of interactive learning on the development of logical-mathematical thinking skills in eleventh grade high school students in Barranquilla-Colombia. The methodological route of the project was framed in a quantitative approach, inductive empiricist, quasi-experimental method. A sample of 65 11th grade students was selected, divided into two groups, one control and one experimental; A technological device called RED was applied to this group. A sample of 5 mathematics teachers was selected, to whom, like the students, a survey was applied in order to measure the variables: pedagogical mediation, interactive learning and mathematical logical thinking. The results showed the impact of pedagogical mediation based on interactive learning on the development of logical-mathematical thinking in eleventh grade students, because it enables the apprehension and strengthening of the interpretation and representation, formulation and execution and argumentation skills of the area.

Keywords: pedagogical mediation, interactive learning, ICT, digital educational resources, mathematical logical thinking.

1. Introduction

The passage of the COVID-19 pandemic in the world and especially in Colombia forced educational institutions to think of new pedagogical strategies that would prevent the increase in the decline in the development of basic skills in reading, writing and mathematics in children and young people, since the confinement significantly affected the educational activities that were carried out in person. It was two years where the way of educating students in preschool, primary, middle and vocational high school had to be changed, devising autonomous learning at home through virtual schemes, but the lack of access to information and communication technologies in a significant number of students, in addition to the low development of technological competencies and skills in some teachers, it has left consequences on training

processes and on students' academic performance, which caused the Ministry of National Education (MEN) to devise new strategic advances called "Pact for Equity, Pact for Education" (2021).

Based on international evidence and strategies, and especially on the experience of the MEN in the design and execution of programs to improve student learning, this policy is additionally based on the following conceptual and technical premises: Student learning must contemplate the development of competencies in Mathematics, Language, Natural Sciences, Social Sciences, Citizenship and Socio-Emotional Sciences. These learnings are essential to contribute to closing the gaps between students, ensuring their permanence in the educational system and facilitating the transition between educational levels. The training must take into account the connectivity particularities of the educational establishments in which the directors and teachers work. In accordance with this, training can be done with the mediation of ICT, through hybrid models (combination of ICT and face-to-face) or in person. (MEN, 2021)

For this reason, schools and classroom teachers, since the return of students to the institutions, have seen the need to restructure the curricula, prioritize contents, design new teaching strategies and restructure the methodological planning of each subject, and thus guarantee the education of children and young people. for which teachers appropriated new resources, applications and technological platforms such as virtual learning methods. However, there are institutions that do not have the amount of technological resources: necessary and functional computers or tablets or internet access with sufficient coverage.

Taking into account that each of the students faced autonomous learning at home, which caused their academic level not to reach the minimum expected, in some cases, due to the lack of support from parents at the time of the development of activities, stress and anxiety, generated by isolation, and the loss of study habits, among other factors, the need arises to offer interactive experiences that facilitate the learning of mathematics, motivation, participation and creativity in a pleasant and fun environment, and that at the same time can develop logical-mathematical skills in students.

It is highlighted that, in the understanding of mathematical language, it is not enough to know the algorithm by heart, it is necessary for the student to contextualize the information and apply it effectively in a problem situation, which obviously cannot be achieved with only the information, it is necessary that, through the appropriate use of ICT, the abstract mathematical concept is formalized and materialized. (Jiménez, 2019, p. 8)

In studies carried out (Lovianova I., Yu Kaluhin R., Kovalenko D., Rovenska O., Krasnoshock A., 2022), (Kayhan, O., Korkmaz O., Çakır R., 2023), it is evident that the academic performance of students in the area of mathematics in recent years has been basic, with some of the causes being: difficulty in accessing connectivity, The support of parents or guardians is insufficient, sometimes due to lack of knowledge regarding the contents of the aforementioned area, or the inadequate management of time in the assigned commitments, due to the immersion of the common chores of the home or the distracting activities in it.

Today, there are still math teachers who were trained with the board and chalk, they develop the classes with the traditional methodology, where the resources used focus on texts, workshops, guides, and written evaluations. Therefore, it is difficult for them to enter the new digitized world; although innovation has begun in the use of technology and in the incorporation of creativity, at the time of implementing certain activities; However, it should be borne in mind that it is not enough to use a computer, video beam, cell phone, among others, as resources, but it must go beyond a simple exploration of the digital resource.

Therefore, it must be taken into account and it is necessary to have the necessary knowledge, skill and abilities to use ICT as a proposal in the teaching-learning process. "Digital technology has dramatically increased access to teaching and learning resources." (Unesco, 2023).

The home education modality, implemented in recent years, generated great difficulty in transmitting the explanation and assimilation of some mathematical content, adding to this another inconvenience, the complexity of some topics in the area. It has also been observed that when face-to-face classes were restarted in alternation, the students who attended classes in the classroom, most reflected a very passive or apathetic attitude towards the area, this is largely due to the fact that it is considered by them one of the areas with the greatest difficulty.

Adding to the above, that when young people requested help from an adult at home, most of them presented themselves with a new difficulty, due to the lack of knowledge of the subjects, on the part of parents or companions, which limited them to provide them with adequate guidance. It should be noted that the families of the students participating in this research belong to a low socioeconomic stratum, either one or two; and although this is not a limitation, the reality is that generally adult education in this type of family nucleus is basic or even non-existent, especially in the most vulnerable sectors, and not only in terms of mathematical knowledge, but also in terms of the use of ICTs.

Similarly, it is known that generally the virtual or face-to-face methodology, when explaining a new topic, begins with an exploration of previous ideas, continues with an explanation of new concepts, where examples and activities are developed with exercises of less complexity. And the exercises that were of greater complexity, are left for the student to analyze and solve as a commitment; that is, they are resolved in the home where there is no longer the tutoring of the teacher, which was another reason why they did not solve all the activities of the proposed guides. And in most cases, sometimes because of time.

Each of the different causes mentioned above result in not all students being able to develop the necessary competencies to enhance the learning processes, present in each of the moments and activities proposed in the classes or didactic guides of the subject of mathematics, for example: problem solving, reasoning, communication and modeling; comparison and exercise of procedures (Carmona & Espinoza, 2020). Likewise, the different mathematical thoughts, such as: numerical thinking, spatial thinking, metric thinking, random thinking and variational thinking (MEN, 2006), applied in situations of their context, avoiding the development of skills that allow them to solve problems in their daily lives.

Consequently, the student constructs his or her own learning and the acquisition of new information depends to a large extent on the pertinent ideas that already exist in the cognitive structure of the learner, since significant knowledge arises from an interrelation that occurs between the new information and the previous knowledge that underlies it (Ausubel, 1983). Hence, the importance for teachers to try to discover these ideas, so that the student relates them to the new information.

2. Methodology

The research is framed in a quantitative approach, of a quasi-experimental type, The survey was used as a data collection technique, with closed questionnaires as instruments, a pre-test and a post-test;

Quasi-experimental designs identify a comparison group, as close as possible to the treatment group, in terms of the characteristics of the baseline study (prior to the intervention). The comparison group captures the results that would have been obtained if the programme or policy had not been implemented (i.e. the counterfactual). Therefore, it can be established whether the programme or policy has caused any difference between the results of the treatment group and those of the comparison group. (White & Sabarwal, 2014).

Population and Sample

The population was made up of 1650 students from an official educational institution in the Colombian Caribbean, located in the urban area of Barranquilla.

As for the sample, it was non-probabilistic due to convenience due to the proximity of the participating actors, all students in the last grade of secondary education, in Colombia. which represents the 11th degree.

The students selected as a sample are characterized by having frequent access to the Internet, which allows them to access the different websites and applications, a fundamental premise to achieve the objectives of the research.

The sample was made up of 65 students in the last year of secondary education, and 5 teachers in the area of mathematics, in this way, they were consulted about learning strategies, access to the internet, knowledge of ICT and processes of development of mathematical logical thinking, which allowed as a fundamental purpose to make assessments on measurable scales.

The groups were organized as follows: control group of 11°A and experimental group of 11°B. With this, the mathematical logical thinking variable was measured, by implementing different virtual learning environments, during several work sessions.

A pre-test was applied to these groups at the beginning, which gave the result of the level of development of mathematical logical thinking in which they are, as well as the knowledge and use of Virtual Learning Environments (VLEs). Next, the use of Classroom and Socrative as didactic tools was implemented in the Experimental group. In these applications, different

activities were hosted to be developed by the students, during a period of time stipulated within the schedule.

At the end of the activities, the post-test was applied to the experimental group and the control group. Next, with the results, the degree of incidence caused by the use of digital educational resources as a didactic tool in the development of students' mathematical logical thinking was verified, and failing that, affirming or denying the hypothesis raised, which is stated below:

H1. Pedagogical mediations based on interactive learning improve the development of mathematical logical thinking in students in the eleventh grade of secondary education.

The hypothesis being null the following:

H0 Pedagogical mediations based on interactive learning do not improve the development of mathematical logical thinking in students in eleventh grade of secondary education.

Research Technique and Tools

For the development of this research, one of the data collection instruments used to compile the information was the questionnaire, aimed at students in the last grade of secondary education. It had twenty-four (24) closed response items.

It should be noted that the questionnaire was designed with four multiple-choice alternatives: always, almost always, almost never and never, which was self-administered, in order to measure the availability of internet access, knowledge of interactive applications and the frequency of their use in academic situations.

Similarly, another survey was designed aimed at primary and secondary school mathematics teachers, in order to measure the variables: Pedagogical mediation, interactive learning and mathematical logical thinking, as well as to collect information on the learning strategies used, the different interactive or technological applications they know and which of them they use regularly or occasionally in the development of their classes. The questionnaire was designed with four alternative answers: always, almost always, almost never and never, which was self-administered.

And finally, a pre-test and a post-test were created for eleventh grade students, in order to have a point of comparison and departure after the interactive tool was applied. It included; presentation and instructions, and 12 multiple-choice items with a single answer, which seek to measure the three specific competencies of the mathematics area in students, interpretation and representation, formulation and execution and argumentation.

Formative assessment was used as a strategy to strengthen the competencies worked on in each experience. The evaluation helped to verify learning and reorient it during the training process.

The data obtained in the instruments applied to the Control and Experimental groups, as well as to the mathematics teachers, were treated using descriptive statistics; this involves the collection, classification and coding of the data obtained in the assessments and questionnaires; to later analyze, interpret and describe them.

The information obtained was decoded in tables of percentage distribution by indicators for analysis. The description and behavior of each of the groups, the control and the experimental, were executed separately, as well as their statistical analysis were carried out independently, in order to determine the association between them.

Data processing

The statistical treatment that was applied in the research is due to the calculation of the distribution of absolute and relative frequencies, together with the qualitative analysis of the data produced as a result of the application to the population determined in the study. It was considered to make a matrix where the items of the instrument and the responses of the subjects belonging to the sample would be reflected, all guided by the systematization of the variables studied; these data were processed through Excel and SPSS version 21.

Similarly, the data were organized in tables with the absolute and relative frequency distribution, for each indicator, dimension and finally for each variable in order to facilitate the analysis and discussion of results through comparison with authors cited in the theoretical bases; These data will be located and compared in the categories shown by scales designed for the study variables for a specific purpose.

For the analysis of the results of the surveys carried out on students and teachers, the scale presented below was taken into account:

Table 1 Survey Data Scale

Ranges	Analysis Categories
4.00 > 3.25	Very Sufficient
3.25 > 2.5	Enough
2.5 > 1.75	Insufficient
1.75 > 1.00	Very insufficient

Note. Authors, 2023. Scale of interpretation of survey data.

In this sense, the structuring of the scale was carried out as follows: for the calculation of the range, the highest value of the answer alternatives was taken, which is represented by four (4) and the lowest which is one (1), they were subtracted and the result is divided by the number of alternatives which is four (4), hence, the value of zero point seventy-five (0.75) is obtained as a range, that is, each range allows the response of the subjects to be located according to what is established in Table 2 above.

Similarly, for the analysis of the pre-test and post-test, the following scale was taken into account:

Table 2 Pre-test and post-test data interpretation scale

Ranges	Analysis Categories
0% ≤ 30%	Homogeneous
30% > 100%	Heterogeneous

Note. Authors, 2023. Range for the interpretation of homogeneous or heterogeneous groups.

The structuring of the above scale was made taking into account the percentage of the coefficient of variation that refers to the relationship between the variability of the variable and the size of the mean, which is interpreted taking into account that if the C.V is less than or equal to 30%, it means that the set of data is homogeneous. Conversely, if the CV exceeds 30%, it will result that the data set is heterogeneous. It was calculated taking into account the following formula:

$$C_V = \frac{\sigma}{\underline{x}} \cdot 100\%$$

Where, = standard deviationσ

y = arithmetic mean To$\underline{x}$ give a quantitative assessment to the results of the pre-test and post-test, the assessment scale of the institutional system of evaluation of SIEE students was taken as a reference, which is found in the Coexistence Agreement of the educational institution selected for the study.

Table 3 Assessment scale of the institution.

Rank	Performance
4.6 to 5.0	Superior
4.0 to 4.5	High
3.0 to 3.9	Basic
1.0 to 2.9	Low

Note. Coexistence Agreement. Numeral 17.2, 2020.

3. Analysis of the Results

The results were analyzed in each dimension, based on the respective indicators. In this sense, the planning indicator, according to the opinion of the students, obtained an average of 3.71 and according to the opinion of the surveyed teachers an average of 3.76, which indicates that the planning within the category of analysis is "Very sufficient". Similarly, the results gathered in the evaluation indicator are evidenced, which for students presents an average of 3.79 and according to the opinion of the teachers an average of 3.87, placing it in the category of analysis "Very sufficient". Finally, for the dimension of pedagogical interaction, the average closure according to the opinion of the students was 3.73 and for the opinion of the teachers it was 3.76, indicating "Very sufficient" according to the category of analysis.

With these first results, it is concluded that the evaluation of learning is conceived as a practical instrumental tool, which allows evidenced processes, achievements and products; it is characterized by its continuity and globality. Likewise, a different trend is observed where the objective and comprehensive diagnosis is assumed as a starting point for the estimation of the route and the achievement; it involves students as a peer evaluator of their process and that of others, and in these moments it affirms to acquire a formative character.

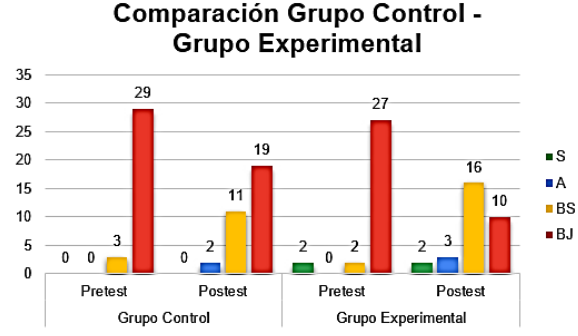
On the other hand, these results affirm what Prado and Gutierrez (2015) propose, where they express that pedagogical mediation is thought not only as a break with many traditional forms of teaching, because it proposes strategies, activities, procedures and new forms of learning in order

to make possible the educational act, within a horizon, of an education conceived as participation, creativity, expressiveness and rationality.

In addition, they affirm that teachers must build bridges between students, knowledge and context; likewise, to give meaning to their teaching practice based on pedagogical mediation. That is, it seeks to enhance pedagogical interaction from analysis, logical thinking and constructive criticism; which indicates that it is necessary to mediate from a pedagogical task, which enhances the exchange of arguments and promotes analysis, problematization, deconstruction, understanding, complex thinking, constructive criticism and the consolidation of school projects, from which it is possible to exchange challenges, visions and actions so necessary for today's world.

The following graph describes the comparison of the performance of mathematical competencies of the Control Group and the Experimental Group.

Graph 1: Comparison of control group and experimental group



Source: own elaboration. In original language Spanish

In this graph, considering the results obtained in both groups, with respect to the pre-test and the post-test, it was observed that in the Control Group there was a minimal improvement, taking into account that 3 of the 32 students passed the pre-test and that subsequently, 13 of the 32 students in the same group passed the post-test. It should be clarified that this group worked with questions for competence, analysis and problem solving, as well as the socialization of written workshops in order to develop mathematical logical thinking. On the other hand, in the Experimental Group, there was a significant increase due to the fact that 4 out of 31 students passed the pretest, while when taking the post-test 21 out of 31 students passed it. It is highlighted that in this experimental group, interactive activities were carried out through applications such as Google Classroom and Socrative, which shows a better reception by students in the development of mathematical skills.

Table 4: Performance in mathematical skills. Control group and experimental group.

Desempeños		S	A	BS	BJ	Total	$\bar{X}$	S	CV
Grupo Control 11A	Pretest	0	0	3	29	32	2.0391	0.7103	34.83%
	Postest	0	2	11	19	32	2.4531	0.9968	40.64%
Grupo Experimental 11B	Pretest	2	0	2	27	31	2,0242	1.0475	51.75%
	Postest	2	3	16	10	31	3.3629	0.6703	19.93%

Source: own elaboration (2023)

The table above shows the comparison of the performance of mathematical competencies of the control group and the experimental group. It is worth mentioning that the control group in the pretest presents a coefficient of variation of 34.83% and in the posttest presents a coefficient of variation of 40.64%, showing that there is heterogeneity and in turn indicates that it presents a degree of diversity in its levels of mathematical competences, unlike the experimental group, which in the pretest presents a coefficient of variation of 51.75%. showing that there is greater heterogeneity with respect to the control group. However, a coefficient of variation of 19.93% is presented in the post-test, showing that there is homogeneity, which indicates that it presents a degree of similarity in their levels of mathematical competences. This fact makes it clear that the implemented strategy based on interactive learning presented positive results and that it effectively achieved a strengthening in the development of mathematical logical thinking, which is efficient in the process of teaching and learning mathematics.

Depending on the indicators observed, the following is specified, the total sum of the tests applied is equivalent to 65 (includes control and experimental group); In the case of the control group, only 94.12% of the planned tests were applied (32 out of 34), the remaining 5.88% of students did not participate because they did not attend the class on the day the pretest was applied, on the contrary; in the experimental group they applied 100% of the tests, likewise, it is highlighted that the questions solved have different intentions: Interpretation and representation (oriented to communication, representation and reasoning); formulation and execution (modeling, formulation, comparison and exercise of procedures; as well as the formulation, treatment and resolution of problems); and argumentation (in relation to the ability to justify any procedure, strategy, or knowledge used in the resolution of a problem (Ospina, 2021).

It is then concluded about the contribution of pedagogical mediation based on interactive learning, to the development of competencies that strengthen logical-mathematical thinking in eleventh grade students, because it enables the apprehension and strengthening of the competencies (interpretation and representation, formulation and execution and argumentation) of the area, specifically in eleventh grade. In relation to the low levels of mathematical logical thinking obtained with the pretest, it is concluded that the traditional didactic strategies used by

mathematics teachers have an impact on the low level of development of skills and more specifically on the competence of formulation and execution and the competence of argumentation, which implies applying innovative didactic strategies supported by technological tools and/or digital educational resources. It was evidenced that despite being in the very sufficient and sufficient category, as observed in the analysis and interpretation of the information regarding planning, evaluation, the virtual learning environment (VLE), the management of learning styles and rhythms, access to and use of digital tools, in classroom practices, It is necessary to use appropriate digital tools to improve the development of mathematical logical thinking, in particular, cognitive skills. Therefore, the hypothesis of the research is confirmed by showing that pedagogical mediations based on interactive learning improve the development of mathematical logical thinking in students of the eleventh grade of secondary education. In this sense, the design of interactive educational resources aimed at the development of mathematical logical thinking is recommended, addressing learning needs through constructivist and meaningful work. A considerable difference was demonstrated with the post-test when implementing the different strategies contained in an interactive educational resource, called RED, in the development of mathematical logical thinking, compared to the pre-test, the correct answers were higher. The students were motivated to continue learning with the use of the RED, which generates the need to continue relying on digital tools in the area of mathematics, in order to strengthen and improve cognitive skills, innovate in the training process and enrich the communicative dimension.

It was also observed that when characterizing interactive learning with respect to access to ICT, it is sufficient, which means that students do not have difficulties in using technological resources and supporting the performance of school activities, have access to the internet inside and outside the institution, as well as use WhatsApp to receive or send information related to their learning. in addition to regularly reading emails.

Finally, the value and contribution of interactive experiences in the classroom is highlighted, as they promote motivation, participation and creativity in a pleasant and fun environment; therefore, the activation or generation of relevant previous knowledge and experiences is suggested.

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