Research Article

Received: 1 August 2024 / Accepted: 23 October 2024 / Published: 05 November 2024

Effectiveness of an Educational Program in the Development of Mathematical Competencies in Peruvian Elementary School Students

Jhemy Quispe-Aquise[1]

Edwin Gustavo Estrada-Araoz[1*]

Roger Calsin-Vilca[2]

Yasser Malaga-Yllpa[2]

Osbel Mora-Estrada[2]

Marceliano Arias-Jalire[1]

[1]*Universidad Nacional Amazónica de Madre de Dios, Puerto Maldonado, Perú*
[2]*Universidad Andina del Cusco, Puerto Maldonado, Perú*
**Corresponding Author*

DOI: https://doi.org/10.36941/jesr-2024-0160

Abstract

The present research aimed to determine the effectiveness of an educational program in the development of mathematical competencies in Peruvian elementary school students. The research adopted a quantitative approach, the design was experimental, and the type was quasi-experimental. The sample consisted of 102 students enrolled in the third grade of elementary education in a Peruvian public educational institution. An educational program based on playful strategies was developed and a questionnaire was applied to evaluate its effectiveness. The results show that, in the pre-test, most of the students in the experimental group were at the "beginning" level (90.2%). However, in the post-test, most were at the "expected achievement" level (51%). Regarding the control group, during the pre-test, most were also at the "beginning" level (88.2%), However, in the post-test, although there was a slight improvement, most remained at the same level (82.4%). Finally, it was concluded that the application of an educational program was effective in the development of the mathematical competencies of Peruvian elementary school students.

Keywords: *Didactics; playful strategies; pedagogical innovation; mathematics; active learning*

1. Introduction

The teaching of mathematics faces numerous challenges in the current educational context (Vera et al., 2023). Often, this subject is perceived with rejection, fear, or apathy by students, which contrasts with the small group that enjoys it due to stimuli, motivation, or its relationship to everyday life

(Quispe et al., 2024). In addition, the inadequate implementation of teaching strategies and techniques by teachers contributes to negative results in student learning (Lugo et al., 2019). Similarly, the excessive and inappropriate use of technologies has also reduced the application of playful materials, essential for effective learning (Pérez & Moraima, 2022).

The results of student performance in mathematics, measured through the Program for International Student Assessment (PISA), show that in Latin America only countries such as Guatemala, Paraguay, and the Dominican Republic have improved learning, while Peru, Mexico, Uruguay, and Costa Rica have worsened in 2022 compared to 2018. Peru, in particular, has faced considerable challenges to improve the results of its students. For example, in science, the score was 408 in 2022, four points more than in 2018; in reading, 408 was obtained in 2022, seven points more than in 2018. However, in mathematics, the results decreased from 400 in 2018 to 391 in 2022, nine points less, placing it below the OECD average of 472 points (Organization for Economic Cooperation and Development, 2022).

In Peru, the Ministry of Education monitors the progress of learning through census evaluations. The 2023 results in mathematics for the fourth grade of primary school were significantly lower than in 2019, with only 22.5% of students achieving satisfactory learning, a decrease of 10.7% compared to 2019 (Ministry of Education, 2024). The global pandemic has been one of the many factors that have negatively affected the development of learning, exacerbating educational gaps and limiting access to quality education (Chaverri, 2021).

In the city of Puerto Maldonado, Madre de Dios region (Peru), a low performance in the subject of mathematics has been observed. The national evaluation of learning achievements carried out in 2023 revealed that only 14% of students reached a satisfactory level, which represents a decrease of 6.1% compared to 2019 (Ministry of Education, 2023). This worrying trend highlights the need to implement effective educational strategies to improve mathematics performance in this region (Bautista et al., 2023). Factors such as family disintegration, economic problems, nutritional deficiencies, and the lack of parental support would negatively affect the development of learning. In addition, the lack of preparation of materials by teachers aggravates these challenges.

2. Literature Review

Currently, education is focused on teaching based on the development of competencies, seeking to enhance individual capacities considering the social context, value formation, and the well-being of society. In this sense, the Ministry of Education (2016a) conceptualizes competencies as a set of abilities, skills, and skills that allows people to achieve their goals in a real context, acting with ethical meaning. Thus, competencies imply a comprehensive education, which enables the individual to activate, articulate, mobilize, and combine knowledge in the exercise of his citizenship (López, 2016)
The competency-based approach provides a new significance to learning, developing reasoning and logical skills, and training students to solve problems in real contexts and making accurate decisions (Valderrama, 2021). This approach focuses on active and significant learning, where students not only acquire theoretical knowledge, but also learn to apply them in practical and real situations (Trujillo, 2014).

In the case of the mathematics area, this approach is particularly relevant. Mathematical competences include not only the ability to perform calculations and solve equations, but also the ability to interpret and analyze data, formulate and test hypotheses, and apply mathematical principles to a variety of real-world problems (Jiménez, 2022). This implies deep learning that goes beyond the memorization of formulas and procedures, promoting students a solid and functional understanding of mathematical concepts (emphasis & Clemenza, 2022).

The development of mathematical competencies in primary children is essential for their intellectual growth and success in various areas of life. These skills not only build a solid basis for logical thinking, problem solving and abstract reasoning, but are also essential in daily life (Gómez, 2019). It also facilitates informed decision making, improves the ability to handle practical situations

and contributes to successful academic performance. In addition, the early development of mathematical competences provides children with the necessary tools to face challenges in the modern era, preparing them for professional careers that require skills in science, technology, engineering and mathematics (STEM), and promoting essential analytical and creative thinking in the 21st century (Ramírez, 2022).

In Peru, the subject of mathematics involves the development of four skills: it solves quantity problems, solves problems of regularity, equivalence and change, solves data management problems and uncertainty and solves problems in form, movement and location (Ministry of Education, 2016a).

The competency of "solving quantity problems" implies a pedagogical approach based on the Peruvian national curriculum that advocates the direct connection between learning mathematics and authentic experiences for children. The underlying idea is that this active practice contributes positively to the construction of solid knowledge about numbers, operations and their properties (Ministry of Education, 2016b).

For its part, the competency of "solving regularity, equivalence and change problems" is associated with the generation of general rules, the identification of incognito values, and the formulation of hypothesis to understand the behavior of events or phenomena (Ministry of Education, 2016a). In the context of the resolution of algebraic problems, it is sought that students apply logical and reflective reasoning, incorporating estimate and automation to act with precision and order (Blanco et al., 2015).

In the case of the competency of "solving data management and uncertainty problems", it seeks to promote informed decision making, as well as the ability to make predictions and conclusions backed by specific data (Ministry of Education, 2016b). In the process of learning statistics, the emphasis should not be limited to the transmission of knowledge. Rather, it is about establishing direct connections with reality and context to enhance the student's cognitive understanding (Álvarez & Barreda, 2020).

As for the competency of "solving form, movement and location problems", it involves the teaching of forms (geometry) must focus on problem solving, maintaining a relevant connection with the context to achieve an effective construction of geometric learning (Fernández- Nieto, 2018). This competency covers a set of skills that include modeling, understanding and the use of argumentative strategies related to geometry (Ministry of Education, 2016a).

Now, to evaluate to what extent the students have developed and dominated the competences established in the curriculum, four levels of learning achievement (Ministry of Education, 2016a) have been determined:

- Start: This level indicates that the student has very basic and limited skills and shows difficulties to apply them autonomously.
- Process: At this level, the student demonstrates a partial understanding and an initial development of the necessary skills. Although you can apply some knowledge, it still requires support and supervision.
- Expected achievement: This level reflects that the student has reached the expected learning for their degree. It has adequate understanding and can apply knowledge and skills autonomously and in varied contexts.
- Outstanding achievement: At this level, the student has not only reached the expected learning, but also demonstrates a deep understanding and can apply their knowledge and skills in a creative and innovative way in various contexts.

One of the most effective ways to develop mathematical skills in primary education is through playful strategies, which are not only fundamental in the academic field, but also have significant applications in everyday life (Zulay, 2021). In order to respond to the educational problem associated with the teaching of mathematics, in this research an educational program based on recreational activities was applied.

This program proposed to improve the understanding of mathematical contents in third grade

students of elementary education through the use of concrete playful strategies and materials. These strategies are designed to make teaching and learning understanding, competitive and motivating, thus promoting interest in learning mathematics through the game. The application of recreational materials will allow children to automate and familiarize themselves with the construction of learning and mathematical thinking. Table 1 shows the issues and activities addressed during the development of the program.

Table 1: Organization of activities during the educational program

Organization of activities carried out during the educational program			**Mathematical competencies**			
			Dimensions			
Weeks	**Activities**	**Contents**	**D1**	**D2**	**D3**	**D4**
1	Multiplying with cards and dice	Multiplicative operations	**X**			
2	Abacuses	Additive operations	**X**			
3	Nest building game	Decomposition	**X**			
4	Tallest tower game	Equivalence	**X**			
5	More and less game	Change in magnitude		**X**		
6	Pattern race	Repetitive patterns		**X**		
7	Always rectangle	Decomposition		**X**		
8	Shape forming game	Shape relationships			**X**	
9	Reproducing geometric figures	Understanding shape elements			**X**	
10	Shape bank, involves recognition	Conventional and non-conventional measurements			**X**	
11	Shape board	Frequency with equivalence				**X**
12	Playing with Dice	Counting				**X**
13	Marble box	Simple frequencies				**X**
14	Roulette wheels	Sequences				**X**

The program includes recreational activities based on various development and learning theories. According to Piaget (1951), the game is essential for the cognitive development of children, since it allows them to explore and understand their environment. Vygotsky (1978) complements this idea by highlighting that the game is part of the next development zone, where children can practice more advanced skills with the help of others. Freire (1970), on the other hand, promotes the game as a tool for freedom and creativity, allowing children to be active in their own learning. Finally, Ausubel (1968) argues that learning is more effective when new knowledge is related to the previous knowledge of the student. In this context, the game facilitates this connection, making learning more significant and lasting.

The implementation of a program to develop mathematical competences in primary education students is essential to improve their academic performance and promote critical skills such as logical thinking and problem solving. Using concrete recreational strategies and materials not only makes learning more attractive and motivating, but also helps reduce anxiety and fear towards mathematics. In addition, this approach prepares students for future opportunities in fields related to STEM, closes educational gaps and promotes equity by providing all students, regardless of their context, the necessary tools to achieve high levels of mathematical competencies.

Finally, the objective of this research was to determine the effectiveness of an educational program in the development of mathematical competences in Peruvian students of Primary Education.

3. Methodology

3.1 Design

The research was characterized by following a quantitative approach, based on the collection of numerical data to identify behavior patterns in the study sample. Regarding its design, it was classified as experimental, since an educational program was implemented based on playful strategies (independent variable) to evaluate its effectiveness in the development of mathematical competences (dependent variable) of students. In addition, it was quasi-experimental type, since a pre-existing student sample was used, dividing them into two groups according to practical criteria (experimental and control group).

3.2 Population and sample

The population of the study was made up of a total of 789 students from a public educational institution in the city of Puerto Maldonado, Peru. From this population, a sample of 102 students were selected that were the third degree of primary education. The exhibition was divided into two groups: 51 students formed the experimental group, which received the intervention of the educational program based on recreational strategies, and 51 students formed the control group, which did not receive said intervention. This division allowed an effective comparison to evaluate the impact of the program on the development of mathematical competences.

3.3 Technique and instrument

The technique used was the survey, and the instrument used was an ad hoc questionnaire composed of 26 items distributed in four dimensions: quantity (7 items), regularity, equivalence and change (7 items), form, movement and location (6 items), and data management and uncertainty (6 items). The metric properties of the questionnaire were determined through procedures for validity and reliability. In that sense, after submitting the instrument to the judgment of experts, it was found that it had an adequate level of content validity (V of Aiken = 0.900). In addition, after performing a pilot test with the participation of 16 students, it was found that the questionnaire had an adequate internal consistency (KR-20 = 0.832).

3.4 Procedure

The investigation consisted of three stages. In the first stage, the procedures were carried out to obtain the necessary permits, which implied coordination with the management team of the focused educational institution. Once the authorization was obtained, the pre-test was applied, both in the experimental group and in the control group. The second stage focused on the implementation of the educational program, which was developed for 3 months and consisted of 14 learning sessions of 120 minutes each, using an active and playful methodology. Finally, in the third stage the post-test was applied in both groups in order to determine the effectiveness of the program.

3.5 Data analysis

Data analysis for this study used both descriptive and inferential statistics. In the descriptive part, frequency and percentages distributions were used, which were represented in tables to facilitate their interpretation. As for inferential statistics, the non-parametric U of Mann-Whitney was used to determine whether there were statistically significant differences between the experimental group and the control group with respect to the pre-test and post-test.

3.6 Ethical aspects

As for ethical considerations, this investigation was carried out following the principles established in the Helsinki statement. Each family father received an informed consent letter, in which the purpose of the investigation was explained and their voluntary consent was requested. In this way, it was guaranteed that students could participate in the application of the program and in data collection, both in the initial stage, during the execution of the educational program, and in the final stage of the research.

4. Results

Table 2 shows that, in the pre-test, 90.2% of the students of the experimental group were at the level of learning achievement "start", 5.9% at the "process" and 3 level, 9% at the "expected achievement" level. In the control group, the pretest results show that 88.2% of the students were at the "start" level, 9.8% at the "process" level and 2% at the "expected achievement" level. In the post-test, a significant improvement in the experimental group was evidence 17.6% reached the "outstanding achievement" level. In contrast, in the control group, 82.4% of the students continued at the "start" level, 17.6% reached the "process" level and none reached the levels of "expected achievement" or "outstanding achievement".

Table 2. Development of mathematical competencies during the pretest and posttest, according to the experimental and control groups

Levels of learning achievement	Groups							
	Experimental				Control			
	Pretest		Posttest		Pretest		Posttest	
	n	%	n	%	n	%	n	%
Start	46	90.2	0	0.0	45	88.2	42	82.4
Process	3	5.9	16	31.4	5	9.8	9	17.6
Expected achievement	2	3.9	26	51.0	1	2.0	0	0.0
Outstanding achievement	0	0.0	9	17.6	0	0.0	0	0.0
Total	51	100.0	51	100.0	51	100.0	51	100.0

Table 3 can see that there are no statistically significant differences between the experimental group and the control group before the application of the educational program (pre-test) ($p>0.05$). However, after the application of the program (post-test), statistically significant differences were found between the groups ($p<0.05$). That is, the experimental group showed results other than the control group. These data allow to affirm that the application of an educational program was effective in the development of the mathematical competencies of Peruvian students of elementary education.

Table 3. Results of the Mann-Whitney U Test in the experimental and control groups (pretest and posttest) regarding mathematical competencies

Statistics	Experimental group and control group (pretest)	Experimental group and control group (posttest)
Mann–Whitney U	1278.500	72.000
Wilcoxon W	2604.500	1398.000
Z	-0.274	-8.675
Asymp. Sig. (2-tailed)	0.784	0.000

Regarding the competence “solving quantity problems”, in Table 4 it is observed that, in the pre-test,

60.8% of the students of the experimental group were at the level of learning achievement "start", on 25, 5% at the "process" level and 9.8% at the "expected achievement" level. In the control group, the pre-test results show that 74.5% of the students were at the "start" level, 9.8% at the "process" level and 13.7% at the level "achievement expected". Now, in the post-test, a significant improvement in the experimental group was evidence 6% reached the "expected achievement" level and 72.5% reached the " outstanding achievement" level. On the other hand, in the control group, 49% of the students continued at the "start" level, 27.5% reached the "process" level, 15.7% reached the "expected achievement" level and only 7.8% reached the "outstanding achievement" level.

Table 4. Development of the mathematical competency "solves quantity problems" during the pretest and posttest, according to the experimental and control groups

Levels of learning achievement	Groups							
	Experimental				Control			
	Pretest		Posttest		Pretest		Posttest	
	n	%	n	%	n	%	n	%
Start	31	60.8	3	5.9	38	74.5	25	49.0
Process	13	25.5	1	2.0	5	9.8	14	27.5
Expected achievement	5	9.8	10	19.6	7	13.7	8	15.7
Outstanding achievement	2	3.9	37	72.5	1	2.0	4	7.8
Total	51	100.0	51	100.0	51	100.0	51	100.0

Table 5 shows that there are no statistically significant differences between the experimental group and the control group regarding mathematical competency of "solving quantity problems" before the application of the educational program (pre-test) ($p>0.05$). However, after the application of the program (post-test), statistically significant differences between the groups ($p<0.05$) were evidenced. That is, the experimental group showed results other than the control group. These data allow to affirm that the application of an educational program was effective in the development of mathematical competition "solves quantity problems" among Peruvian students of Primary Education.

Table 5. Results of the Mann-Whitney U Test in the experimental and control groups (pretest and posttest) regarding the mathematical competency "solves quantity problems"

Statistics	Experimental group and control group (pretest)	Experimental group and control group (posttest)
Mann–Whitney U	1152.0000	288.500
Wilcoxon W	2478.0000	1614.500
Z	-1.202	-7.117
Asymp. Sig. (2-tailed)	0.229	0.000

Regarding the competency of "solving regularity, equivalence and change problems", in Table 6 it can be seen that, in the pretest, 80.4% of the students of the experimental group were at the level of learning achievement “start", 9.8% at the “process" level, 5.9% at the "outstanding achievement" level, while 3.9% at the "expected achievement" level. In the control group, the pre-test results show that 76.5% were at the “start”, 15.7% at the “process” level, 3.9% at the “expected achievement” level and also 3.9% at the “outstanding achievement” level. On the other hand, in the post-test, a significant improvement in the experimental group was evidence % at the “expected achievement” level and 9.8% remained at the “start” level. However, in the control group, 80.4% continued at the “start” level, 9.8% at the “process” level, 5.9% at the “expected achievement” level and 3.9 % at the "outstanding achievement" level.

Table 6. Results of the Mann-Whitney U Test in the experimental and control groups (pretest and posttest) regarding the mathematical competency "solves quantity problems"

Levels of learning achievement	Groups							
	Experimental				Control			
	Pretest		Posttest		Pretest		Posttest	
	n	%	n	%	n	%	n	%
Start	41	80.4	5	9.8	39	76.5	41	80.4
Process	5	9.8	13	25.5	8	15.7	5	9.8
Expected achievement	2	3.9	12	23.5	2	3.9	3	5.9
Outstanding achievement	3	5.9	21	41.2	2	3.9	2	3.9
Total	51	100.0	51	100.0	51	100.0	51	100.0

According to Table 7, there are no statistically significant differences between the experimental group and the control group regarding mathematical competency of "solving regularity, equivalence and change problems" before the application of the educational program (pre-test) (p>0,05). However, after the application of the program (post-test), statistically significant differences were reported between the groups (p<0.05). That is, the experimental group showed results other than the control group. These data allow to affirm that the application of an educational program was effective in the development of mathematical competency of "solving regularity, equivalence and change problems" among Peruvian students of elementary education.

Table 7. Results of the Mann-Whitney U Test in the experimental and control groups (pretest and posttest) regarding the mathematical competency "solves regularity, equivalence, and change problems"

Statistics	Experimental group and control group (pretest)	Experimental group and control group (posttest)
Mann–Whitney U	1260.500	313.000
Wilcoxon W	2586.500	1639.000
Z	-0.373	-7.013
Asymp. Sig. (2-tailed)	0.709	0.000

Regarding the competency of "solving data management and uncertainty problems", in Table 8 we could observe that, in the pre-test, 80.4% of the students of the experimental group were at the "start" level, 15,7% at the "process" level and 3.9% at the "expected achievement" level. In the control group, 94.1% of the students were at the "start" level, 2% at the "process" level and 3.9% at the "outstanding achievement" level. In the post-test, the experimental group showed a significant improvement because 31.4% reached the “expected achievement” level, 25.5% was at the “outstanding achievement” level, 25.5% at the “process" level and 17.6% remained at the "start" level. On the contrary, in the control group, 88.2% of the students continued at the "start" level, 9.8% progressed to the "process" level and only 2% reached the "expected achievement" level.

Table 8. Development of the mathematical competency "solves data management and uncertainty problems" during the pretest and posttest, according to the experimental and control groups

Levels of learning achievement	Groups							
	Experimental				Control			
	Pretest		Posttest		Pretest		Posttest	
	n	%	n	%	n	%	n	%
Start	41	80.40	9	17.60	48	94.10	45	88.20
Process	8	15.70	13	25.50	1	2.00	5	9.80
Expected achievement	2	3.90	16	31.40	0	0.00	1	2.00

Levels of learning achievement	Groups							
	Experimental				Control			
	Pretest		Posttest		Pretest		Posttest	
	n	%	n	%	n	%	n	%
Outstanding achievement	0	0.00	13	25.50	2	3.90	0	0.00
Total	51	100.0	51	100.0	51	100.0	51	100.0

According to Table 9, no statistically significant differences were reported between the experimental group and the control group regarding mathematical competency of "solving data management and uncertainty problems" before the application of the educational program (pre-test) (p>0,05). However, after the application of the program (post-test), statistically significant differences between the groups (p<0.05) were evidenced. That is, the experimental group showed results other than the control group. The foregoing allows us to conclude that the application of an educational program was effective in the development of mathematical competency of "solving data management and uncertainty problems" among Peruvian students of Elementary education.

Table 9. Results of the Mann-Whitney U Test in the experimental and control groups (pretest and posttest) regarding the mathematical competency "solves data management and uncertainty problems"

Statistics	Experimental group and control group (pretest)	Experimental group and control group (posttest)
Mann–Whitney U	1131.000	310.000
Wilcoxon W	2457.000	1636.000
Z	-1.960	-7.235
Asymp. Sig. (2-tailed)	0.051	0.000_

As regards the competency of “solving movement and location problems”, in Table 10 it is observed that, in the pre-test, 82.4% of the students of the experimental group were at the "start" level, the 13.7% at the "process" level and 3.9% at the "expected achievement" level. In the control group, 94.1% of the students were at the "start" level and 5.9% at the "process" level. In the post-test, the experimental group showed a significant improvement, since 31.4% reached the “expected achievement” level, 29.4% remained at the “start” level, 25.5% reached the “outstanding achievement" level and 13.7% at the "process" level. However, in the control group, 90.2% of the students continued at the "start" level and 9.8% progressed to the "process" level.

Table 10. Development of the mathematical competency "solves form, movement and location problems" during the pretest and posttest, according to the experimental and control groups

Levels of learning achievement	Groups							
	Experimental				Control			
	Pretest		Posttest		Pretest		Posttest	
	n	%	n	%	n	%	n	%
Start	42	82.40	15	29.40	48	94.10	46	90.20
Process	7	13.70	7	13.70	3	5.90	5	9.80
Expected achievement	2	3.90	16	31.40	0	0.00	0	0.00
Outstanding achievement	0	0.00	13	25.50	0	0.00	0	0.00
Total	51	100.0	51	100.0	51	100.0	51	100.0

According to Table 11, no statistically significant differences were reported between the experimental group and the control group regarding mathematical competency of "solving form, movement and location problems" before the application of the educational program (pre-test) (p>0,05). However,

after the application of the program (post-test), statistically significant differences between the groups ($p<0.05$) were evidenced. That is, the experimental group showed results other than the control group. The foregoing allows us to conclude that the application of an educational program was effective in the development of mathematical competency of "solving form, movement and location problems" among Peruvian students of Elementary education.

Table 11. Results of the Mann-Whitney U test in the experimental and control groups (pretest and posttest) regarding the mathematical competency "solves form, movement and location problems"

Statistics	Experimental group and control group (pretest)	Experimental group and control group (posttest)
Mann–Whitney U	1144.500	437.500
Wilcoxon W	2470.500	1763.500
Z	-1.869	-6.546
Asymp. Sig. (2-tailed)	0.062	0.000

5. Discussion

The development of mathematical competencies at the primary level plays a fundamental role in the education of students, since it feels the basis for their academic success and intellectual development throughout their lives. Therefore, in this research it was sought to determine the effectiveness of an educational program in the development of mathematical competences in Peruvian students of elementary education.

The main finding of this research shows that the educational program was effective in the development of mathematical competencies. Before the application of the program, it was observed that most students in both groups, control and experimental, were located at the “start” level and only a small percentage was in “process” or “expected achievement” level. However, after the intervention of the program there were significant changes in the results. In the experimental group, the percentage of students at the “start” level was reduced and most advanced to the “expected achievement” and “outstanding achievement” level. In contrast, in the control group, the decrease in the "start" level was less marked, showing a little significant trend. Finally, the U-Whitney test corroborated these differences ($p <0.05$).

The foregoing is related to previous research that indicates that the application of the heuristic and playful method with the development of mathematical thinking skills enhances problem-solving abilities. Therefore, contribute to the improvement of educational quality (Dominguez & Espinoza, 2019). Likewise, Cacqui (2019) carried out an investigation and concluded that the playful strategies exert a significant influence on the development of mathematical competency in students. Finally, Rosas (2013) developed an investigation and concluded that playful strategies have a positive impact on the understanding and assimilation of mathematical concepts, which suggests that they can constitute a highly effective tool to improve the learning process in this area.

The implemented educational program was based on a series of playful strategies, carefully selected to make mathematics learning more engaging, comprehensible, and motivating for elementary school students. These strategies included activities such as card and dice games to reinforce multiplicative and additive operations, the use of the abacus to develop addition and subtraction skills, and tower-building activities to work on concepts of equivalence and magnitude. Additionally, activities for recognizing geometric shapes were employed through shape-making games and repetitive patterns, which facilitated the understanding of spatial relationships and measurements. These activities were selected not only to make often abstract mathematical concepts more tangible and practical but also to encourage learning based on experimentation and discovery, which are key aspects of contemporary mathematics pedagogy. In line with current educational best practices, these active and participatory strategies not only promote the acquisition of mathematical

skills but also stimulate critical thinking and problem-solving in real contexts (Rosas, 2013).

The development of mathematical competency in primary children is essential for their intellectual growth and success in various areas of life. These skills not only build a solid basis for logical thinking, problem solving and abstract reasoning, but are also essential in daily life (Gómez, 2019). The ability to understand and apply mathematical concepts facilitates informed decision making, improves the ability to handle practical situations and contributes to successful academic performance. In addition, the early development of mathematical competency provides children with the necessary tools to face the challenges in the modern era, preparing them for professional careers that require skills in science, technology, engineering and mathematics (STEM), and promoting analytical and creative thinking essential in the 21st century (Ramírez, 2022).

Another finding indicates that the educational program was effective in developing competency of "solving quantity problems". Before the application of the program, most students in the control and experimental groups were at the "start" level. After the intervention of the educational program, there were significant changes in the results: the experimental group evidenced a reduction in the percentage of students at the "start" level, with a migration to the "outstanding achievement" level. However, the control group reduced the "start" level, but the trend remained static. Finally, the U-Whitney U test corroborated these differences ($p<0.05$).

Similar results were obtained by Domínguez & Espinoza (2019), who performed an intervention program and concluded that the heuristic method of Polya and recreational strategies facilitate the solving problems in students because the empowers of the tools to solve A situation raised taking into account the four steps stipulated by this theoretical: understand the problem, develop a plan, execute the plan and finally carry out feedback of this process.

It was also found that the educational program was effective in developing competency of "solving regularity, equivalence and change problems". Before the application of the program, it was observed that most students in experimental and control groups initially were located at the "start" level. However, after the intervention, the results experienced significant changes. In the experimental group, the percentage of students at the "start" level was drastically reduced, with a majority migration towards "outstanding achievement" and "expected achievement" levels. On the other hand, in the control group, the "start" level increased slightly. The U-Whitney U test corroborated these differences ($p<0.05$).

The exposed result is similar to what was reported by Rosas (2013), who conducted a study in order to implement recreational strategies to develop capacities related to the resolution of linear equations. When analyzing and comparing the statistical results of both data sets, a clear viability is identified in the implementation of recreational strategies in the teaching of mathematics. These strategies demonstrated a positive impact on the understanding and assimilation of concepts related to equations and inequalities, suggesting that they can be an effective tool to improve the learning process in this area.

In addition, it was determined that the educational program was effective in developing competency of "solving data management and uncertainty problems". Before the application of the program, it is observed that most students, both in the experimental group and in the control group, were at the achievement "start" level. However, after the intervention of the program there were significant changes in the results. In the experimental group, the percentage of students at the "start" level decreased, with the majority migrating to the "expected achievement" and "outstanding achievement" levels. In contrast, in the control group, the "start" level decreased, but minimally, indicating an almost static trend compared to the experimental group. Finally, the U-Whitney test corroborated these differences ($p<0.05$).

Similar results were obtained by Escobar (2020), who conducted an investigation aimed at knowing to what extent the application of a mathematical games program develops the data management competition and uncertainty in students of an educational institution in Ayacucho (Peru). The author concluded that the implementation of the workshop focused on mathematical games proved to be effective in improving the previously mentioned competition. The statistical

analysis by means of the Wilcoxon sign ranges obtained a minor p-value than the level of significance ($p<0.05$). This result confirms that the difference between the level of achievement of the students before and after the application of the intervention program was significant.

Similarly, it was found that the educational program was effective in developing competency of "solves form, movement and location problems". After the application of the program, it is observed that most students, both in the experimental group and in the control group, were initially located at the performance "start" level. However, after the intervention of the program there were significant changes in the results. In the experimental group, the percentage of students at the "start" level decreased, with a majority migration towards the "expected achievement" and "outstanding achievement" levels. On the other hand, in the control group, the "start" level was reduced, indicating an almost static trend. Finally, the U-Whitney U test corroborated these differences ($p<0.05$).

The exposed finding is related to the research of Culqui (2019), who carried out a study with the purpose of evaluating the impact of an educational program that was based on the implementation of recreational strategies in the development of mathematical competencies among the students of primary education. The results of the research concluded that the play of playful strategies exerts a significant influence on the development of skills to solve geometric problems in the population studied. This was evidenced by the increase in the arithmetic mean of the experimental group, which went from 2.9 in the pretest to 18.7 in the post-test ($p<0.05$). On the other hand, the control group experienced a minimum increase, from 2.0 in the pretest to 2.3 in the posttest ($p>0.05$).

Teaching mathematics through games is highly beneficial for the learning of mathematics (Guisvert & Lima, 2022). This approach allows children to strive their knowledge from an early age and helps them to develop better in everyday life. Similarly, the United Nations Educational, Science and Culture Organization (2019) promotes various approaches to teaching mathematics, recognizing and integrating interactive experiences and recreational elements to achieve effective learning. Consequently, playful strategy is not simply an attraction, improves both understanding and the application of mathematics (Aristizábal et al., 2016).

Although the results of this study have demonstrated a significant improvement in mathematical competencies in the short term, it is essential to consider the possible long-term effects of such interventions. Previous research suggests that early success in mathematics, combined with positive learning experiences, can have a lasting impact on students' attitudes toward this subject area (Ramírez, 2022). Thus, it is possible that students who have participated in programs based on playful strategies not only maintain their academic achievements but also develop greater confidence in their mathematical skills and a more favorable attitude toward problem-solving. This would not only benefit their performance in later educational stages but could also influence their choice of professional careers related to STEM.

The strengths of this research include their contribution to knowledge when addressing a relevant topic, the use of a solid research design comparing an experimental group and a control group, the practical relevance of results in the educational field, the use of appropriate analysis statistics, the reliable measurement of mathematical competencies and their potential positive impact on the teaching of mathematics at the primary level. These strengths support the quality, relevance and ethics of research, underlining their contribution to the field of education and the development of mathematical competencies in primary education students.

Despite the favorable results obtained, it is necessary to recognize the limitations of the present investigation. First, the sample size was relatively limited, which could affect the generalization of the results. In addition, the intervention of the program was carried out for a specific period of time, which could have influenced the results. On the other hand, the particular context in which the study was conducted, which includes geographical, socioeconomic and environmental factors, could have had an impact on the results. Finally, unusual variables cannot be ruled out that could influence the development of mathematical competences. These limitations must be carefully taken into account when interpreting the results and by applying the findings in broader educational contexts. In addition, they offer opportunities for future research in this important area of education.

6. Conclusion

The findings of this research allow us to conclude that the application of an educational program was effective in the development of the mathematical competencies of Peruvian students of Primary Education. Before the application of the aforementioned educational program, the student's learning achievement belonging to the experimental group was located at the "start" level. However, after the application of the program it was located at the "expected achievement" level and "outstanding achievement". In contrast, in the control group, the vast majority of students remained at the aforementioned level. Therefore, it is recommended to replicate the educational program based on recreational strategies in other educational institutions, due to its proven efficacy in the development of mathematical competencies. In addition, it is essential that teachers receive specific training in these strategies through workshops and that periodic evaluations are carried out to adjust and optimize the program.

References

Álvarez, E., & Barreda, L. (2020). La estadística descriptiva en la formación investigativa del Instructor de Arte. *Revista Conrado, 16*(73), 100-107. https://conrado.ucf.edu.cu/index.php/conrado/article/view/1277

Aristizábal, J., Colorado, H., & Gutiérrez, H. (2016). El juego como una estrategia didáctica para desarrollar el pensamiento numérico en las cuatro operaciones básicas. *Sophia, 12*(1), 117-125. https://doi.org/10.18634/sophiaj.12v.1i.450

Ausubel, D. (1968). *Educational psychology: A cognitive view*. Holt, Rinehart and Winston.

Bautista, J., Estrada, E., Yana, M., Gallegos, Z., Coaquira, R., Reyes, B., Sosa, J., & Alanoca, V. (2023). Monitoring, support and inter-learning in teaching performance in basic education of the area of mathematics. A case study in Puno (Perú). *International Journal of Learning, Teaching and Educational Research, 22*(5), 474-492. https://doi.org/10.26803/ijlter.22.5.24

Blanco, L., Cárdenas, J., & Caballero, A. (2015). *La resolución de problemas de Matemáticas en la formación inicial de profesores de Primaria*. Universidad de Extremadura.

Chaverri, P. (2021). La educación en la pandemia: Ampliando las brechas preexistentes. *Actualidades Investigativas en Educación, 21*(3), 120-143. https://dx.doi.org/10.15517/aie.v21i3.46725

Culqui, R. (2019). *Programa de estrategias lúdicas y su influencia en el desarrollo de competencias matemáticas en los estudiantes de 4º grado del Nivel Primaria, Institución Educativa Nº 15509, Talara–Piura, 2017* (doctoral thesis). Universidad César Vallejo. https://repositorio.ucv.edu.pe/handle/20.500.12692/28848

Domínguez, L., & Espinoza, B. (2019). *Potenciar la resolución de problemas matemáticos desarrollando habilidades de pensamiento desde una mirada heurística* (undergraduate thesis). Universidad de la Costa. https://repositorio.cuc.edu.co/handle/11323/4929

Escobar, M. (2020). *Juegos matemáticos para mejorar la competencia de gestión de datos e incertidumbre, en estudiantes de una institución educativa, Pararca 2019* (undergraduate thesis). Universidad César Vallejo. https://repositorio.ucv.edu.pe/handle/20.500.12692/48047

Fernández, E. L. (2018). La geometría para la vida y su enseñanza. *AiBi Revista de Investigación, Administración e Ingeniería, 6*(1), 33-61. https://doi.org/10.15649/2346030X.475

Freire, P. (1970). *Pedagogy of the oppressed*. Continuum.

Gómez, F. (2019). El desarrollo de competencias matemáticas en la Institución Educativa Pedro Vicente Abadía de Guacarí, Colombia. *Universidad y Sociedad, 11*(1), 162-171. https://rus.ucf.edu.cu/index.php/rus/article/view/1104

Guisvert, R., & Lima, L. (2022). La gamificación en el aprendizaje de la matemática en la Educación Básica Regular. *Horizontes Revista de Investigación en Ciencias de la Educación, 6*(25), 1698-1713. https://doi.org/10.33996/revistahorizontes.v6i25.447

Hincapié, N., & Clemenza, C. (2022). Evaluación de los aprendizajes por competencias: Una mirada teórica desde el contexto colombiano. *Revista de Ciencias Sociales, 28*(1), 106-122. https://doi.org/10.31876/rcs.v28i1.37678

Jiménez, A. (2022). Competencias matemáticas para el desarrollo de habilidades cognitivas en estudiantes universitarios. *Revista Latinoamericana de Difusión Científica, 4*(7), 141-167. https://doi.org/10.38186/difcie.47.10

López, E. (2016). En torno al concepto de competencia: un análisis de fuentes. *Profesorado, 20*(1), 311-322. https://revistaseug.ugr.es/index.php/profesorado/article/view/18589

Lugo, J., Vilchez, O., & Romero, L. (2019). Didáctica y desarrollo del pensamiento lógico matemático. Un abordaje hermenéutico desde el escenario de la educación inicial. *Revista Logos Ciencia & Tecnología, 11*(3), 18-29. https://doi.org/10.22335/rlct.v11i3.991

Ministry of Education (2016a). *Currículo Nacional de la Educación Básica*. MINEDU.

Ministry of Education (2016b). *Programa curricular de Educación Primaria*. MINEDU.

Ministry of Education (2024). *Evaluación Nacional de Logros de Aprendizaje (ENLA) 2023*. MINEDU.

Organization for Economic Cooperation and Development (2023). *PISA 2022 Results (Volume I): The State of Learning and Equity in Education*. PISA, OECD Publishing, Paris. https://doi.org/10.1787/53f23881-en

Pérez, N., & Moraima, P. (2022). Consecuencias adversas en el aprendizaje por el uso inadecuado de las herramientas tecnológicas actuales. *Killkana Social, 6*(S1), 139-150. https://doi.org/10.26871/killkanasocial.v6i4.1196

Piaget, J. (1951). *Play, dreams, and imitation in childhood*. Norton.

Quispe, J., Estrada, E., Ttito, S., Huamani, A., Baez, J., & Velasquez, L. (2024). Math anxiety in Peruvian students of regular basic education: A descriptive study. *Salud, Ciencia y Tecnología - Serie de Conferencias, 3*, 688. https://doi.org/10.56294/sctconf2024688

Ramírez, J. (2022). Experiencia STEM: desarrollo del pensamiento matemático a través de videojuegos meteorológicos. *Revista Colombiana de Educación, 1*(85), 147–164. https://doi.org/10.17227/rce.num85-12756

Rosas, O. (2013). *Matemática recreativa como estrategia de enseñanza-aprendizaje en la resolución de ecuaciones algebraicas de problemas literales* (master's thesis). Universidad TecVirtual. https://repositorio.tec.mx/handle/11285/619609

Trujillo, J. (2014). El enfoque en competencias y la mejora de la educación. *Ra Ximhai, 10*(5), 307-322. https://www.redalyc.org/pdf/461/46132134026.pdf

United Nations Educational, Science and Culture Organization (2019). *Una herramienta de aprendizaje basada en un juego dirigida a los niños de regiones en conflicto fue galardonada con el premio Unesco de innovación en la educación*. UNESCO.

Valderrama, D. (2021). Competencias matemáticas: una mirada desde las estrategias de enseñanza en educación a distancia. *Góndola, Enseñanza y Aprendizaje de las Ciencias, 16*(2), 382-398. https://doi.org/10.14483/2346474712.16167

Vera, D., Zambrano, A., & Loor, A. (2023). Desafíos de la educación matemática en estudiantes universitarios. *Revista Peruana de Investigación e Innovación Educativa, 3*(1), e23643. https://doi.org/10.15381/rpiiedu.v3i1.23643

Vygotsky, L. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.

Zulay, N. (2021). Estrategias lúdicas dirigidas a la enseñanza de la matemática a nivel de Educación Primaria. *Mérito - Revista De Educación, 2*(6), 143-157. https://doi.org/10.33996/merito.v2i6.261