

How to Cite:

Moreira-Párraga, J. A., & Alcívar-Castro, E. J. (2022). Cognitive development of students in solving mathematical problems. *International Journal of Health Sciences*, 6(S2), 12655–12665. <https://doi.org/10.53730/ijhs.v6nS2.8415>

Cognitive development of students in solving mathematical problems

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Abstract--This research was based on the cognitive development of students in solving mathematical problems of the School of Basic Education "2 de Agosto" in the 2021-2022 academic period. The results of the research carried out through a survey applied to students are exposed, to emphasize the importance of knowledge and cognitive development. The problem of learning focuses on middle school students, especially on the mechanisms of memorization and application of methods and strategies that help solve mathematical problems. An exhaustive study of concepts was carried out to enhance the methods and strategies that help improve student learning. The objective of evaluating the educational model and the practice in the learning processes of the students in relation to their practice in the classroom. The research has a quantitative approach, using the inductive and deductive methods. The technique used was an observation guide during class development to determine the results of the investigation. The result was to change the teacher's methodology according to the previous knowledge of the students, leaving aside the rigor of the curriculum, to avoid gaps in the cognitive level.

Keywords--cognitive development, problem solving, memorization mechanisms, learning.

Introduction

The research analyzes how to support students to understand how their cognitive development influences, along with the possible methods and strategies that help

them solve problems. mathematicians from a better perspective, to understand from their analysis and execution of the processes, raising their level of understanding and their cognition. The student at a certain stage of his life begins to think in a concrete and analytical way what happens around him, after identifying and interpreting everyday problems, it is normal for students to infer these problems to adapt them to mathematical resolutions which helps them to overcome these difficulties faster. Enhancing their cognitive development by strengthening their knowledge and boosting their intellectual abilities, thus highlighting their academic knowledge and at the same time their emotions of feeling capable of solving mathematical problems, the satisfaction of having helped others and the conformity with the knowledge acquired in the area. For Piaget cited by (Vergara, 2017).

Cognitive development is a progressive reorganization of mental processes because of biological maturation and environmental experience, as students grow, they relate to the environment where they develop their activities and create their cognitive development, always increasing their knowledge acquired in this process. Students have difficulty reasoning and understanding mathematical problems that involve reading and understanding problems of that subject where they must analyze data and seek solutions through basic operations (addition, subtraction, multiplication, and division), which can be one or more. combined. To overcome these problems, it is necessary to analyze the methodology with which the students are learning and verify that the strategies that are being used to improve the processes that the students are using to comply with the statements. For Cáceres & Chamoso (2015) cited by (Sanabria Cachope, 2019) "*based on the Polya Model, problem development competence is achieved through a process that is divided into four general aspects that students must take into account: the understanding of the problem, the planning and execution of the resolution strategy, the solution of the problem and the analysis of the process and the solution*" (P.34).

The teacher in the classroom is in charge of transmitting the knowledge and depending on the interactions with the student, the practice in the classroom will be much more efficient, Molina (2017) cited by (Martínez, Asparó, & Moreno, 2019) "*The importance of interactions and the role that teachers have in promoting them, requires the incorporation of effective forms of interaction that promote student learning, not only those with more difficulties, but all students as a whole*" (P .58).

The ability that people have to focus persists from a stimulus or activity that allows us to maintain our high level of alertness, which is conditioned by motivational factors, age, interests, needs (Ferrando, 2015). Cognitive development will depend on the kinds of stimuli that the teacher applies to encourage the student to pay attention in class, thus being able to work correctly, imparting new knowledge and reinforcing the old. Learning based on the concept of "action", of experience, the child adds and restructures knowledge and skills, thanks to active interaction with the world around him (Calvo, 2018). The cognitive development of the students is evolving according to the knowledge that the students are acquiring according to the experience that they add in the school

year they are in, the age and the environment that surrounds them are essential in the evolution of cognitive development.

With the intention of responding to these research problems, the objective was to evaluate the educational model and the practice in the learning processes of the students in relation to their practice in the classroom. Problem solving will provide possible solutions, modeling of reality, development of strategies and application of techniques (Cruz, 2017). One of the purposes of teaching mathematics is problem solving, because it becomes the essential means to achieve learning in an active way, in addition to providing opportunities to pose, explore and solve problems with significant effort. Problem solving not only complies with the national curriculum but also encourages the constant practice of students in their environment.

The resolution of mathematical problems breaks the monotony of the classes, this obviously, because it breaks the idea that it is an activity based on the repetition of actions or strategies already assimilated and makes clear the challenge that the individual faces situations that must put to the test, due to its novelty, due to the diversity of possibilities by changing the conditions in which this situation manifests itself (Pérez & Beltrán, 2011).

Materials and Methods

The applied methodology has a qualitative approach, it allows to assume an individual, dynamic reality and composed by composition of contexts, privileging the deep and reflexive analysis of the individual meanings that are part of the realities studied within the educational context, based on the logic and the inductive process detailing verbal and non-verbal expressions, as well as behaviors or manifestations.

As a qualitative approach according to (Guerrero, 2016) it focuses on understanding and deepening the phenomena, analyzing them from the point of view of the participants in their environment and in relation to the aspects that surround them. It is normally chosen when seeking to understand the perspective of individuals or groups of people who will be investigated, about the events that surround them, delve into their experiences, opinions, thus knowing how they subjectively perceive their reality.

Some quantitative contributions were appreciated as indicated (Campo & Zamora, 2020), established in the knowledge of the statistical data to be used to verify a relationship between variables is essential to carry out the initial process of causal inference of the population that is being studied. , such as the collection of information through surveys and written tests, the study phenomenon was determined, applying the inductive method, having the advantage of promoting the researcher and putting him in contact with the subject under investigation or object of investigation; the analytical method because it dismembers a whole, breaking it down into its parts or elements to observe its causes, nature and effects.

The documentary research method according to (Dugarte, 2017), is a process based on the search, recovery, analysis, criticism, and interpretation of secondary data, obtained and recorded by other researchers in documentary sources: printed, audiovisual or electronic, the purpose of this design is the contribution of new knowledge. The population studied was 34 students distributed between elementary and middle school, who were given the appropriate evaluation instruments for data collection in the second part of the second semester of the School of Basic Education "2 de Agosto"

Analysis and discussion of the results

The results that are shown are the data obtained from the observation made to the students in the educational process which was later reflected in a checklist to know the knowledge that the students have about the process and resolution of mathematical problems and their cognitive level according to the year they attend the Basic Education school "2 de Agosto", according to the cognitive development the student solves problems according to the degree of complexity that is presented, in the cognitive development of the student the emergence of thought can be mentioned conceptual, the conscious and voluntary nature of psychic processes (Flores, 2017).

Importance of cognitive development of students

The importance of cognitive development during the first years of life is something relevant, great psychologists like Piaget formulated a pedagogical model where the student learns under the concept of "action", of experience. The student is adding their knowledge and learning from them for future problems, it is essential that the teacher adjust their methodology and learning techniques according to the student's cognitive development.

According to Benedet (2013), children learn to speak naturally, however, it is not normal for them to learn to read and write without receiving formal instruction, through which the brain creates the necessary neural networks to support these skills. Teachers have the power to teach strategies so that the student learns to read mathematical problems correctly, which is essential in mathematics, a well-done reading helps to better understand the problem (Susana, 2017). The teacher's first priority is to create a classroom environment where students want to share their personal views on their readings (Cairney, 2018). One of the biggest mistakes as teachers is to plan daily activities in such a way that they do not allow the appearance of informal opportunities for children to share their answers. The training spaces help the students to better understand the texts because it is a work between pairs since everyone wants to give their point of view, the same thing happens in the reading of mathematical problems, reading and interpreting the writings in some cases works better when the students do this type of activity in small groups.

According to the description of (Águila, Castillo, Guardia, & Nieves, 2015), the cognitive and affective processes that the student perceives from the impact of academic stressors. That is, the student evaluates various aspects of the academic environment and classifies them as threatening, as challenges or

demands to which they can respond effectively or not; These appreciations are related to anticipatory emotions such as: concern, anxiety, confidence, anger, sadness, satisfaction, relief, etc. The attention and self-control of the student is one of the challenges that must be overcome so that these distractors do not disturb the activity within the classroom.

For Piaget (1976), the cognition of the human being is made up of two subsystems, the first "understands or structure" and the second is that of "knowing how to do" or the "procedural" and that these subsystems are inseparable, they cannot be separated (Villegas & Pereira, 2015). It is necessary to ensure that these two subsystems are mastered by students to relate previous knowledge to new concepts. But according to Vygotsky (1988), cognitive development is not only based on individual changes, but is part of a constant process between the correspondence of internal and external factors mediated by the adaptive processes that Piaget establishes (Cortez Estrella & Tunal Santiago, 2018).

Piaget, also in his writing's states that early stimulation in children is of vital importance in the first years of schooling for a better cognitive development, for (Albornoz Zamora & Guzmán, 2016), the development and orientation of the educational process that is carried out. It must be in accordance with children's interests and needs, which contribute to facilitating future educational activities and not according to the interests of teachers.

Problem solving in the educational context

In the solution of any problem, there is a certain discovery (Meneses Espinal & Yaneth, 2019), the problem that arises can be modest; but, if it tests the curiosity that induces the inventive faculties to be put into play, if it is solved by one's own means, one can experience the charm of discovery and the joy of triumph. (P.13). It is taught for life, so the teacher must pose problems in which the student is interested in applying their knowledge in order to solve them.

To do this (Diago, Arnau, & Antonio, 2018), they establish that problem solving is considered a process standard, related to those that require the student to "do math" and achieve significant learning. Under this standard, students must understand that there are many strategies to approach mathematical problems in an easier way, applying the strategies with which they feel most comfortable. In this sense, Domenech (2004) shows that problem solving contributes to developing metacognitive processes that favor student autonomy in learning mathematics (Arteaga-Martínez, Macías, & Pizarro, 2020).

The resolution of mathematical problems needs new paradigmatic visions to guide its methods and ways of teaching and learning in this context it is necessary to overcome the tendency to pure abstraction, seeking its applicability in life and in the real contexts in which it is lived. (Díaz & Careaga, 2021). New guiding taxonomies are needed, based on solid theoretical arguments and reconceptualizations, that allow exploring a mathematical theory that facilitates clearing its scientific nature in the contextual roots of its problems, so as not to be reduced to the sole formulation of abstract statements. Teachers must look for

new alternatives in which they can draw the student's attention, to break the monotony with which they have been working for years.

Teachers must break traditional education to end this iceberg in the teaching of mathematics, the constant updating of teachers invites them to seek new strategies to develop cognitive processes and how they inhibit student learning. Thought styles are fundamental in these processes, especially logical-abstract thought. The development of logical-abstract thinking is essential to improve mathematical intelligence, which overcomes the barrier of numerical abilities and provides important benefits to understand concepts in other areas of knowledge, basic and complementary, thus establishing relationships between knowledge and articulated to the daily life experiences (Lilian & Luis, 2016).

In problem solving, the student's memory is essential in mathematical processes, it goes hand in hand with the cognitive, it develops throughout the student's life, since its inception memory increases its retention capacity favoring knowledge and problem solving previously learned. According to (Llanga, Logacho, & Molina, 2019) memory depends on the interest of the person, demonstrating a positive attitude when assimilating something, therefore, there is a constant variable and widely used by teachers, which is the student motivation. If the motivation is constant, the memory remembers much better the processes to carry out the activities.

In problem solving, the student's attention throughout the educational process is essential for (Valenzuela Matute, 2018), this is a fundamental cognitive process where specificity is needed to perform certain tasks, focus the senses to be able to execute an activity. Attention time has to do with age, because each boy or girl has their own rhythm of perceiving their environment and this will depend on their ability, it must be borne in mind that according to the basic year and chronological age of the student the level of attention will vary and if the teacher's methodology is stimulating it is much higher.

In this research that has had as objective, to analyze the cognitive development in the resolution of mathematical problems, the methodology of the teacher in the classroom, the learning of the students and how they incorporate in their daily practice in the classroom are highlighted:

- a) The teacher's methodology
- b) Approach of the problems and clarification of terms
- c) Geometric problems
- d) Monetary problems
- e) Problems applied to their social environment

It was investigated through surveys and a written test to the students of the basic average, of the School of Basic Education "2 de Agosto", in small work meetings focused on solving mathematical problems. The first question was related to the application of adequate methodology by the teacher. Table 1 shows the results obtained.

Table 1. The teacher applies an appropriate methodology in teaching the class

Alternatives		Frequency	Percentage (%)
A.	Yes	30	88
B.	No	4	12

As can be seen in literal A, 88% of the students surveyed indicate that the teacher applies an appropriate methodology in the subject of mathematics throughout the class plan, demonstrating that a correct methodology applied in the teaching-learning process affects cognitive development, achieving an absolute understanding in the solution of mathematical problems, demonstrating mastery over it and insight into its procedure and 12% in literal B do not consider that the teacher applies an adequate methodology to the mathematics subject throughout the class plan, which generates boredom and little understanding of the learning process.

In the case of the question related to the statement of the problem and clarification of terms, demonstrating that the teacher can expand the problems correctly, so that the students can perfectly recognize and interpret the problem, Table 2 shows the results.

Table 2. The teacher poses mathematical problems in a simple way

Alternatives		Frequency	Percentage (%)
A.	Yes	32	94
B.	No	2	6

As observed in literal A, 94% of positive responses were obtained from the students surveyed, they maintain that teachers pose mathematical problems effective and efficient, constructing new simple questions with the appropriate information, strengthening cognitive development by demonstrating that with the appropriate information new problems can be formulated and 2% of literal B does not agree that the teacher poses effective and efficient mathematical problems, constructing new simple questions with the appropriate information, since they believe that the problems are repetitive and only change their numerical value.

To analyze and carry out a process of the exercise for the students, a questionnaire was applied with different types of problems focused on variants of their structure and different types of resolution shown in table 3 of the problem to be solved. Prefabricated wooden houses have 8 square-shaped windows, if each side is 60 cm. Approximately how many centimeters of wood are needed to make the window frames (stringers)?

Table 3. Response to the problem

Alternatives		Frequency	Percentage (%)
A.	1920 cm of wood is needed to make the window frames	32	94
B.	1820 cm of wood is needed to make the window frames	2	6
C.	1720 cm of wood is needed to	0	0

 elaborate the window frames

As seen, literal A has a 94% response where it is noted that the students answered the question correctly, demonstrating their knowledge about the perimeter of parallelograms applied in solving mathematical problems, demonstrating that they have adequate knowledge to solve the mathematical problem posed by their teacher, but the literal B that corresponds to 6% answered that 1820 cm of wood is needed to make the windows, demonstrating that they have mastery over the perimeter of the parallelograms but they need more practice in solving this type of exercises.

The importance of detailing this type of exercises is that a sequence of the problem-solving process must be carried out, contributing to comprehensive reading, attention to the problem, the practice of correct mathematical operations and the tactical empowerment of previous knowledge. It was analyzed how the students solve, synthesize, and present the monetary problems, as detailed in table 4, through the following problem: In the market of your city potatoes are sold by quintals and arrobas. If a producer sold 5 quintals of potatoes at \$12 each and 2 quintals divided into arrobas at \$3.50 each arroba, how much money did he earn in total?

Table 4. Monetary problems

Alternatives	Frequency	Percentage (%)
A. The seller earned 98 dollars	22	6
B. The seller earned 88 dollars	30	88
C. The seller earned 78 dollars	2	6

As literal A can be seen, 6% of the students surveyed answered the question incorrectly, they dominate the process but in a part of the exercise they failed, the literal B that corresponds to 88% of the students answered the question correctly by multiplying the amount of quintals and arrobas, multiplying them by their value and adding both products to find the correct result demonstrating a mastery of problems with monetary exercises, literal C, 6% of the students, as well as literal A, dominate the process but failed in a part of the exercise.

Students identify the correct formula to use in solving problems, applying the correct procedures and the proper use of mathematical language in carrying out exact mental calculations, considering the units of positional measurements, favoring their cognitive development, enhancing their thinking, perception, memory, reasoning, attention, problem solving, etc.

Likewise, it was analyzed how students interpret and solve mathematical problems of environmental interest, such as the following example: Forests absorb 2.5 tons of carbon dioxide (CO₂) per hectare each year and release 6.67 tons of oxygen (O₂) per hectare each year. How much carbon dioxide will they absorb in 5 years? The results are shown in table 5.

Table 5. Solving mathematical problems related to the environment

Alternatives	Frequency	Percentage (%)
A. 12.5 tons	32	94
B. 12 tons	2	6

As can be seen in the table, literal A, 94% of the students correctly answered the exercise that asks to find the amount of carbon dioxide that the forest absorbs in 5 years, which the answer 12.5 tons indicates that we must quintuple the initial amount for the annual value of 2.5. 6% answered the literal B of 12 tons, which is incorrect when making an error in the application of the mathematical operation, it could be the error indicating that the students are limited to developing the mathematical problem trusting that they have done it correctly without the need for review and correct errors.

The analysis interpreted in the written test that was applied to the 34 students of the middle school, after having observed the application of several problem-solving exercises, detailed that the vast majority of the students are clear about the processes necessary to carry out mathematical problems, it took a progressive impulse that was the basis of this article to activate their knowledge and provide strength in their cognitive levels, the minimum percentage of students highlights a loss of interest in the basic processes of solving mathematical problems.

The results obtained show that the cognitive development of the student must be constantly exercised, through reading and solving complex problems, because these will generate a conceptual change in the previous knowledge that the student has, with the known knowledge and those who are going to meet in the future build new knowledge achieving the cognitive development of the student.

Conclusions

The results obtained demonstrate the need to promote the cognitive development of students through practices involving the knowledge learned and the difficulties presented in the community where they are, but always rivaling the previous knowledge of the students. . It was possible to demonstrate that prior knowledge is always present in the student's mentality, that only active programs are needed that are constantly encouraging the use of this knowledge. With the application of the questionnaire, it was possible to verify the participation of the students in the realization of practical exercises of the daily life and the autonomy of the student when carrying out by themselves, resolutions that go from the simple to the complex and how these generate more knowledge giving a progressive contribution to the difficulties of society.

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