Video tutorials for strengthening mathematical reasoning in rural schools

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Abstract

This article is based on a research work whose objective was to strengthen the competence of mathematical reasoning from spatial thinking and geometric systems in fifth-grade students in an educational center of a rural sector through didactic sequences supported with video tutorials that helped improve performance for meaningful learning. The approach of the project was qualitative with an action research design. The techniques used were participant observation, diagnostic tests, development of didactic sequences as evidence of the students' production, field diary and final test. The diagnostic and final tests made it possible to evaluate the level of performance of fifth-grade students in the area of mathematics, specifically in spatial thinking and geometric systems. It was of great interest to learn about Ausubel's theory to strengthen meaningful learning and the structure proposed by Tobón for the construction of didactic sequences, which helped improve performance in the area. By achieving the objectives achieved, mathematical reasoning is strengthened from spatial thinking for meaningful learning, with the help of educational videos where it is shown how to give a relevant management to the mediating material (geo plane, tangram and soma cube), to better understand the mathematical processes according to the Basic Learning Rights).

Keywords: didactic sequence, mathematical reasoning, meaningful learning, rural education, video tutorials.

Introduction

Mathematical reasoning is one of the skills that requires more planning and guidance at the time of teaching mathematics significantly in the early years of schooling; teaching reasoning from a meaningful learning involves knowing concepts of experts, relating information already possessed with new information.

Many times, teachers in rural sectors in particular -and in all sectors of public education, in general- the teaching of mathematics are far from meaningful learning, leaving huge gaps in the design and orientation of content that should be mediated by the construction of teaching materials; these problems demonstrated the low performance in the Saber tests by fifth-grade students in rural areas. It is also necessary to take into account the basic standards in competences posed by the Ministry of Education, which can help improve performance levels in elementary school students.

Considering the above, it was necessary to propose a research work aimed at strengthening mathematical reasoning from spatial thinking and geometric systems supported by meaningful learning in fifth grade students in the rural area of Tona, Santander.

This article presents the results obtained in the research work after the design, development, implementation and evaluation of didactic sequences that, through sequential challenges mediated by didactic material, strengthened mathematical reasoning. By means of this instrument, students reached recognition, construction and analysis competences that allowed them to reach basic and high-performance levels.

Didactic sequences applied in three work sessions of 10 sets each were structured as follows: o. 1 had seven challenges and was mediated by the construction of a soma cube to strengthen the learning of geometry, specifically three-dimensional figures, to achieve the competence of construction of three-dimensional objects; No. 2 had a tangram as mediating material which is integrated by nine challenges that achieve the performance of applying transformations to figures in the plane to build designs; and No. 3 had seven challenges that reach the competence of identifying congruence and similarity relations between figures, which is mediated by the geo plane.

The implementation of the didactic sequences to strengthen mathematical reasoning, allowed the teacher to contextualize students' prior knowledge and through the application of activities, significant progress was observed in the performances set out in the Basic Learning Rights.

In its methodology, action research was applied, a diagnostic test was applied, then the design and implementation of didactic sequences as a contribution to meaningful learning to strengthen reasoning in the area of mathematics, finally a final test was applied where students that participated in the project achieved levels of basic and high performance, reaching recognition and construction of mediating material in compliance with the Basic Standards in competences for mathematics in a simple and easy to understand.

In the implementation of the didactic sequences a great progress was observed in the level of recognition and analysis of plane geometric figures, construction and calculation of measures in three-dimensional figures; this was mediated by video tutorials.

Methodology

Theoretical references

Meaningful learning

The theory of meaningful learning according to Ausubel (2007) establishes that "student learning depends on the prior cognitive structure that relates to the new information." (p.115). It is very important to know the cognitive structures of students, in addition to identifying the amount of information you have, it is also interesting to identify student's prior knowledge.

When we talk about meaningful learning, we refer to learning that can be understood or learned; understanding depends on what is seen and being able to learn what the words convey and this often depends on the prior knowledge of each student.

For Ausubel (2007), meaningful learning "occurs when new information is connected with the relevant concept, three kinds of meaningful learning can be identified and classified by Ausubel as follows: learning of representations, learning of concepts and learning of propositions" (p.116).

Ausubel (2007), in his theory of learning by representations, says that learning "occurs when arbitrary symbols are equated in meaning with their referents (objects, events, concepts) and mean for the student any meaning to which their referents allude" (p. 119); therefore, it is important that the concepts that are transmitted to students be close to their context; for this reason, the mathematical objects or mathematical content as they are called are grounded to the meaning that is easier to internalize by students and can relate concepts with symbols already known so that understanding is even easier for them.

In propositional learning, the learner must understand the meaning of ideas and be more

Sacro Santa Basílica de Nuestra Señora del Socorro (Santander) propositional, the learner makes new meaning of ideas by adding them to their cognitive strategies.

In the theory of learning by concepts, "objects are defined as events, situations or properties that possess attributes of common criteria and that are designated by a symbol or signs" (Ausubel, 2007, p. 119).

New School

Florez (2010) reminds us of the ten most relevant principles of the new school:

1. Affection
2. The natural experience
3. Environmental design
4. Progressive development
5. The activity
6. The good teacher
7. Individualization
8. Anti-authoritarianism
9. Group activity
10. The ludic activity (Florez, 2010, p. 203-204)

In the new school model, Dewey (2004) says that "the new school is based on learning through experimentation, imitation and the importance of imagination" (p. 109). Very close to the significant learning proposed by Ausubel, in the new school, the concepts acquired through experience and the previous concepts that accompany the learner are related to the process of learning representations; for this reason, the work that is developed in the educational institution to strengthen significant learning in the new school model must be accompanied by experiential learning, construction of learning, imitation based on what is observed and propositions accompanied by lots of imagination.

Because of the above, teachers receive in their classroom children of young ages, four or five years old, who come to preschool with the illusion of being part of an environment different from the one they live in their families. The interest in play would be the best strategy that we can take advantage of with these children to undertake a long and rigorous path of transformation and adaptation to the school environment. The great responsibility of the teacher to find the best ways to guide these creative beings and with great illusion to receive the best significant learning; teachers are concerned with how to teach in the early years in a rural environment with multiple economic and social needs without forgetting learning types and where the imagination appears as a fundamental stage of learning and being proactive and innovative.

According to the Ministry of National Education (2010), the tests that the ICFES has been applying in educational institutions have the purpose of:

> Contributing to the improvement of the quality of education in Colombia, by carrying out periodic evaluations to obtain, process, interpret and disseminate reliable information and make relevant analyses of education, so that the country knows the level of education of children and young people, and thus have a starting point to implement the necessary measures to improve the quality of education in all educational establishments in the country. (p. 9).

The ICFES applies tests in all public and private educational institutions in the country, while it is true that the tests are based on basic learning standards, but certain things are not taken into account when evaluating students: the context, the location in the rural area, the difficulties of connectivity; this apparently does not affect academic performance of students, but it is a great disadvantage when measuring knowledge compared to the more developed urban areas of the country.

Didactic sequence

With regards to the didactic sequence, Tobón (2010) states that "they are simply articulated sets of learning and evaluation that, with the mediation of a teacher, seek the achievement of certain educational goals, considering a series of resources" (p.35). The line of didactic sequences is made up of three types of activities: opening, development and closing.

The teacher in his pedagogical practice must take into account the context in which he/she is immersed and the performances that he/she orients to solve the needs and situations of the students; these should help reinforce their competences, taking into account their prior knowledge and using didactic strategies in the diverse areas of knowledge. Didactic sequences, in the competence model, are very important for the formative mediation of learning.

The didactic sequence is the product of the design of a series of activities for learning that are ordered, its impact depends on whether the prior knowledge of the learners is taken into account, in them strategies for meaningful learning are applied (Díaz, 2013, p. 4).

In the structure of the didactic sequence for formative evaluation according to Scallon (cited by Diaz, 2013), there are three types of activities: opening, development and closing. In the opening activity they give room to prior knowledge opening discussion to significant questions related to the topic to be addressed in the sequence. In a second activity, there is the development in which the student has the opportunity to link his/her prior knowledge with a new learning and a closing stage where the acquired learning processes are synthesized, there are also exercises to solve specific situations.

Catedral de Santa Clara – Pamplona (Norte de Santander)

Methodological aspects

Approach and type of research

According to Miguélez (2000), "action research presents, in more participatory terms and with a view to clarifying the origin of the problems, the programmatic contents, the didactic methods, the significant knowledge and the community of teachers, giving participation to the subjects under investigation" (p. 4).

According to the context where the research takes place, an area of difficult access, the teacher seems to be the only person with the possibility of bringing knowledge, transforming realities and motivating for change, the teacher is responsible for accompanying the research processes.

The above leads to the application of instruments for the development of research in the classroom for students in rural contexts, which help strengthen learning mathematics, the observation of behaviors in the classroom, the work developed by students through peer support, and analyzing situations and actions related to practical problems to try to solve them.

Elliot (2000) states that "action research relates to the practical, everyday problems experienced by teachers, rather than to the theoretical problems defined by pure researchers in the setting of a discipline of knowledge" (p.5). Therefore, it can be developed by teachers themselves or by those whom they commission.

In the rural educational institution where the research protocols are applied, the problems are experienced by the teacher, the only one in this case who must handle different classes with different learning styles, even with students in the classroom who have learning difficulties; the project seeks to strengthen the reasoning of all students, specifically in the area of mathematics which is evaluated by the state through tests of knowledge and ability.

Depending on the type of research, it includes a social critical paradigm, which contemplates the collaborative and participative action research by the subjects directly involved in the research process. This paradigm seeks that research be oriented towards action, the critical resolution of problems and the training of subjects for their emancipation; it also seeks to build theories from the reflections in action.

Paradigms become patterns for researchers to follow in a given field of action. Melero (2011) says that "the socio-critical paradigm adopts the idea that critical theory is a social science that is neither purely empirical nor only interpretive; its contributions originate from community studies and from participant research" (p.98).

This paradigm helps understand that research should give answers to the problems that affect the educational community, the low performance in the Saber tests for the fifth grade of rural schools that follow the Escuela Nueva (New School) model, answers that should be cleared with the participation of members of the community students and teachers. The research is methodologically based on the technique of participant observation, as it allows the teacher researcher to design diagnostic tests, then pedagogical strategies to be used in the research process, from meaningful learning based on students' prior knowledge; it seeks to improve educational practices and strengthen learning specifically in the area of mathematics in fifth-grade elementary school students, without forgetting to plan workshops on basic standards in competences established for the area and the Basic Learning Rights established by the Ministry of Education.

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Research Methodology

This project was developed in four stages; according to Sandin (1987), "the action research process, in its flexibility and interactivity, has all stages of the cycle: clarifying and diagnosing, formulating strategies, implementing and evaluating strategies" (p. 43).

- Diagnosis The results of four tests applied by the ICFES in the third and fifth grades of elementary school at educational institutions, especially in the rural sector of Berlin, in the last eight years, have been analyzed in mathematics; said results are below average compared to the results of public and private urban institutions in the country, showing difficulties especially in mathematical reasoning.

To verify the results issued by the ICFES, the design and application of a diagnostic test comprising 15 Saber-Test-style questions, structured to integrate three mathematical aspects: metric-spatial, randomness and numerical variational (5 questions per aspect), focused on tests where students need to perform mathematical logical reasoning; spatial thinking and geometric systems had the lowest test results, according to the ICFES report, in the last four tests.

According to the application and respective analysis of the diagnostic test, none of the six (6) students had more than 50% of correct answers in any of the three aspects according to the structure of the test, obtaining very low results in spatial thinking and geometric systems; then it is necessary to strengthen the didactic sequences with topics related to said aspects.

- Design of didactic sequences for learning as a strategy: In this second stage, the design of three didactic sequences for meaningful learning is carried out; integrated are the corresponding D.B.A established by the Ministry of Education, which are guided by video tutorials that are subsequently sent via video to the WhatsApp of each student; this due to the situation that the country is going through in terms of social distancing, because of Covid.

The didactic sequences have a structure that includes: the opening activity, the development activity and the closing activity, based on the structure that Tobón proposes for didactic sequences. First, we get familiar with students' prior knowledge. Then concepts are consolidated and learning is strengthened; the following stages are assigned in the sequence: What am I going to learn? What am I learning? I practice what I learned. How did I learn it? How do I know I learned it? What did I learn? According to Ausubel, the student must assimilate prior knowledge by associating it with new learning and thus obtain more significant training. The sequences are designed so that the students develop the activities according to virtual orientation through micro videos that will be fed back according to the production of the students who will offer their comments or questions through the same virtual medium, as a mediator of a learning based on doing.

The sequences for learning are designed so that the students, after making an observation and reading the concepts, develop an assignment at home. They can elaborate the didactic material assigned in each didactic sequence, each one oriented with the video tutorials that serve as mediators to reach more significant learning, trying to develop approaches to logical reasoning in mathematics and very specifically in spatial thinking and geometric systems.

For the elaboration of the didactic sequences, the levels of geometric thinking proposed by Van Hiele -cited by Reyes (2015)- the levels that are intended to be developed in students to strengthen spatial thinking and geometric systems are related to visualization, analysis, classification, deduction and rigor. They must be progressive and are hierarchical, you cannot move to another level if the previous level is not reached.

- Implementation of the didactic sequence, putting the strategy into practice. The strategy is implemented with the participation of six fifth-grade students in the development of three didactic sequences that they will execute individually and guided by video tutorials prepared by the head teacher; the accompaniment of the educator is very relevant in the processes of induction and development of practical activities. Virtually and through phone calls in their practice scenario, students can find -attached to the printed material- two videos for each didactic sequence, to reinforce the concepts and activities. They will also be available to the group and may be projected later for feedback purposes as often as necessary.
- *Evaluation of the strategy:* For the evaluation of the strategy, the design of a final test will be carried out, which helps us know the advances of the implementation of the didactic sequences for the learning applied in fifth grade. The final test will have in mind the significant learning in the spatial thinking and geometric systems, helping us see if there are advances in the strengthening of the competence of mathematical reasoning.

Students are also invited to record and send micro videos showing some of the activities indicated in the sequences, which support the learning acquired in the training process. The The Saber-style test strengthened students' competences such as: 1. construction and decomposition of shapes in three-dimensional objects from given conditions according to the orientation of the didactic sequences. 2. Comparison and classification of three-dimensional objects according to their components.

Analysis categories

The categories are based on the data collected through the diagnostic test, the field diaries, the elaboration and orientation of didactic sequences accompanied by educational videos based on the basic standards in mathematical competences for fifth grade, the production of the students and the participation in videos elaborated by the students and the final Saber-style test.

The categories of analysis were based on the levels and phases of the teaching process in geometric thinking, In the project, three categories of analysis with their corresponding subcategories are established as follows:

Table 1. *Categories of analysis*

Objectives	Competition	Didactic sequence	Category	Subcategory
To design didactic sequences based on the basic standards of competences for the area of mathematics, which help strengthen mathematical reasoning from spatial thinking for meaningful learning.	Mathematical reasoning spatial thinking and geometric systems	**Didactic Sequence No. 1** Identifies and describes properties that characterize a body in terms of two and three dimensions and solves problems related to the composition and decomposition of shapes.	Recognition S1 (C1) Construction S1 (C2) Analysis S1 (C3)	Recognizes the pieces that make up the soma cube C1.1 Manages to recognize the size of each soma cube that make up its pieces C1.2 Can recognize the number of faces of the constructed cube C1.3 Begins to recognize some parts of the cube, edges, faces and side measurements. Distinguishes the shape of the pieces of the soma cube and the number of cubes that make up each piece C1.4 Uses the indicated material for the construction of the soma cube parts C2.1 Properly constructs the seven pieces that make up the soma cube C2.2 Correctly draws the pieces of the soma cube on the grid C2.3 Constructs three-dimensional figures and justify their characteristics C2.4 Recognizes the soma cube pieces to create his/her own designs C3.1 Makes close guesses about the characteristics of the pieces of the soma cube C3.2 Finds differences in the volume of the pieces of the soma cube C3.3 Uses techniques to make conjectures related to the volume of a cube C3.4

Objectives	Competition	Didactic sequence	Category	Subcategory
To implement the didactic sequences, by means of tutorial videos to fifth-grade students of of a rural region.	Mathematical reasoning, spatial thinking and geometric systems	**Didactic Sequence No. 2** Explains the relationships between perimeter and area of different figures (variations in perimeter do not imply variations in area and vice versa) from measurements, superimpositions of figures, calculus, among others.	Recognition S2 (C1) Construction S2 (C2) Analysis S2 (C3)	Recognizes the number of pieces that make up the tangram C1.1 Recognizes geometric shapes by observing their characteristics and classifies them according to size, color, and shape C1.2 Recognizes the number of sides, vertices, and angles of each geometric figure in the tangram C1.3 Properly uses the indicated material for the construction of the tangram pieces C2.1 Designs polygons with the tangram pieces on the C2.1 grid. Constructs polygons with given conditions of measurements C2.3 Recognizes the area of constructed polygons on tangram pieces C3.1 Hypothesizes about the area of the figures C3.2 Checks perimeters by constructing tangram plane figures C3.3 Identifies equivalences between plane figures with the help of tangram pieces C3.4
To evaluate the implementation of the didactic sequence, by means of a Saber-type saber in order to know students' progress in mathematical reasoning and spatial thinking.	Mathematical reasoning, spatial thinking and geometric systems	**Teaching Sequence No. 3** Explain the relationships between perimeter and area of different figures (variations in perimeter do not imply variations in area and vice versa) from measurements, superimpositions of figures, calculus, among others.	Recognition S3 (C1) Construction S3 (C2) Analysis S3 (C3)	Recognizes the role of the geoplane in the construction of polygons C1.1 Recognizes the measurement in square centimeters of the area of the geoplane C1.2 Starts to recognize the area on the geoplane C1.3 grid. Uses the appropriate material for the construction of the C2.1 geoplane. Constructs and draws polygons with established areas C2.2 Uses the definition of polygons to place them on the geoplane and makes the corresponding drawing on the grid C2.3 Recognizes that the shapes of polygons do not influence the area and perimeter of polygons C3.1 Finds the area of the figures in polygon exercises C3.2 Finds ways to perform rotation of figures in a plane C3.3 Identifies the perimeter of a figure with the help of the geoplane C3.4

Results

Diagnostic test

Diagnostic Test Results
"LUZ DE ESPERANZA" SCHOOL.
Santander

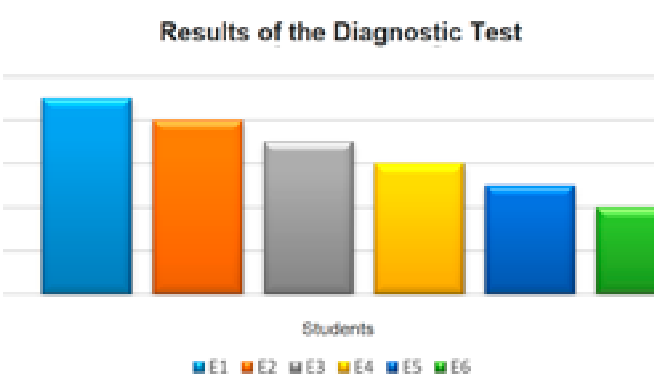
Berlín - Tona.

Results of the mathematics diagnostic test taken by fifth-grade students of elementary school.

Table 2. *Summary of diagnostic test results*

Question	E1	E2	E3	E4	E5	E6
1	1	0	1	1	0	0
2	1	0	1	1	0	0
3	0	1	0	0	0	0
4	1	0	0	0	0	0
5	1	1	1	1	1	1
6		1	0	1	1	1
7	1	0	1	1	1	0
8	0	0	0	0	0	0
9	0	1	0	0	0	0
10	0	0	0	0	0	0
11	1	1	0	0	0	0
12	1	1	1	0	1	1
13	1	1	1	0	0	0
14	1	1	1	1	1	1
15	0	0	0	0	0	0
Total	**9**	**8**	**7**	**6**	**5**	**4**

Figure 1. *Graph of diagnostic test results*



The diagnostic test was designed taking into account the aspects in which the insufficient performances were observed; five questions make reference to each process. The math test was taken by 6 fifth-grade students.

The results, divided by competence, are as follows:

Table 3. *Results by competences*

Type of Thinking	E1	E2	E3	E4	E5	E6	Correct answers
Metric	1	0	1	1	0	0	3
Metric	1	0	1	1	0	0	3
Metric	0	1	0	1	1	1	4
Metric	1	0	1	1	1	0	4
Metric	0	0	0	0	0	0	0
Total	**3**	**1**	**3**	**4**	**2**	**1**	**14**
Spatial	0	1	0	0	0	0	1
Spatial	0	0	0	0	0	0	0
Spatial	1	1	1	0	0	0	3
Spatial	1	1	1	1	1	1	6
Spatial	0	0	0	0	0	0	0
Total	**2**	**3**	**2**	**1**	**1**	**1**	**10**
Numeric	1	0	0	0	0	0	1
Numeric	1	1	1	1	1	1	6
Numeric	0	1	0	0	0	0	1
Numeric	1	1	0	0	0	0	2
Numeric	1	1	1	0	1	1	5
Total	**4**	**4**	**2**	**1**	**2**	**2**	**15**

Analysis of the results of the diagnostic test

In Table 3, we find the following:

- In spatial thinking: 10 correct answers out of 30 (each of the 6 students answered 5 questions).
- In metric thinking: 14 correct answers out of 30 (each of the 6 students answered 5 questions).

- In numerical thinking: 15 correct answers out of 30 (each of the 6 students answered 5 questions).
- In total: 29 correct answers of 90 (adding the 30 questions per type of thinking) for the 6 students.

In conclusion, we have low performance in all three types of thinking, not reaching more than 50% of correct answers, specifically the test showed an insufficient performance for spatial thinking. For this reason, it is necessary to strengthen topics related to spatial thinking and geometric systems.

In order to strengthen students' spatial thinking and geometric systems, it is essential to work under the basic standards of competences indicated by the Ministry of Education based on performance and Basic Learning Rights for fifth grade of elementary school.

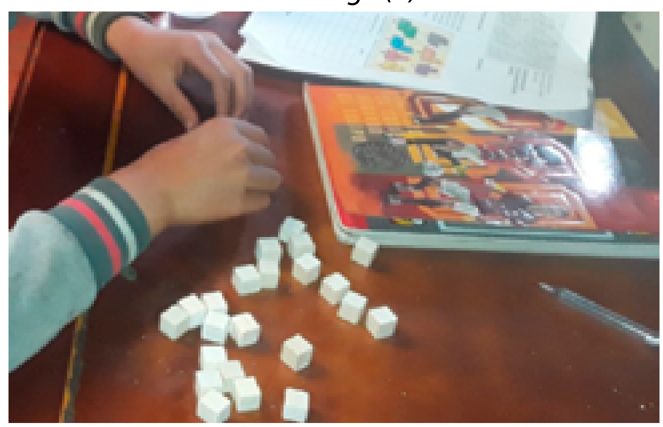
Implementation of the didactic sequences

For the implementation of the proposal, didactic sequences are designed and implemented as a strategy for meaningful learning that helps strengthen mathematical reasoning based on spatial thinking and geometric systems; in this training process, the strategy applied reinforces the concepts related to the construction of three-dimensional objects, verification of the results of the transformations to figures and analysis based on estimations set by students and based on the proposal of Van Hiele in relation to the levels of geometric thinking. We found three (3) didactic sequences: opening, development and closing activities.

In didactic sequence No. 1, we find 7 challenges; in didactic sequence No. 2, we can find 10 challenges and in didactic sequence No. 3, we find 7 challenges. In the activities proposed for each didactic sequence, students must build their work-mediating material (soma cube, tangram and geo plane) which helps solve the difficulties that students have in their process of spatial thinking when solving situations of volume, area and perimeter of three-dimensional figures and plane figures.

In the didactic sequence No. 1, activity A, challenge (1), students must watch the video tutorial and read the steps that guide the construction of the 7 pieces of the soma cube; most of the students of the sample used balsa wood as material for its elaboration.

Figure 2. *Production of Johan Vera (construction of the soma cube). Didactic sequence No. 1, Challenge (1)*



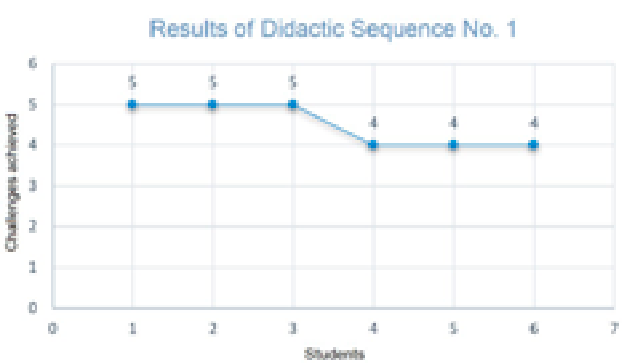
In conclusion, when analyzing the productions of the 6 students who participated in the development of the didactic sequences, it can be said that most of them achieved the objective, comparing or classifying three-dimensional objects according to their components (faces, sides) and properties; they attained significant learning as indicated by the theory of meaningful learning, The use of the mediating tool (geo plane) strengthened geometric reasoning through its elaboration, recognition and analysis.

Table 4 shows that the students who participated in the development of the didactic sequence No. 1 reached basic and high-performance levels.

Table 4. *Results achieved with the implementation of the didactic sequence Nº 1.*

Students	Challenges achieved	Remaining challenges	% achieved
1	5	2	71.4%
2	5	2	71.4%
3	5	2	71.4%
4	4	3	57.1%
5	4	3	57.1%
6	4	3	57.1%

Figure 3. *Results of the implementation of didactic sequence Nº 1*

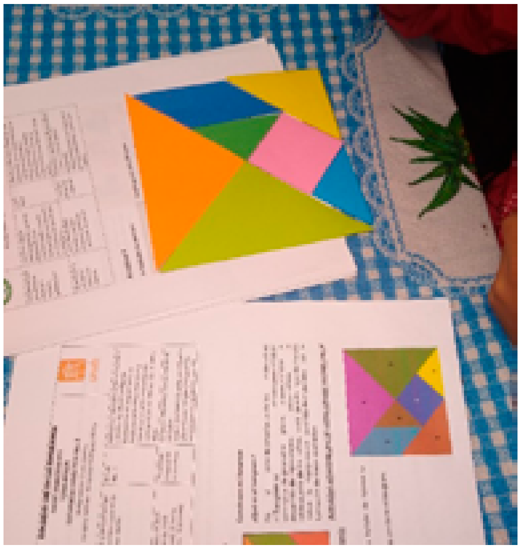


In didactic sequence Nº 2 we used a tangram as mediating material. Students elaborated its pieces and carried out activities of construction and decomposition of figures from given conditions. The didactic sequence is constituted by 9 challenges in the opening, development and closing activities.

In challenge Nº 1, students built the seven (7) pieces of the tangram using school cardboard, including in the didactic sequence the orientation of the construction of the material and accompanied with a video tutorial; the pieces of the tangram are composed of flat geometric figures including: 5 triangles, 1 rhomboid and 1 square. This challenge is assigned the category C1 (recognition) and the subcategory C1.1 (recognizes the number of pieces that make up the tangram) and the subcategory C1.2 (recognizes the geometric figures by observing their characteristics and classifies them according to size, color and shape).

In the challenge that Lina made, we observe that its construction was adequate, it can be visualized in the photograph that the pieces that are part of the tangram comply with the instructions specified in the didactic sequence regarding size and shape.

Figure 4. *Didactic sequence Nº 2, challenge (1)*



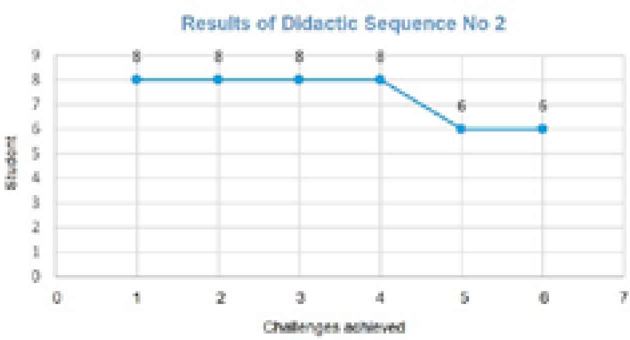
To conclude the work done in the didactic sequence N° 2, the objective was achieved, which sought to explain the relationships of perimeter and area of different plane figures, from measurements, superposition of figures, calculation, among others. Based on the levels proposed by Van Hiele cited by Reyes (2015), students have reached levels 1 and 2 which are related to visualization or recognition and analysis in geometric thinking.

Table 5. *Results achieved with the implementation of the didactic sequence Nº 2.*

Students	Challenges achieved	Remaining challenges	% achieved
1	8	1	88.8%
2	8	1	88.8%

Students	Challenges achieved	Remaining challenges	% achieved
3	8	1	88.8%
4	8	1	88.8%
5	6	3	66.6%
6	6	3	66.6%

Figure 5. *Results of the implementation of didactic sequence No. 2*



The previous result suggests that the design of the didactic sequences in the structure according to Tobón (2010) and the challenges posed based on Van Hiele's theory was significant to strengthen the learning of mathematics specifically in spatial thinking, reaching the performance targets established by the basic standards in competences for the area and grade.

In didactic sequence Nº 3, we find 7 challenges mediated by the material in the construction of the geo plane; the activities to carry out were related to the construction of figures in a plane to make easier the learning of concepts of areas and perimeters.

For challenge Nº 1, the objective is the construction of the geo plane; it is oriented through a didactic sequence and video tutorial; it is based on a simple design and elaborated with materials easy to obtain in the context. It belongs to the category C1 and the subcategory C1.1 (recognizes the function of the geo plane in the construction of polygons).

Lina sent a photograph of the construction of her geo plan, complying with the characteristics indicated for its elaboration.

Figure 6. *Didactic sequence N° 3, challenge (1)*

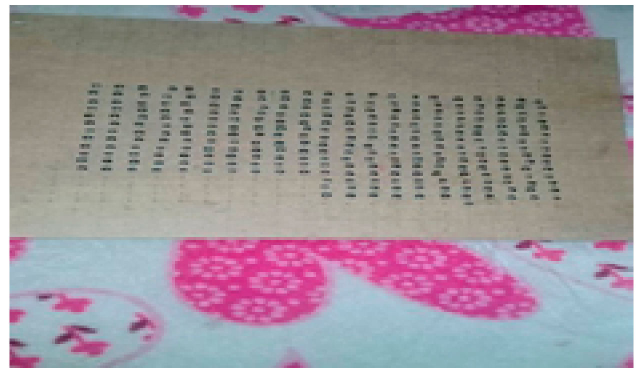
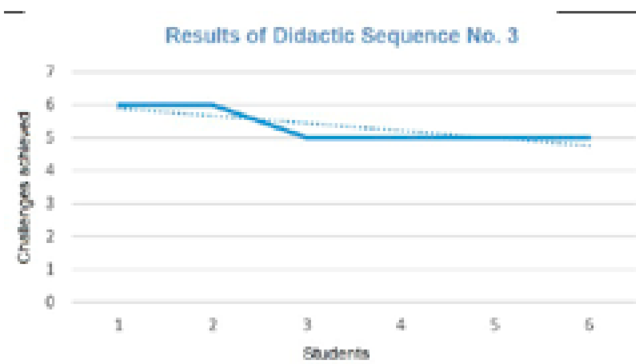


Table 6. *Results achieved with the implementation of didactic sequence Nº 3.*

Students	Challenges achieved	Remaining challenges	% achieved
1	6	1	85.7%
2	6	1	85.7%
3	5	2	71.4%
4	5	2	71.4%
5	5	2	71.4%
6	5	2	71.4%

Figure 7. *Results of the implementation of didactic sequence Nº 3*



In conclusion, the work developed in the didactic sequence shows the responsibility and motivation plus the learning acquired by the fifth-grade students, recognizing that figures with different areas can have the same perimeter and verifying the results of applying transformations to figures in the plane to build designs, reaching the levels of recognition and analysis in Van Hiele's theory cited in Barrera Mora & Reyes Rodríguez (2015).

The use of the 3 didactic sequences was able to strengthen in the 6 students the process of mathematical reasoning based on spatial thinking and geometric systems, supported in the competences set by the Ministry of Education (2006) and the Basic Rights of Learning that will be evaluated by the ICFES through the Saber Test in more advanced grades.

Final test

Fifth-grade students take the final math test, which consists of 10 multiple choice questions, related to the competence of spatial thinking and structured to improve mathematical reasoning; it includes 4 response options, in which one is true and the others are incorrect.

We take into account the contributions of the teacher when giving the student good mediating material to ease learning have them retain information for more time. Then the student acquires significant knowledge when he/she observes real facts and links them to his/her prior knowledge and finds meaning in what he/she does.

The final test is designed to enable students to recognize, construct, and analyze given figures to answer lengths, areas of plane figures, and construction of solids.

- Question 1: Find the perimeter of the model figure. It is necessary to know the length of its sides (recognition of the photograph - work on the geo plane).
- Question 2: The figures must be rotated to find equal areas (tangram).
- Question 3: Find perimeter of the figure (recognition - geo plane).
- Question 4: Find the number of cubes that make up the figure (construction of a solid - soma cube).
- Question 5: Find the area of the figure (recognition of the pieces that make up the polygon - tangram and geo plane).
- Question 6: Find the areas and perimeters (analysis of figures - geo plane).
- Question 7: Build the figures with given indications (geo plane and soma cube, three-dimensional objects faces and sides).
- Question 8: Build solids (soma cube).
- Question 9: Find perimeter and areas (geo plane - construction and analysis of plane figures).
- Question 10: Observe and recognize three-dimensional figures (faces, sides) and their properties.

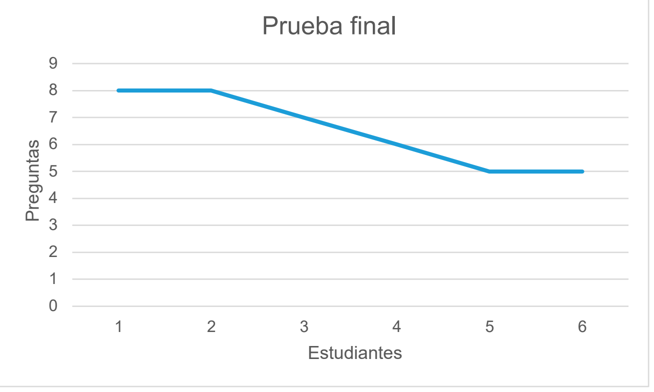
Table 7. *Final test results.*

Student/ Question	1	2	3	4	5	6	7	8	9	10	Total
1	1	1	1	1	0	1	1	0	1	1	8
2	1	1	1	1	0	1	1	0	1	1	8
3	1	1	0	1	1	1	0	1	1	0	7
4	0	1	1	1	1	1	0	0	1	0	6
5	0	1	1	0	1	1	0	0	1	0	5
6	0	1	1	0	1	1	0	0	1	0	5

In the final test, it was observed that students, in an easier way and supported by the development of the didactic sequences and the elaboration of the mediating material (tangram, soma cube and geo plane) and the accompaniment of video tutorials, applied the concepts related to volume, area and perimeter corresponding to spatial thinking, having better performances that surpass the basic standards in competences for the area of mathematics and achieved the objectives for fifth grade.

The graph of the final test is shown below.

Figure 8. *Final test results*



It is important to clarify that none of the students who took the final test obtained scores that placed them in low or minimum performances, this means that most of the students achieved the proposed performances in the didactic sequences according to the standards and Basic Learning Rights proposed for the fifth grade in elementary school, despite being a work directed by videos and phone calls, far from the face-to-face orientation.

Conclusions

With the development of the research work it was demonstrated that, through the recognition, construction and analysis of the mediating material and the contents oriented in the didactic sequences, knowledge was integrated that helped strengthen mathematical reasoning to develop the competences set out by the Ministry of National Education and the Basic Learning Rights in relation to contents related to the comparison and classification of three-dimensional objects according to components (faces, sides) and properties, as well as the construction and decomposition of figures and solids from given conditions, estimation and verification of the results of transformations to figures in planes.

To answer the research question "if it was possible to strengthen in great part the processes of mathematical reasoning, specifically in spatial thinking and geometric systems, using mediating material and orienting the contents through didactic sequences motivating the students towards learning with visual material", reflective analysis from the theory to practice of the concept of didactic sequence made in this proposal allows us to affirm that they do favor the significant learning mentioned by Ausubel (2007), because they constitute dynamic, conscious and intentional processes, based on student motivation, taking into account the context, prior knowledge and the contents of mathematics for students in the fifth grade of elementary school.

The implementation of the didactic sessions guided by video tutorials and mediated by the construction and analysis of mediating material for learning, helped strengthen learning based on spatial thinking and geometric systems, an approach cited by Barrera Mora & Reyes Rodríguez (2015), according to the levels of geometric thinking proposed by Van Hiele.

Considering that the activities were not carried out in person, the performance of the students in the elaboration and development of the activities was a great motivation and strengthened their capacities.

Links to watch video tutorials

https://youtu.be/wH6EqEsCe-k

https://youtu.be/Z3WluNoWKKM

https://youtu.be/fMm3iRH2YwA

https://youtu.be/DX2PdVlgYMY

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