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# Fostering mathematical logical intelligence in primary school students

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**Abstract.** Education must form thinking people, who develop all their potentialities, among them, those referring to mathematical logical intelligence. The objective is to elaborate a didactic proposal that fosters mathematical logical intelligence in students. For this, the research was framed in a quantitative approach with fieldwork design and at a descriptive level. The survey was applied as a technique and as instruments a questionnaire for teachers and a test for students. The population was made up of all teachers and students in basic primary education. An intentional non-probability sample was applied, made up of 22 teachers who attend primary school programs and 30 students of the same educational level. The results identify the lack of strategies related to the processes of classification, serialization, and number of primary school teachers during their pedagogical work. Next, we describe the shortcomings that students have in applying mathematical logic processes in a series of activities proposed in the evaluative test. Finally, didactic strategies are defined according to the conditions of the learning environment analyzed so that from the work of the classroom it is possible to promote logical mathematical intelligence, since cognitive stimulation in the student by means of learning experiences according to the level of development allows to reach levels of thought of greater complexity.

## 1. Introduction

Colombian education and the training of children, adolescents and young people is a current concern of the country. In Colombia, young people were born and grew up in a country in crisis and social and armed conflict, and despite being a right and a constitutional duty of obligatory fulfillment, they have not had the experience of living in a country in peace, since this mandate has not yet been fulfilled, but next to it we can say that these young people are the first generation in the country defined by the law subject to rights [1].

Thus, today, the teacher who facilitates teaching processes must become the person who organizes learning situations in order to ensure that students are capable of constructing knowledge; inasmuch as the child must not only be active, but also express his or her interests and needs in order to form his or her knowledge, because the learner is not a passive being who mechanically memorizes what others teach him or her; on the contrary, he or she is an apprentice who thinks, opines, participates and constructs knowledge on the basis of his or her previous experiences [2].

On the other hand, the child can learn if he interacts with the external environment in order to have the experience that he assimilates and incorporates into his mental structures, which are integrated and modified through a process of equilibrium; when he applies his mental schemes when acting on objects, the process of assimilation takes place; likewise, objects and situations influence mental schemes, in a process called accommodation. In development, adaptation is always transitory, because when acting on the environment or situations, new imbalances appear that give rise to assimilations and



accommodations, which is what allows progress in development. That is why it is necessary that many learning situations take place in order for the child to advance in his cognitive development [3].

It is thus that for the formation of the subject, it is necessary that the students reach competences in the different disciplines, inside which is mathematics, which must be acquired in a progressive way, in accordance with the evolutionary development of the students, for that reason it is necessary to consider the approach of Vigotsky [4] who in his theory exposes the process of mediation, that is no more than it allows the apprentice to go from a level of lesser knowledge to another greater one, if you have the support of another person of greater cognitive competence to help you move from a level of real development (what you can learn by yourself) to another of potential development (what you can learn because you have the cognitive possibilities and find a mediator who poses challenges), this distance between the two levels is what the author calls close development area.

That is to say, the teacher goes from being a facilitator of learning to a mediator, which is very important for logical mathematical knowledge, because it is the student who must evolve in his or her learning with the support of the mediator, for example, it is the student who must reach the logical classification through groupings whose criteria must be established and not under those indicated by the teacher, because in this way it is the teacher who classifies, so the challenge should only be to place together what he or she believes that because of its characteristics should go together.

However, Piaget [3] points out that the child constructs three types of knowledge: physical, logical and social. Through physical knowledge he can know the properties and attributes of objects; social knowledge is acquired in interpersonal relationships with other people. As for logical knowledge, the author indicates that it contains mathematical logical knowledge, infralogical notions of space and time, and representative functions.

In relation to the mathematical logical knowledge, the author in reference, indicates that they are constructed by means of the relations between the objects, they are the classification, the seriation and the number; the first one is achieved through the grouping by similarities and separation by differences, which is going to allow to include minor classes in major classes and to dissociate classes in subclasses. On the other hand, serialization consists in establishing comparative relations between the elements of a set and ordering them according to their differences, in an increasing or decreasing form. The synthesis of classification and serialization allows the construction of the notion of number, which is the class formed by all the sets that have the same numerical property and that occupies a range in a series that has also been considered from numerical property.

As can be seen, the above gives an idea of the importance of fostering in children the development of mathematical logical intelligence, which according to Gardner [5] should be stimulated alongside other intelligences; therefore, in the activities that the teacher proposes to primary school students, the development of other intelligences should be included; For example, children of first grade can carry out activities of classification of seeds collected from the surrounding trees, thus stimulating not only the classification process, but also the naturalistic intelligence, they can also label the seeds (linguistic intelligence), sing an allusive song (musical intelligence), work in groups (interpersonal intelligence), self-evaluate their product (Intrapersonal intelligence), walk and move to collect the seeds (corporal kinesthetic intelligence), move in the indicated space (spatial intelligence).

However, despite the importance of developing mathematical logical intelligence in children, authors such as Ramírez [6] argue that teachers do not give due attention to the promotion of processes that are implicit in it, which is why this author considers that many of the learning problems that are revealed in students are in part a consequence of this, so children drag up to high school deficiencies, which are obstacles to overcoming the objectives of the subject of mathematics, which is in all years of this educational level.

This can lead to children not developing their mathematical logical intelligence sufficiently, and they run the risk of continuing with problems in the construction of operations related to the construction of logical knowledge. Therefore, it is necessary to ensure that teachers promote logical mathematical intelligence, through interesting strategies for students, that allow them to carry them out are satisfying, because they are meaningful to them.

The proposed problem supports the purpose of the research whose objective is to elaborate a didactic proposal that fosters logical mathematical intelligence in students; which implied the realization of a study to identify as a first measure the strategies referred to the processes of classification, seriation and number that the primary teachers of the Andrés Bello Educational Institution present to the students; secondly, to describe how the students apply the logical mathematical processes in the activities they carry out and, finally, based on the results obtained, to design didactic strategies according to the factors that are presented within the educational context.

## 2. Method

The research process corresponds to the quantitative paradigm, with field design and descriptive level [7,8]. In this case, we quantified the data collected on the strategies referred to the processes of classification, serialization, and number presented by the institution's primary school teachers, as well as on how students apply mathematical logic processes. In terms of field design, the researcher worked directly on the reality found in the aforementioned institution [9]. At the descriptive level, the strategies that teachers present on the processes of classification, serialization, and number are described, as well as on the application of these processes by students [10].

In this research, the population is made up of all the teachers and children who attend primary education in the "Institución Educativa Andrés Bello". From the population indicated, 22 teachers who attend primary education were selected as a sample, mainly those who attend the mathematics area, and 5 children from each grade were randomly selected for a total of 30.

Two groups were organized, the first is group A, with 20 members, of this group, 5 children are between 5 and a half and 6 years old, 5 are between 7 and 8 years old; 5 between 8 and 9 years old; 5 between 9 and 10 years old. The second group B, with 10 students between the ages of 10 and 12.

The instruments selected to collect the necessary data are a questionnaire and a pretest according to Balbo's guidelines [11]. The opinion of the professors was also requested, regarding the issues of interest for this research. As for the pretest, which according to the previous source is an instrument to investigate previous knowledge, it is designed to be answered by children, with questions about classification, serialization and number.

The information was interpreted through quantitative procedures, according to the indicators established for the dimensions contemplated in the operationalization of variables. This included the realization of a synthesis of the same ones, to carry out the descriptions of numerical type. For the interpretation of the data that lead to the results, the revised theory and the knowledge of the researchers were used.

## 3. Results

The results are organized according to the established dimensions and indicators, first those of the pretest applied to the students are exposed. Next, the results of the questionnaire applied to teachers are explained. In both cases, the strategies referring to the processes of classification, serialization and number presented by teachers to students are identified.

### 3.1. Results of the pretest applied to students

*3.1.1. Dimension: Construction of the classification process.* Indicator: Sets. Each student was offered logical blocks (squares, circles, triangles, and large, medium, and small rectangles in red, blue, yellow, and green) for each student to do his or her own activity. In terms of age, the children of the A group had to make figurative collections and those of the B group had to have reached the operative classification. They were given as a slogan: to group by characteristics that they have in common.

The data collected show that the students, with respect to what was expected for their ages, did not all make the sets according to the level of development, which they should be, since 60% of group A, which should have made, according to Silva [12] non-figurative collections; that is, to form separate collections, taking into account the differences between the collections and separates according to them,

did not do so. Similarly, 50% of Group B did not carry out the logical class, which according to the previous author should already be done by children aged 7/8 years and older, that is, to separate by differences and group by similarities, according to previously established criteria.

Indicator: Belonging and nonbelonging. In this case, the students of both A and B had to identify when an element belongs or does not belong to a given set. To do this, they were offered a set of animals and another set of flowers on a sheet, under the same different elements, such as a dog, a rose, an apple, a chair and a broom, they were asked to join with a line the element that belonged to each set. As for this indicator of belonging and not belonging, the two groups produced data indicating that the majority were able to comply with the slogan.

*3.1.2. Dimension: Construction of the seriation process.* Indicator: Differences. Each child was given six straws, of the same color and shape, but with different length, the slogan was: How are they different. The results indicate that 50% of group A could recognize differences in the 10 straws delivered and the majority of group B, represented by 80% also did, which means that according to their ages, in group A there was a 50% that could not establish the differences, because according to Silva [12] should have built the series by trial and error, as did their peers; likewise, there was 20% of group B, which did not satisfy the problem presented, because according to the same author, they have already had to do the logical or operative series. For this reason, it is necessary to continue presenting them with didactic strategies that promote their mathematical logical intelligence.

Indicator: Sorting. This indicator offered the same ten elements of the previous year, the slogan was: rank them from lowest to highest. However, there was a minority, represented by 45% of group A and 10% of group B, who did not comply with the given slogan, which means that it is necessary to stimulate ordering, because it is necessary to remember that knowledge is acquired by the child, According to Piaget (1978), through a process of interaction between mental structures and the environment, which requires giving the appropriate stimulation, so that in his interaction with other people (adults and other children) and with various situations that produce cognitive conflicts, which lead him to think and act to resolve them, that in this case, it was a matter of sorting objects by their differences.

*3.1.3. Dimension: Notion of number.* Indicator: Biunivocal Correspondence. In this activity, each student was given several different elements, inside which were six small bottles and six lids of the same, the slogan was: look for elements in this box that can be matched with others that are inside the same box. Regarding biunivocal correspondence, 40% of Group A performed the exercise correctly and 60% did not; 70% of Group B did well and 30% did not. This indicates that it is necessary to reinforce the strategies that foment this notion in the students, because if the notion of number is not constructed, they are going to have difficulties in making calculations and solving mathematical problems [12].

Indicator: Conservation. In this indicator, the researcher worked individually with each student, presenting a row of toy plates and cups, the teacher made a row of ten cups and underneath she gave him the command to place the plates, asked what there are more plates or cups; then, in the presence of the child, she arranged the plates differently, leaving the cups the same and asked the same question again. In the individual exchange carried out by the researcher with each student, it can be seen that in terms of conservation, 65% of the students in group A managed to pass the proposed exercise, but 35% did not; likewise, 100% of group B did it correctly. Conservation is another of the basic notions that is progressively constructed, hence the importance of presenting different learning situations for students to appreciate the correspondence between two groups of ensembles.

### *3.2. Results of the questionnaire applied to teachers*

*3.2.1. Dimension: Thought processes.* Indicator: Troubleshooting. In this indicator, two questions were asked to find out whether the survey teachers encourage students to make their own decisions in mathematical situations, which yielded the following results.

In relation to the problem solving indicator of the thinking processes dimension, the data collected indicate that the majority of the teachers surveyed, represented by 54.54% indicate that they sometimes present students with real-life situations related to mathematics so that they can make their own mathematical decisions; likewise, the majority (59.09%) say that they sometimes stimulate students to make decisions related to mathematical problems. This is a weakness, because problem solving is a cognitive process, this process must be activated by the teacher through mediation, which according to Vygotski [4], the learner must be presented with multiple learning situations that provoke cognitive conflicts and lead him to think and know.

Indicator: Calculations. Two questions were asked to assess the extent to which teachers propose exercises for students to perform calculations. The indicator calculations of the dimension thought processes, shows in the collected data that 50% of the teachers sometimes use different materials for the students to make calculations and 50% claim to do so almost never; however, the majority represented by 45.45% located in the option always and 22.72% in the option almost always claims to present students with problems to perform mathematical calculations, which leads the researcher to infer that she presents insignificant strategies because they rest on the placement of problems, which may cause students not to take an interest in them, but to solve them mechanically, because for Ausubel [13], learning must be significant, with activities that awaken the desire for its realization, with diverse resources and materials that are different from the traditional practices in which paper and pencil prevail.

Indicator: Measurements. The two questions were intended to assess whether teachers placed students in measurement situations. The first question asked to teachers was "I place students in activities to take measurements" in this case, the majority was 50% who said to do it sometimes; the other question was if it guided students to take measurements with specific objects and 45.45% always said to do it. These data reflect that even when the teachers consulted indicate that they use concrete objects for students to make measurements, their responses lead to think that these activities are not frequent, because only one part says to place activities for their students to make measurements.

Indicator: Mental operations. Students asked the teachers two questions concerning strategies for the performance of mental operations and the following data were collected: the majority, represented by 50% of the respondents, indicate that they sometimes propose to students the performance of mental operations; 77.27% state that they sometimes use different resources for students to perform mental operations. This shows a weakness, since mental operations must often be proposed so that students become accustomed to thinking and not always to memorizing, but that their responses, as Silva [12] states, are the product of reflection and divergent thinking.

Indicator: Levels of development. In this indicator, teachers were asked 4 questions because it was necessary to appreciate the strategies, they use to know the developmental levels of students. It was obtained that 36.36% of the respondents were placed in the option sometimes and 36.36% in that of almost never when asked about the design of strategies that allow me to establish the real level of development of each student. On the other hand, 50% said that always and 50% sometimes propose activities for students to perform individually and thus determine the real level of development of each one. Also, 50% indicated that they sometimes ask math questions in order to know the level of potential development of each student and 50% indicate that sometimes when they propose math exercises to students, they interact with them to support them in reaching their level of potential development.

Indicator: Mediation. For this indicator, two questions referring to mediation were foreseen in order to appreciate whether, in the area of mathematics, the teacher consulted developed a mediation that took the student to higher levels of knowledge. These same percentages are those corresponding to the item on whether teacher mediation allows the student to be taken from his level of real development to his potential, since 50% was placed in usually and 50% in some cases. For Vygotski [4], knowledge is attained when there is mediation that leads the student to reach his potential level, that is, to what he is capable of learning.

Indicator: Previous knowledge. In this indicator, the two questions asked were aimed at assessing whether, in the strategies, teachers presented situations that made it possible to know the students' previous knowledge in the area of mathematics. The results show that 50% of those surveyed state that

sometimes before starting teaching in the area of mathematics, they ask the students what their previous knowledge on the subject is, and 50% said almost never. Likewise, 50% indicated that they sometimes plan based on the previous knowledge detected in the students and the other 5% stated that they almost never do so.

Indicator: Participation. In the participation indicator, two questions were asked to find out if the mathematics strategies presented by the teacher give students active participation. In this result, it was obtained that 54.54% of those surveyed state that they usually offer students active participation in classes related to mathematics and 59.1% state that they almost never present strategies for students to participate in cooperative learning activities in mathematics. This is a strength, but they offer them few opportunities for cooperative learning, which is a weakness [2].

Indicator: Group work. The purpose of this indicator is to appreciate how students work in groups in response to the strategies that teachers foresee. It was obtained that 50% of those surveyed state that almost never when teams are organized, students autonomously select co-workers and 20% assert that never. Similarly, 63.3% indicated that almost never students in teams autonomously establish criteria for classifications and series.

*3.2.2. Dimension: Logical mathematical processes.* Indicator: Classification. In the classification indicator, two questions were asked of teachers about the stimulation offered to students for the construction of the mathematical logical process of classification. Fifty per cent of the teachers who participated in the survey said that students sometimes make classifications with specific objects and 50 per cent said that almost never. In addition, the majority represented by 54.54% of respondents said that they almost never use examples from everyday life to ask students to do belong and non-belong exercises.

Indicator: Seriation. In the serialization indicator, two questions were asked to the teachers about the promotion for the construction of the mathematical logical process of serialization in the students. The highest percentage was 40.9% placed in the option sometimes asked about whether teachers design strategies for students to produce series. Likewise, when faced with the question whether teachers invite students to construct series in which they select the criterion for serialization, the majority represented by 40.9% was sometimes placed in the option.

Indicator: Number. In indicator number, two questions were asked of teachers on the promotion of the mathematical logic process referred to the construction of the notion of number in students. Finally, in the case of the "I design strategies for students to establish one-to-one correspondence" approach, the majority of the answers were 50% in the option almost never and in the other approach: "I use various materials for children to perform numerical no correspondence exercises", the majority was also 50% in the same option of almost never.

It must be remembered that according to Piaget [3] there are two basic notions for understanding number, which are progressively acquired throughout the child's development, these notions are one-to-one correspondence or biunivocal and conservation, which, according to the data provided by the teachers surveyed, are not stimulated by different strategies presented to the students.

#### 4. Discussion

Attention to the specific objective: To identify the strategies referred to the processes of classification, serialization and number, it can be pointed out that there are weaknesses in what was found, according to the answers to the questionnaire that was the instrument to collect this information, when this is compared in light of what is exposed in the state of the art of the work, it has to be that the mathematical logical intelligence, which is within the multiple intelligences identified by Gardner [14], is feasible to be developed; its location is in the frontal lobe of the left hemisphere, while, for example, the musical is in the frontal lobe of the right hemisphere. This development is only possible if there are opportunities for subjects to be in contact with situations that lead them to solve problems related to mathematics.

For this reason, in consideration of the few strategies offered by teachers to students on the processes of classification, seriation and number, on the basis of Piagetan theory, as far as mathematical logical

processes are concerned, it is included as training purposes: To analyze the contributions of the theories that support the proposal and Present strategies referring to the development of mathematical logical intelligence in students; these purposes are with the purpose, on the one hand, of offering teachers an update regarding theoretical approaches that facilitate their understanding of the need to introduce changes in their way of teaching; on the other hand, to make them put into practice a series of activities directed at how learning situations are presented and developed for the construction of mathematical logical processes; that is, in the proposal there is a way to solve the manifested weakness.

Likewise, when comparing the results of the pretest applied to students to satisfy the specific objective of the study formulated in the terms: Describing how the students of the Andrés Bello Educational Institution apply mathematical logic processes in the activities they carry out, with what is stated in the theories, it is appreciated that there are students who according to their age, according to what Piaget [3] states in his theory, are below what is expected, because the mathematical logic processes, Therefore, the proposal included a series of activities so that teachers, once they themselves understand and value them, apply them with their students, which is also supported by the series of events that are proposed to analyze the contributions of the theories that support the proposal.

## 5. Conclusions

It was possible to appreciate that the teachers foresee few strategies to foment the processes of thought, as well as for the development of the logical mathematical processes, which are necessary to foment this type of intelligence in the students. Weaknesses were found in the investigation in the levels of real and potential development and in the previous knowledge that the children have with a mediation that allows them to cross the zone of next development in order that they reach significant knowledge.

The stimulation received by the student from the school environment is important so that he can achieve cognitive advances that allow him to pass from one level to another in his thinking.

It is also important that the current teacher knows how this knowledge is produced, so that he or she can design learning experiences according to the level of development of the students; which is why the proposal includes strategies for the development of thinking.

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