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Pedagogical Practice and Problem Solving in Mathematics Teaching

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Abstract

The following study aimed to characterize the pedagogical practices and their relationship with mathematics teachers' problem-solving in thirteen educational institutions in the city of Cúcuta - Norte de Santander. The quantitative-descriptive paradigm oriented the methodology. The sample consisted of 80 teachers who guided the subject of mathematics in elementary and middle school. The research findings show that teachers make an important effort to ensure that students obtain significant mathematics learning, thus promoting logical thinking development.

Keywords: Mathematics Teaching; Elementary and Middle School Education; Pedagogical Practice; Logical Thinking.

1. Introduction

Over the years, education in its various levels has had unpredictable and decisive changes for the educational community since it constantly changes to the demands of society (Gamboa et al., 2020; Gómez, 2020; Gamboa, 2016). Therefore, this research attempts to analyze each of the dimensions that are immersed in the pedagogical practice of basic education teachers and, in particular, to inquire about the formulation and problem-solving since it is the teacher who is responsible for guiding this teaching and learning process and for enhancing all the resources found in the classroom so that students acquire

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mathematical skills and competencies that are significant for their future life (Pineda et al., 2019; Trujillo et al., 2019).

This is why problem-solving has been considered an important strategy for teaching mathematics to elementary and middle school students, since it promotes problem situations close to real life (Hernández et al., 2019; Duarte et al., 2018; Prada et al., 2017). In this sense, the importance of considering problem-solving as the central axis of school mathematics is highlighted since it is conceived as a primary activity that students carry out individually or in groups and where thinking processes are involved, such as the argumentation of the steps performed in the solution of a problem, communication, the use of various representations and the search for connections using an appropriate mathematical language in the results obtained (Prada-Núñez et al., 2020).

According to the National Council of Teacher Mathematics (NCTM), the student should achieve the construction of new mathematical competencies through problem-solving; therefore, problems should be formulated not only in the context of mathematics itself but should be posed transversally to other areas of knowledge, which allows the student to enhance the design, application, evaluation, reflection and search for strategies based on coherent solutions to the proposed problems as referred to in the research findings of Contreras et al. (2019) and Prada-Núñez et al. (2016).

Therefore, problem-solving is a matter of great importance for the advancement of mathematics and also for its understanding and learning (Alonso & Martínez, 2003). That is why in mathematics, one of the most important skills is doing, since the student develops the ability to think critically, refute, criticize arguments, validate proofs, use mathematical language with a certain fluency, and observe mathematical concepts in concrete situations. Nevertheless, enjoy the excellent learning path; the valuable thing is reaching the solution and the arduous path that leads to it (Prato et al., 2018; Ignacio et al., 2006).

In this same sense, it has been stated that doing mathematics is par excellence problem solving (Alonso & Martínez, 2003, p. 2). Throughout time, problem-solving has been studied by various philosophers such as Descartes and Dewey; Polya and Hadamard being great mathematicians and Greer, Bell and Fishbein as mathematics educators giving a characteristic approach to problem-solving research; therefore, problem-solving is not a new trend, since ancient times various scientists have emphasized in understanding and teaching the skills needed to solve mathematical problems. For this reason, problem-solving is conceived as one of the most important methodological strategies for understanding mathematical content.

Now, although students indeed develop mathematical knowledge through problem-solving that great scientists have proposed throughout history, since 1945, this activity has become very important, thanks to the work of Polya (1945), who distinguished four fundamental stages for problem-solving: understanding the problem, designing a plan, executing the plan and examining the solution obtained. He also proposes the existence of two types of problems: routine and non-routine. Likewise, another mathematician who devoted himself to the study of problem-solving was Alan Schoenfeld, who deepened and complemented Polya's work (Rojas & Del Rosario, 2020). He proposes four dimensions to solve problems: mathematical knowledge domain, cognitive and metacognitive strategies and belief systems. Therefore, it is in this sense that we say that students develop mathematical processes as they solve problems obtaining great skills to discover the appropriate strategies in the various types of problems, allowing the development of new mathematical understandings that will serve them throughout their lives in the solution of conflicts not only in this area (Rincón-Ramírez, 2017; Pérez & Ramírez, 2011).

In short, mathematical processes and especially problem-solving are important for education because through them, a quality society is formed, where each individual can develop skills and abilities such as thinking and arguing critically and intellectually. Therefore, teachers must know how to cover both mathematical content, as well as how to learn and use that content. It should be emphasized that each of the mathematical processes (Problem Solving, Reasoning and Proof, Communication, Connections and Representation) are indispensable since they help interpret and use diverse contents in meaningful contexts for students. Likewise, this research intends to lead teachers to perform an analysis and reflection of their pedagogical practice at different moments (before, during and after class); with the purpose that teachers make a change in their mind regarding their preparation and updating since this somehow affects the academic performance of students (Patiño et al., 2021; Prada et al., 2021).

In addition, this research benefits teachers of basic education institutions since this project is collecting important information about the pedagogical practices of teachers from different educational institutions and the results may improve the practice of these teachers, generating better academic performance in their students and managing to combat illiteracy and the high dropout rate. Likewise, the improvement in school performance is expected to be evidenced in the SABER 11 tests, offering a greater possibility of access to higher education. In short, this research offers to become aware of the importance of the teacher in this process and of the mission that entails that the teacher integrally forms the students, that is, that the teacher is not conceived as a process and teaching machine but as a human being who guides a process and interacts with other human beings.

2. Method

The present research is located in the quantitative approach, at a descriptive level with a field design, because it is intended to capture the perception of practicing teachers through a descriptive level report of each of the variables considered in our research.

Population and sample

The population is made up of all teachers working in 13 public and private educational institutions in the city of Cúcuta and its metropolitan area in Colombia, from which a non-probabilistic sample of 80 teachers was obtained under the purposive sampling technique whose inclusion criterion was that they were teaching mathematics and that they wished to be part of the sample.

2.2. Instruments

The technique used to obtain the data in this research was a questionnaire. The instrument used was a questionnaire divided into three sections: the first of general information, the second of the affective domain towards mathematics, and the third section included the items on Mathematical Processes in Teaching Practice. The following variables are presented in this paper:

2.2.1. Mathematical processes (items associated with the formulation and resolution of problems)

It consists of a nine-item questionnaire, all rated on a Likert scale with five levels of frequency of occurrence, from 1 for Never to 5, which corresponds to Always.

2.2.2 Teaching practice

Like the previous one, it is a questionnaire composed of 44 items distributed as follows: 11 items associated with class planning and preparation, 8 items related to learning environments and 15 items related to pedagogical practice. They were also evaluated with a Likert scale of five acceptance levels.

3. Results and discussion

The study of mathematical processes has sought to understand, from different authors or organizations, the presence or absence of these processes in both teachers and students of basic education, as well as to seek strategies to enhance them and create tools to support teaching and teacher training.

In the conceptual and exploratory tour that has been made of each of the mathematical processes, it has become evident that problem-solving has undoubtedly been one of the most required and necessary in mathematics education.

The statement of a problem involves the immediate context in which the mathematical task acquires meaning in those situations of daily life, being significant for students. So it is important to achieve that through problem-solving, the student can build new concepts and mathematical learning, where problem-solving can be applied in their context and be a tool to solve situations of other kinds.

One of the best tools that mathematics teachers have is to apply problem-solving in the meetings, since in the face of so many enigmas in the area, it is necessary to look for viable solutions where children and young people make incursions, with sense in the realization and solution of real situations, as indicated, that is, human beings live in constant situations that make it necessary to seek alternative solutions that lead to a result either positive or negative.

Therefore, based on the information provided by the mathematics teachers surveyed, this research analyzes and interprets the results obtained using the SPSS v25 program, applying to cross tables, and in them, the relationship between the various items of the constructs problem-solving and pedagogical practices. Some of the tables are presented below and their results are analyzed.

Table 1. In class, he poses problem situations using different types of support (oral, with parallel analogies, with manipulative or concrete material to work on, or pictorial material) vs. When designing learning activities, he considers the diverse learning rhythms of his students.

		When designing learning activities, consider the diverse learning paces of your students.		Total
		Sometimes	Always	
In class, pose problem situations using different types of support (oral, parallel analogies, manipulative or concrete material to work on, or pictorial material).	Few times		2,8%	2,8%
	Sometimes	2,7%	8,2%	11,0%
	Always	5,5%	80,9%	86,3%
Total		8,2%	91,8%	100,0%

According to the relationship between pedagogical practice and problem-solving, it can be observed that approximately 81% of the surveyed teachers affirm that in mathematics classes, they always pose problem situations using different types of support (oral, with parallel analogies, with manipulative or concrete material to work on or pictorial material), promoting meaningful and constructive learning. They also recognize the importance of designing activities that consider the students' learning pace and their tastes for the subject.

The strategies teachers propose in their classes must carry out and propitiate influential spaces in a person's daily life. Depending on these, students become interested and feel various emotions that will allow true learning and the development of mathematical competencies (Wiggins, 2011).

Mathematics is a complex science that needs good practices and meaningful experiences that lead the student to be competent for life. For this reason, the following is an observation of the relationship that exists between the problem situations that the teacher poses using different types of support (oral, with parallel analogies, with manipulative or concrete material to work on, or pictorial material) and the planning of the activities considers the particular needs of the students.

Table 2. In class, he poses problem situations using different types of support (oral, parallel analogies, manipulative or concrete material to work on, or pictorial material). When designing learning activities, he considers the particular needs of his students.

		When designing learning activities, consider the particular needs of your students.		Total
		Sometimes	Always	
In class, pose problem situations using different types of support (oral, parallel analogies, manipulative or concrete material to work on, or pictorial material).	Few times		2,8%	2,8%
	Sometimes	6,8%	4,1%	11,0%
	Always	6,9%	79,5%	86,3%
Total		13,7%	86,3%	100,0%

Analyzing the cross table, it is observed that approximately 80% of the surveyed sample has a correct organization both in the challenging situations they present to the students and in knowing the needs and learning pace of each one of them, where, based on the observation and knowledge of the person, the teacher can design, create and plan meetings and activities that allow reflecting real learning applied to real life.

Mathematics teachers have an arduous task, not only to teach the area but also to adapt to the needs of the population being educated. Analyzing another aspect regarding the practice about problem-solving, there is an aspect on the importance of knowing how to plan and that in such planning, all aspects that include teaching and learning are reflected; among them is the question of knowing what is expected that the student learns, that is, in addition to answering how, when, we must also have clarity about what children and young people should learn, as shown in the following table.

Table 3. Problem situations in class using different types of support (oral, parallel analogies, manipulative or concrete material to work on, or pictorial material) vs. When planning lessons, he identifies exactly what he expects his students to learn.

		When planning lessons, identify exactly what you expect your students to learn.		Total
		Sometimes	Always	
In class, pose problem situations using different types of support (oral, parallel analogies, manipulative or concrete material to work on, or pictorial material).	Few times		2,8%	2,8%
	Sometimes		10,9%	11,00%
	Always	2,7%	83,6%	86,3%
Total		2,7%	97,3%	100,0%

Approximately 97% of practicing teachers showed in the planning construct that they understand the importance of setting objectives and being clear about what the student should learn. However, at the same time, they understand that what they learn should serve them to apply it in their lives and put it into practice in different situations that arise daily, thus making learning indispensable for life.

Table 4. Contextualizes problem situations to the student's daily life vs. When in the class he/she must expand explanations, he/she uses examples related to the student's interests or previously seen topics.

		When the class needs to expand the explanations, use examples related to the students' interests or previously seen topics.		Total
		Sometimes	Always	
Contextualizes problem situations to the daily life of students	Few times	1,4%		1,4%
	Sometimes		9,6%	9,6%
	Always	12,3%	76,7%	89,0%
Total		13,7%	86,3%	100,0%

Starting from another evaluated aspect, it can be inferred that approximately 86% of the teachers choose in their classes to expand the explanations, implementing examples related to the student's interests or with previously seen topics. That is, they give value to what we can call feedback; in this sense, it is affirmed that the feedback before, during and after the classes are significant spaces both for the student and for the teacher, where the latter adjusts his teaching strategies, manages to break down the conceptions and allows the student to analyze every detail and develop his logical thinking.

Opening spaces for dialogue and questions in the meetings are strategies that teachers can propose when including and promoting research and participation. For this reason, the following is an analysis of the

relationship between solving mathematical problems and applying inquiry techniques to promote personal and social development meetings.

Table 5. Questions encourage investigation and exploration to solve a mathematical problem vs. use inquiry and discussion as techniques to deepen student understanding.

		Makes use of inquiry and discussion as techniques to deepen student understanding		Total
		Sometimes	Always	
Asks questions that encourage investigation and expropriation to solve a mathematical problem.	Sometimes	6,8%	13,7%	20,5%
	Always	9,5%	69,8%	79,5%
Total		16,4%	83,5%	100,0%

From Table 5, it is observed that approximately 10% of practicing teachers, although they usually ask questions to encourage research, sometimes allow discussion either among peers or between students and teachers; therefore, it is evident that more preparation is needed in the investigative part of mathematics teachers, since despite being the inquiry and discussion an excellent technique for student understanding, not always its objective revolves around this purpose.

Table 6. Questions that encourage investigation and exploration to solve a mathematical problem vs. The questions presented to students to invite them to formulate hypotheses, make connections, or challenge previous ideas.

		The questions you present to your students invite them to formulate hypotheses, make connections or challenge previous ideas.			Total
		Few times	Sometimes	Always	
Asks questions that encourage investigation and expropriation to solve a mathematical problem.	Sometimes		6,8%	13,6%	20,5%
	Always	2,7%	6,8%	69,8%	79,5%
Total		2,7%	13,7%	83,6%	100,0%

In the planning construct, it was evidenced that approximately 70% of the teachers surveyed ask questions to their students to encourage research and exploration through mathematical problems, whereby they formulate hypotheses and make connections. Thus, their mathematical thinking is strengthened.

It is an arduous task for the teacher-researcher to ignite this flame in students since mathematics is a broad field. The resolution and formulation of problems are one of the general processes of mathematical activity, which is of great significance in the student's knowledge. Because of this, teachers must deepen and ask relevant questions for teaching and treatment in the classroom since this is a process that generates fear and apathy toward mathematics.

Table 7. Promotes discussion around problem-solving strategies and the validity of the results obtained vs. using inquiry and discussion as techniques to deepen student understanding.

		Makes use of inquiry and discussion as techniques to deepen student understanding		Total
		Sometimes	Always	
Promotes discussion of problem-solving strategies and the validity of the results obtained.	Sometimes	4,1%	4,1%	8,2%
	Always	12,3%	79,5%	91,8%
Total		16,4%	83,5%	100,0%

Analyzing the cross table, it is observed that approximately 12% of the surveyed population always promotes discussion around possible solutions or strategies for problem-solving, observing the results obtained to corroborate their validity. This allows to say that teachers sometimes use inquiry and discussion as pertinent techniques to corroborate the student's understanding. Therefore, it is evident that few teachers are not aware of the importance of inquiry as a strategy for deepening and research, where through dialogue, experiences, ideas and possible solutions for problem-solving are shared (Salamanca & Hernández, 2018).

Table 8. Proposes situations in which he/she has too much or too little information so that students must propose the questions vs. Occasionally, he/she does not provide all the information available to encourage students to think for themselves.

		Occasionally, it does not provide all available information in order to encourage students to think for themselves.			Total
		Few times	Sometimes	Always	
Proposes situations in which there is too much or too little information, so that students must provide the questions.	Few times		4,1%	2,7%	6,8%
	Sometimes		9,6%	8,2%	17,8%
	Always	8,3%	20,5%	46,6%	75,3%
Total		8,2%	34,2%	57,5%	100,0%

The table shows that about 8% of the teachers always propose problem situations in which information is missing so that the students propose questions, but they rarely do it to encourage the students to think for themselves. Therefore, it is evident that some teachers think about grading and knowing how attentive their students are but not about encouraging them and pushing them to be autonomous in their academic formation.

With each of these situations, students are expected to develop skills for the understanding and studying mathematics, which are associated with aspects of mathematics, i.e., everyday situations in which problem-solving is immersed.

Table 9. Proposes situations in which students have too much or too little information so that they must propose the questions vs. Motivates students to express their points of view through appropriate language.

		Motivates students to express their points of view through the use of appropriate language.			Total
		Few times	Sometimes	Always	
Propose situations in which you have too much or too little information, so that the students must propose the questions.	Few times		2,7%	4,1%	6,8%
	Sometimes		1,4%	16,4%	17,8%
	Always	1,4%	4,1%	69,8%	75,3%
Total		1,4%	8,2%	90,4%	100,0%

Starting from another aspect, it can be inferred that approximately 70% of the respondents always motivate their students to express their points of view using appropriate language through situations in which information is over or missing in order for them to propose questions. Therefore, it is evident that most of the teachers surveyed approach the teaching of problem-solving as a great challenge in education since it is not a matter of looking for a meaningless problem or transforming routine problems but requires a transformation of evaluation strategies, methods and conceptions.

Table 10. Allow students to invent their problems and motivate them to solve them in class vs. Observe what students write or the questions posed by them to evaluate whether further activities or explanations.

		They observe that students write down the questions they pose to evaluate whether further activities or explanations are needed.			Total
		Few times	Sometimes	Always	
Allows students to invent their own problems and motivates them to solve them in class	Few times		1,4%		1,4%
	Sometimes		5,5%	10,9%	16,4%
	Always	1,4%	10,9%	69,9%	82,1%
Total		1,4%	17,8%	80,9%	100,0%

Analyzing the cross table, it is observed that approximately 70% of the teachers surveyed always allow students to invent their problems and motivate them to solve them in class. In the same way, teachers

observe the questions posed by students to evaluate whether it is necessary to expand the explanations or activities to encourage their mathematical thinking. This is why, to learn to solve mathematical problems, students should enhance their ways of thinking, their curiosity and confidence in the explorations of those unknown situations. This will improve their mastery of similar situations by taking a reflective, methodical, critical, and self-critical attitude in each of the eventualities of the work, social, family and school environment. Now, it is necessary the constant updating by the teacher for the theoretical and methodological foundations of problem-solving, facilitating the student teaching of this in order to pose problems that have a good structure, which invites them to reason, create and discover in order to reach the solution.

From the above analysis, it can be deduced that the mathematical process of problem-solving and the implementation of this in teaching practices allows students not only to understand mathematical concepts but, in turn, these can take them to real-life situations, to avoid routine mathematics classes, little impact and the classroom environment becomes unmanageable (Hernández Suárez et al., 2021).

4. Conclusions

After the analysis and study of the pedagogical practices of a non-probabilistic sample of teachers in the area of mathematics of public and private institutions of Cúcuta and its metropolitan area, through the application of the survey to teachers where the categorization and interpretation of the information are prioritized, several results were obtained which allowed the researcher to reach the following conclusions.

The presence of mathematical processes in teachers' pedagogical practice was determined, observing that a good percentage of them encourage students to solve and formulate mathematical problems.

In the analysis of the results, it became evident that teachers strive to ensure that students obtain significant learning in mathematics, thus encouraging the development of logical thinking. For this reason, teachers carry out activities attractive to students, enriching their knowledge and ability to transform problems based on their daily lives, for example.

It was observed that teachers motivate students to think for themselves, making them invent problems and develop skills for the understanding and study of mathematics.

As educators, we must understand that problem-solving is not only an end to teaching mathematics but the essential means to learning. Through the teaching of problem formulation and solving, students will be able to explore, analyze, solve and evaluate the whole context that surrounds them. In the same way, it can be stated that problem-solving is a valuable didactic strategy that can be addressed in all subjects, and in addition, the content of each problem can refer to any discipline or the context of each student (Hernández-Suarez et al., 2022).

Finally, it can be concluded that few teachers do not address the formulation and resolution of problems in mathematics teaching.

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