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Methodological Strategies in Strengthening the Psychological Resolution of Mathematical Problems in Secondary Level Students

Trujillo Quezada Maria Soledad[1], Rosa Huaraca Aparco[2]
[1] Universidad Cesar Vallejo, Perú
mtrujilloqu9@ucvvirtual.edu.pe
[2] Universidad Cesar Vallejo, Perú
rhuaraca@unajma.edu.pe

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Abstract

The present research aims to explain how methodological strategies strengthen the resolution of mathematical problems in students of the secondary level, from the systematic review of the literature, which allows an assessment of the variety of methodological strategies that exist to solve problems that can be applied by students and teachers in teaching. Learning mathematics, allowing students to develop their mathematical skills in solving problems of their context and finding meaning in their learning. The methodology used was a bibliographic review and different information search strategies were used in the exploration of documents by keywords, by topic, by author and by word trick. The data used were: processes, strategies, metacognition, flexibility, problem solving, mathematical competence, technology among others, found in the databases Google Scholar, Scopus, Redalyc, Scielo, Proquest, Oaji, Doaj, Latindex, and Dialnet. Being subjected to criteria of validity and reliability. It was concluded that methodological strategies such as processes, metacognition and flexibility favor problem solving accompanied by technology; for this, teachers and students must be prepared and break with traditional and mechanistic teaching.

Keywords: Strategies; metacognition; flexibility, processes; problem solving; technology.

1. Introduction

At this time, it is unthinkable not to include the teaching of mathematics in the basic skills that every person must have to face the challenges of social life. (UNESCO, 2016) Therefore, the area of mathematics is fundamental in the educational curricular design, since it must allow to develop ways of acting and thinking mathematically in different situations that encourage the student to explain and participate in their context (Minedu, 2015), Learning mathematics is not only learning a set of individual concepts, facts, skills and processes; but that teachers facilitate students to actively experience the application of these concepts, strategies, skills and processes in problem solving, (Peng Yee, 2014) being the focus of attention of Mathematics (Pérez and Ramírez, 2011). In this regard, problem solving is conceived as the primary didactic tool for the development of competencies and skills in students that allows them to face and solve situations. (Patiño et al., 2021). It is also a fundamental condition and a powerful mechanism in the process of teaching and learning mathematics, helping students to assess the level of acquisition and application of concepts and processes; of research and analysis of metacognitive strategies that each student sets in motion when confronting uncertain works. (Arteaga et al., 2020). However, students' problem-solving skills are so low that they have generated a crossroads for the universe (Novriani and Surya, cited by Munayco and Solís, 2021), so we can ask: How do methodological strategies strengthen mathematical problem solving in high school students?

In response to the question, it can be stated that teachers work in a monotonous and mechanical way, exercises and problems, often without any practical application of daily life, causing demotivation in the student's cognitive process (Leal et al., 2021) Therefore, it is essential that teachers understand what a problem truly symbolizes, The classifications that exist in the problem, its characteristics, the stages of problem solving, as well as the teaching strategies, so that they can make interesting, creative statements, and diversity as a protagonist constitutes a challenge for students, and implies perceived effort when addressing them. (Pérez and Ramírez, 2011)

Likewise, the change in mathematics teaching requires students to be independent in their problem-solving procedures and to make the decision to invent, rather than relying on predetermined algorithms to solve problems

(Darling and Barragan, 2021). It is essential to solve problems in the teaching of mathematics, teachers must renounce traditional methods that do not allow to achieve competences, skills and mathematical abilities in students, being important and necessary to implement new strategies that facilitate the development of problem-solving skills and the growth of understanding mathematically in students (Munayco and Solís, 2021).

Reason why the objective of this research is to explain how methodological strategies strengthen mathematical activities for secondary school students, because students need new changes in the traditional learning model, new learning methods should be applied in class meetings to create a more active and effective learning process, The role of the teacher should be to guide, guide and direct the introduction of new teaching strategies in the classroom, which will improve the education in which we find ourselves. (Gutiérrez. 2017) allowing students to learn to think mathematically, to propose strategies to solve specific situations, identify principles, laws, operations and categories, all in a collaborative way, developing mathematical knowledge and its practice, inside and outside the classroom (Patiño et al., 2021). Problem solving must be applied with flexibility, taking into account the reality of students, cognitive abilities and abilities to obtain favorable results concretized in school activities, which allow them to face specific situations at a social and professional level, for this it is necessary to take into account mathematical processes such as reasoning, representation, modeling, connection and communication that facilitate problem solving and therefore it is considered essential that teachers encourage them in the classroom. (Patiño et al, 2021) Mathematical problems must have not only algorithmic processes, but also intellectual and cognitive difficulties, with motivating characteristics and relevant to the real and social contexts of the learners. In addition, a mathematical problem must be solved or approached in different ways or solved by a different method, as the case may be, emphasizing that problem solving is seen as a fundamental aspect of teaching and learning mathematics. (Villalobos, 2008, cited by Gamarra and Pujay, 2021).

We must take into account that this work arises through a bibliographic review, which are in valid and reliable databases such as: Scopus, Redalyc, Scielo, Proquest, among others. The study will address the theoretical support of mathematical competences, concept of problem solving, metacognition, flexibility, mathematical processes, and technology as a resource for problem solving.

2. Methodology

The purpose of this study is to explain how methodological strategies strengthen the resolution of mathematical problems in students of the secondary level, from the bibliographic review, which consists of a systematic, retrospective and observational research methodology that selects, analyzes, interprets and discusses theoretical positions, results and conclusions, contained in scientific articles published in recent years on a topic selected for Obtain relevant information that contributes to the solution of a problem. (Fuster, 2020) Systematized reviews provide a rigorous and systematic framework for conducting literature reviews (Codina, 2018)

Different information search strategies were used in the exploration of documents by keywords: processes, strategies, stages, metacognition, flexibility, problem solving and technology; published between 2011 and 2022, found in the databases Google Scholar, Scopus, Redalyc, Scielo, Proquest, Oaji, Doaj, Latindex, and Dialnet. The keywords searched were the following: "solving mathematical problems", in English; "Solving mathematical problems" in Spanish. "metacognition", in English "metacognición" "processes in solving mathematical problems", in English; "Processes in problem solving" in Spanish. "Problem resolution", in English; "Solving problems in Spanish" "resolução de problemas matemáticos" in Portuguese; Solving mathematical problems in Spanish. The articles taken into account belong to the following countries such as Brazil, Colombia, Cuba, Chile, Ecuador, Spain, United States, Holland, Indonesia, Peru and Venezuela; Likewise, the publications in English selected were 3, 6 in Portuguese and 40 in Spanish.

The process resulted in 65 research articles that were found relevant, submitted to a selection through a table of validity and bibliographic reliability taking into account the following indicators: What are the results or conclusions of the research? The results can be trusted. Why? Results are relevant or applicable in the problem area being addressed. Leaving in the end 49 selected documents representing 75.38% of the total. From the documents that were selected, the most notable data were extracted to answer the questions raised in the table of validity and reliability. The exclusion criteria were: no search keywords, no rigorous scientific methodology, no results, no discussions and no conclusions.

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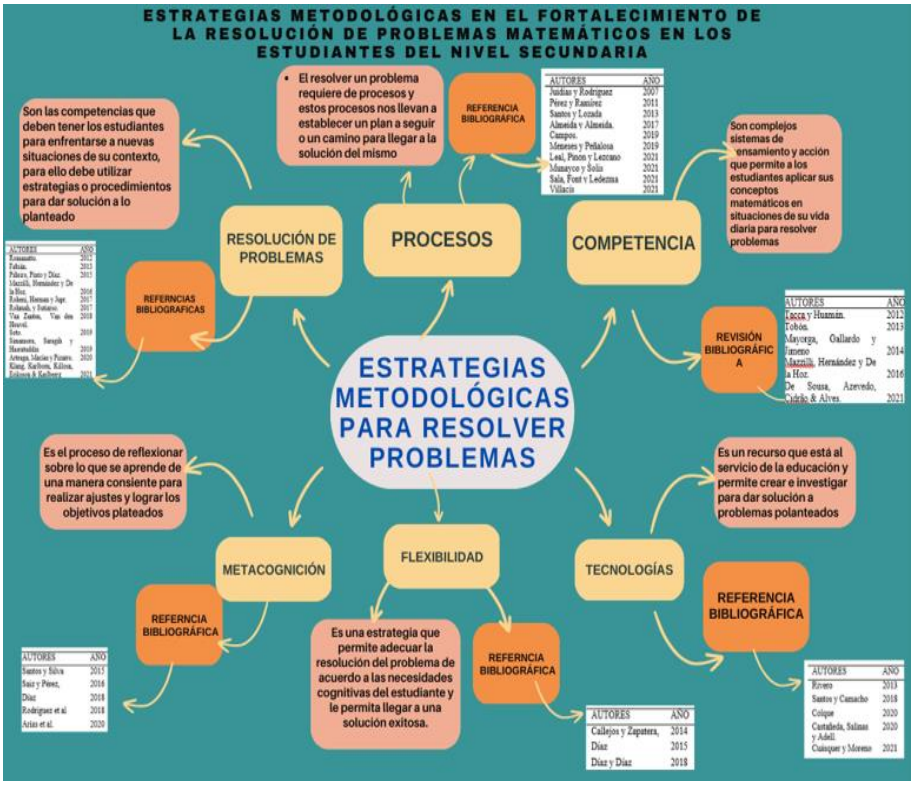
3. Development, Results, and Discussion

At this stage, ascheme is presented that includes in a general way, the documents selected to respond to our dimensions. It is divided by author, type of documentation, search strategy and database; The topics to be addressed are competence, problem solving, metacognition, flexibility, problem-solving processesand technology.

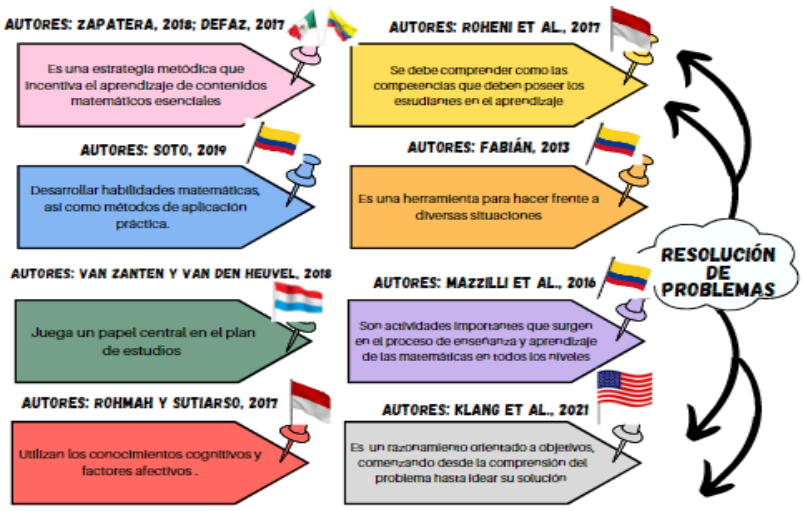


C webegin by approaching the definition that is a competence, there are many authors who define what a competence is and there are others that complement this definition for this we present a scheme to give us an idea of the concepts, authors and year, which were used for this definition:

To develop the problem-solving process we must take into account the definition of competence that are understood as complex systems of thought and behavior, which include combinations of knowledge, attitudes, skills, feelings and values that are used to understand and apply them in their professional, social and personal lives. (Tacca, 2012 and Sousa et al., 2021) It is also comprehensive and requires the teacher's ability to deal with specific and unusual situations that arise in the classroom context. (Mayorga et al., 2014) One of the mathematical

competencies is problem solving, which allows students to strengthen their ability to apply mathematical knowledge in their daily lives, implement mathematical reasoning processes, effectively use available resources and strategies and solve problems in different situations. (Mazzilli et al., 2016). In the process of developing mathematical competences, teachers and students must demonstrate that their competences are progressing and mobilizing; This is verified when students face mathematical activities with increasingly complex tendencies and develop affective and cognitive processes; bringing into play skills and socializing these mathematical skills in school and extracurricular contexts. (Garcia et al., 2015) For them to be approached as they should be, mathematics teachers need to be trained to solve basic educational problems of mathematical competencies that are present in the development of their classes (Godino et al., 2017). Two fundamental aspects are highlighted: purposeful learning is when the student relates the newly acquired knowledge with the previous knowledge in his mind, but not mechanistically, but in a rational associative way, that is, in a logical sense (representative, conceptual, hypothetical) and comprehensive learning occurs when socially significant and adaptive behavioral changes are developed and implemented by language, from an individual's response to things or events. (Tobón, 2013) Therefore, we can say that mathematical competence is complex systems of thought and action that allows students to apply their mathematical concepts in situations of their daily life to solve problems; For this, the teacher must be prepared using the appropriate strategies with the necessary resources.

Competition leads to the development of *problem solving* and let's see how it is defined by several authors who take it into account



Problem solving is a methodical strategy that encourages the learning of essential mathematical content and promotes the development of skills and abilities that will be useful to students in their day to day. (Zapatera, 2018; Defaz, 2017) It is also a comprehensive and complex activity that requires training, activities, solutions and special procedures to develop mathematical skills, as well as methods of practical application. (Soto, 2019)

Problem solving plays a central role in the curriculum and is situated at the heart of the Mathematics Curriculum (Van Zanten and Van den Heuvel, 2018); is considered as the interaction between knowledge and errors of the application process that use cognitive knowledge and affective factors in problem solving (Rohmah and Sutiarso, 2017) should be understood as the competencies that students must possess in learning, who are expected to be able to build a new knowledge of mathematics in other situations, implement and adapt many different strategies to solve, monitor and reflect on the process (Roheni et al., 2017), for this the local culture must be integrated into the learning of mathematics to maximize their achievements (Simamora et al., 2019)

It is also defined as an integral part of learning that requires progressive development using methods, procedures and attitudes that promote the acquisition of skills by students. (Soto, 2019; Romanatto, 2012). It should therefore be considered as a tool for dealing with various situations, which, among other important functions, performs functions that provide direct experience of phenomena; allows abstraction to be confronted with reality (Fabián, 2013), and it must also be taken into account that it is one of the important activities that arise in the process of

teaching and learning mathematics at all levels; The content makes sense when students correctly understand and relate mathematical operations to solve various significant situations in their daily lives. (Mazzilli et al., 2016)

We must take into account that it is a matter of goal-oriented reasoning, starting from understanding the problem to devising its solution using known mathematical models (Klang et al., 2021). That is why problem solving is research, science, education; presenting every concept, every nuance that education experts or academics should know; Only in this way will it be able to occupy its rightful place and what it needs in the various fields in which it has scope of work to make its contribution. (Piñeiro et al., 2015). Therefore, we can say that problem solving are the skills that students must have to face new situations in their context, for this they must use strategies or procedures to solve what is raised.

When we talk about strategies we refer to the set of mental actions that the student performs to reach the solution of a problem. Among the strategies to take into account is metacognition, let's see how some authors define it:

Making use of metacognitive strategies allows them to analyze, discuss and solve the problems they face (Santos and Silva; 2015) this process is reflected in the critical awareness of individuals about how they think and learn, as well as in their evaluation as thinkers and learners; It is facilitated through problem-based learning activities that require peer collaboration and encourage students to work in a new environment to apply what they have learned. (Rodriguez et al., 2018) Cognitive conditioning is related to procedural knowledge, that is, metacognitive control strategies (planning, monitoring and evaluation) using a strategy to solve a problem. (Saiz and Perez, 2016) In addition, we can say that it involves the process of reflecting on the information you receive so that you can organize and judge, according to your criteria, the best way to achieve the objectives; in turn decision making, so it is always a conscious and deliberate reflection that the student plans and makes adjustments to achieve objectives or move them towards the achievement of their learning (Arias et al., 2020) It is also considered as evaluating ways to develop solutions and plans, allowing teachers to use indications to stimulate reflection and critical thinking, For example: Does the result make sense? Why? Is it possible to test the solution? How to do it? Is it possible to solve the problem in less time? What other result can this route produce? How do I get to the solution route? (Diaz, 2018). It also allows students not only to assess their understanding and application of concepts and processes, but also to investigate and analyze the metacognitive strategies they use when faced with problematic tasks. (Arteaga et al., 2020) Therefore, we can define metacognition as the process of reflecting on what is learned in a conscious way to make adjustments and achieve the silver objectives.

Flexibility is taken as a strategy to solve problems, let's take into account how they define it:

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It is the combination of two elements: the knowledge of various solving processes and the ability to know how to choose the right method to solve unknown problems or to find the best solution for other problems with which the student is not familiar. (Star, 2001, cited by Negrete, 2013), is also a modification of the strategies used to solve problems when cognitive needs change. (Callejos and Zapatera, 2014). For the development of the flexibility of mathematical thinking, a quality that guarantees the successful search for problem solutions, it must be taken into account as a support for the development the realization of logical conclusions from the data of the problem, to the extent that logically an organized knowledge is obtained, it is more likely to explore different ways of solution. (Diaz, 2015) Depth, breadth, self-criticism and flexibility of thought characterize the attempt to summarize the mathematical way of thinking, focusing on the competencies necessary for mathematical activity, regardless of the knowledge used. (Díaz and Díaz, 2018). We can say that flexibility is a strategy that allows adapting the resolution of the problem according to the cognitive needs of the student and allows him to reach a successful solution.

The process to solve problems is considered as strategies Let's see how the authors define it:

Processes are articulations of practical sequences that take place over time to solve problems, definitions, procedures and arguments; and they occur through communication, problematization, definition, procedures and argumentation. (Sala et al., 2021), Most authors take as reference the processes carried out by Polya which are:

First process: Understand the problem (Students must fully understand what they are being asked before taking any action to find the solution. Answer the following questions such as: What are you being asked to find? What data do you have? What conditions does it present? Is the condition sufficient to determine the unknown? It's not enough? contradictory? It is critical in this process to determine whether the problem contains the data needed to resolve it.

Second process: Make a plan using your knowledge, imagination and creativity to develop a procedure that allows you to find the solution or solutions necessary to solve the problem, it is important that students answer the following questions Have I encountered a similar problem? Did I see the same problem posed in a slightly different way? Do I know of any problems related to this? Can I define the problem differently? Can I say it in my own words?

Third process: Execute the plan (students must implement a chosen strategy to solve the problem completely. The author recommends allowing a reasonable amount of time to implement the plan.

Fourth process: Look back (they are given the opportunity to review their work and make sure they did not make mistakes, they can be directed with questions such as: Is your solution correct? Does your answer comply with the problem? Can you figure out how to extend your solution to a general case?) If students consciously and carefully use each previous step when solving a problem, they will learn how to design and implement the strategies that will enable them to succeed. (Polya, 1981, cited by Meneses and Peñalosa, 2019)

On the other hand, there are the processes of Wallas: Process 1: Preparation (including awareness and analysis of the situation, as well as all the circumstances and aspects that affect it. It is a moment of great emotion where the person is motivated to investigate, analyze and experiment with the different possibilities to solve the problem). Process 2: Incubation (it is the essence of the problem, it is an internal and unconscious process, it involves the establishment of new relationships). Process 3: Lighting (at this stage the solution appears unambiguously, that is, when everything is logical, coherent and clear) and process 4: Verification (at this stage the solution is adopted) (Wallas, cited by Pérez and Ramírez, 2011). We have Mayer who states: Representation of the problem (transforming the problem into a representation of the inner mind. It consists of two stages: a) Translation: the ability to transform each proposition of the problem into a mental representation, expressed by means of a mathematical formula. b) data integrity: it assumes a specific knowledge of different types of problems, based on a suitable scheme for that problem). Problem solving (presenting a solution plan that includes: a) Planning: Finding strategies to solve it. b) Execution: Implementation of the activities and actions designed) AND verification. (Mayer 1991, cited by Juidías and Rodriguez, 2007)

Likewise, Schoenfeld takes into account the five processes that allow solving and checking a problem: within the first process, it focuses on analysis and understanding through frequent exploration to discover facts and unknowns and reorganize problems to reduce complexity.

The second process has the purpose of developing a plan of the calculations to be carried out. The third process is exploratory, allowing you to analyze different types of decisions when the plan in the second process is not clear. In the fourth process, the operations are resolved, and in the fifth process, the solution and relevance are checked. (Schoenfeld, 1994 cited by Villacís, 2021), some also specify that one should only go through processes that are: orientation, execution and control, not absolute.

In the process, the student should be able to understand the problem, find and implement a way to solve it, check the correctness of the solution obtained and how to use it, so that he becomes familiar with the problems, so that he is aware of the ways of thinking (strategy) and working on similar tasks. (Almeida and Almeida, 2017), The following should be taken into account:

Process 1. Become familiar with the exercise or problem. Process 2. Create relationships and dependencies. Process 3. Determine and establish the mathematical relationships necessary to solve the exercise. Process 4.

Determine the relationships and apply the necessary corrective measures to solve the problem. Process 5. Apply the most realistic procedure to solve the exercise. Process 6. Check the solution and rate the path of the solution used. (Fields, 2019)

In the same way, processes are also established such as: Logical language training: (debates, manipulation of concepts, communication with terms and symbols and work with representations of mathematical objects). Simulation, rationalization of resources for intellectual and practical work, formulation and resolution of problems (Leal et al., 2021), in the same way three processes are established that are understanding, invention and problem solving; Understanding is a necessary component in problem solving and creation, without which the process or establishment of relationships between knowledge to create problems cannot continue. Invention or creating mathematical problems brings benefits related to the achievement of higher levels of knowledge and greater motivation and creativity. (Munayco and Solís, 2021)

Similarly the processes of: planning (Internalizes and identifies the problem, recognizing where it wants to go; reflects on rules and conditions; determines what should be done first; is questioning about actions that will help in the task; seeks representations and means of organizing information according to symbols, diagrams, tables, or graphs; He tries to predict the consequences of actions and identify an action plan), monitor (reflects on how it has been done, verifies the actions he should remember, looks for what strategies he has used and how it could have been done, asks about the effectiveness of the solution strategy, reviewing his argument to find errors, builds ideas when he does not understand something, plans to direct their actions based on the errors found) and evaluate (reflects on how they carried out the process, recognizes the type of reasoning that has been used, analyzes how they can use reasoning to other problems, reflects on the best solution, compliance verification and the relevance of the applicable strategy. (Santos and Lozada, 2013). Then we could say that, given what was mentioned by the authors, solving a problem requires processes and these processes lead us to establish a plan to follow or a path to reach the solution of it.

In these times we must take into account technology in solving problems:

Technology plays an important role in supporting pedagogy and helps develop problem-solving skills. (Calle and Agudelo, 2019) It is also a field of knowledge that questions the complex relationship between people and technology in all areas of education and seeks answers of an educational nature. (Castañeda, Salinas and Adell, 2020), which opens the way between the science of education and its application to the solution of educational problems for the presentation, dissemination and access to information and knowledge in various educational contexts. (Area, 2009; cited by Rivero, 2013) The use of different digital technologies can provide students with different opportunities to analyze how to create and investigate problem statements, in the development of assumptions and relationships, in the search for supporting evidence, in the form of discussion and the results of communication. (Santos and Camacho, 2018) The use of technologies serves as motivation for students to actively engage in problem solving, creating new scenarios for the design, modeling and printing of 3D objects to learn

different contents of the curriculum in different areas and educational levels, focusing in a collaborative, inclusive, constructivist and coherent way. (Moreno et al., 2018) Reason why it is essential that teaching is more dynamic with the incorporation of technology according to the needs of students, where they can acquire new knowledge through exploration, research and play, where the teacher must be an intermediary or facilitator. (Thomes, 2019) Therefore, technology is a resource that is at the service of education and allows to create and investigate to solve problems raised.

4. Conclusions

First. - It is important and necessary to implement new teaching and learning strategies that facilitate the development of problem-solving skills and the growth of mathematical understanding in students, for this new learning methods must be incorporated to create a more active and effective process and the role of the teacher must be a guide, guide, facilitator to incorporate new teaching strategies in the classroom, which will allow the development of significant mathematical competences through problem solving.

Second. - Mathematical competencies is problem solving, which allows students to strengthen their ability to apply mathematical knowledge in their daily lives, implementing mathematical reasoning processes, effectively using available resources and strategies and solving problems in different situations, all this is verified when students face mathematical activities with increasingly complex tendencies and develop affective processes. and cognitive; bringing into play different strategies and socializing these mathematical skills in various contexts.

Third. - Problem solving is fundamental in the development of mathematical competence because it develops skills and abilities that all students must possess in their learning to understand, develop, implement and adapt new strategies to solve the situations posed through the evaluation and reflection of the process.

Fourth. – Metacognition is a strategy that allows the process of permanent reflection that the student carries out on the information he receives to organize, judge and make decisions according to his criteria of the best way to achieve the objectives in problem solving.

Fifth. - Flexibility is a strategy of mathematical thinking, which allows the successful search for different paths of solutions to problems that arise, modifying the strategies used to solve problems when the cognitive needs of students change.

Sixth. - The processes are articulated methodological sequences that allow to develop mathematical problems in an optimal way taking into account a series of definitions, procedures and arguments; and are given through communication, problematization, definition, procedures and argumentation.

Seventh. - Technology is a resource that allows students to analyze, create and investigate, motivating students to actively engage in problem solving, creating new scenarios for their learning in a collaborative, inclusive, constructive and coherent way.

Eighth. - This literature review article has allowed a thorough review of articles on various strategies to solve mathematical problems, where it was explained about competence, problem solving, metacognition, flexibility, mathematical processes as strategies and the support of technology as a resource to be able to develop problem solving in a fun way. In addition, it gives teachers and students to choose the most appropriate strategies to apply them in the processes.

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