Playful Activities to Develop Mathematical Thinking in High School Children

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ABSTRACT
The research focused on analyzing how a program of playful activities influences the development of mathematical thinking in early childhood children who attend the preparatory education level, a process of transition between mathematical notions and the basic contents of this area of knowledge. The study used a quantitative methodology and quasi-experimental design based on the comparison of an experimental and a control group. The study population included 70 students aged 5 to 6 years. Initially, a diagnosis was applied based on the mathematical thinking questionnaire that obtained a reliability level of A=.855, through which shortcomings were evidenced in both groups. The final results showed a significant improvement in the experimental group, while the control group showed no significant changes.

1. Introduction

Within academic training, mathematics is established as a fundamental aspect in the integral development of students. Through the teaching of mathematics, children not only acquire the skills necessary to understand numerical concepts and put them into practice, but also strengthen essential skills such as mathematical thinking. (Callejo et al., 2022) (Devlin et al., 2023)

During the first years of education, it is necessary for students to acquire the mathematical skills that allow them to address the different contents taught at each level of learning. Actions as simple as identifying sequences or solving basic calculations are essential for the understanding of the environment. (Lenz, 2022) (Anandarajan, 2020)

However, the approach to mathematics can become a complex process when the necessary means are not used to generate the understanding of these contents in students. (Möhring et al., 2021)

In the case of children in initial levels such as high school, mathematical processes can become frustrating experiences when they are not presented in an appropriate way. (Parviainen et al., 2023)

Many children come to feel a deep aversion when performing activities that involve the analysis and processing of numbers or other mathematical concepts, which clearly affects their performance in the classroom and therefore their school performance. (Ventura et al., 2021)

The development of unsatisfactory experiences for children has a direct influence on their learning. By not feeling comfortable with the way certain knowledge is approached, students can reject it, generating a negative predisposition towards it. (Moreno et al., 2021) (Lin et al., 2020)

This problem is not characteristic of a specific context, but is repeated in different geographical environments, both international and national. In Spain, the weaknesses involved in the teaching processes of mathematics have led to important modifications in the school curriculum. In this context, a greater approach to mathematics is proposed within the framework of an active and participatory methodology that provokes the interest of students. Likewise, at the regional level, the ERCE test implemented in 11 Spanish-speaking countries showed concrete data on this problem, highlighting that between 25% and 80.1% of students do not manage to achieve

the expected skill levels to perform mathematical activities. (Alsina, 2019) (UNESCO, 2019)

On the other hand, in Ecuador, the limited development of activities according to the existing needs in the area of mathematics is established as a repetitive difficulty in the first years of education that is often associated with poor teacher training. (López, 2022)

This problem was evidenced in an Educational Institution in Guayaquil, Ecuador, where the infants who were part of the preparatory level presented significant deficiencies in their mathematical thinking.

This could be seen reflected in their difficulty in assimilating the contents of the mathematics area, as well as the limited predisposition to participate in the planned activities that involved concepts in the area. The above highlighted the need to establish a proposal that would be appropriate to the characteristics of the students, promoting the strengthening of mathematical thinking in a dynamic and participatory way.

Thus, the use of recreational activities was considered as a successful response to the existing difficulties. Playful activities are located as an approach that uses play and other recreational activities as a bridge to facilitate learning. The implementation of playful activities adapted to the particularities of a group can provide a motivating and interesting environment for children. Children's familiarity with play allows them to feel at ease when participating in activities that involve these dynamics. (, 2021) (Aslanian et al., 2024)

With these premises, the general objective of this research focused on establishing the influence of play on the mathematical thinking of infants in a high school group of an Educational Institution in the city of Guayaquil, Ecuador. This action is based on a theoretical approach, as well as an empirical research process that will provide relevant results to the area of early childhood education. In this sense, two hypotheses were determined: Hi: The program of playful activities positively influences the mathematical thinking of infants; Ho: The program of recreational activities does not influence the mathematical thinking of children.

2. Methodology

Type and focus of research

An applied research was considered with the aim of evaluating the impact of a program of playful activities to develop mathematical thinking in high school infants. Under a quantitative approach, seeking to optimize the processes of data collection, analysis and presentation.

Research Design

The design was quasi-experimental, establishing an intervention in an experimental group that was then compared to the control group.

Sample

The sample was made up of 70 high school students from an Educational Institution in Guayaquil. In this sense, 35 students were considered for the experimental group and 35 for the control group of this study. The following aspects were taken into account in the choice of this process.

Inclusion criteria

- Infants of the intervened educational institution
- Infants ages 5 to 6

Exclusion Criteria

- Infants with learning disabilities
- Infants who miss the days of the intervention

Technique and instrument

The technique used was direct observation, taking into account that the participants in this study involved infants from 5 to 6 years old who were sought to assess their level of mathematical thinking. A mathematical thinking questionnaire was used as an instrument, which integrated a checklist with a nominal assessment scale of three levels (beginning, in process, achieved). The instrument went through a process of validation of expert criteria

obtaining a high score, as well as a statistical assessment of reliability acquiring a Cronbach's Alpha =.855. The instrument was composed of 30 aspects associated with mathematical thinking.

Board 1 Protocol for the development of the research by phases.

Stages	Category	Related activities
Stage 1	Revision todocumentary	Theoretical and conceptual definition of the investigated variables, in scientific articles from databases such as Scopus, WoS, Ebscot, and Dialnet through digital platforms. This process concluded with the selection and bibliographic analysis of the variables recreational activities and mathematical thinking.
Step 2	Linking the sample	The study was focused on a privately supported educational institution in the city of Guayaquil. After this, the participants who were part of the sample (high school children) were determined.
Step 3	Instrumentalization	After the mathematical thinking questionnaire was designed, its validation was carried out. Criterion validity was carried out with the participation of experts. In addition, a pilot test was carried out with 35 students giving an Alpha= .855. After this, the questionnaire was applied to the students who made up the research sample.
Step 4	Analysis of results	Descriptive analyses were used, allowing comparison of responses both at the pre-test and post-test level, as well as between the control and experimental groups. An inferential analysis was also used using the parametric Mann Whitney U test in order to accept or reject the research hypotheses.
Step 5	Return	The results were returned, presenting the conclusions and recommendations to the high school teachers of the intervened institution. After this, a scientific product was published in order to disseminate information to the scientific community regarding the effectiveness of playful activities in the mathematical thinking of infants.

Source: own elaboration 2024

3. Results

Pre-test results

From the results obtained in the pre-test test applied to both groups, it was evident that the experimental group presented 74.3% at the initial level, 20% at the level in process and 5.7% at the level reached. In contrast, the control group showed 80% at the initial level, 17.1% at the level in process and 2.9% at the level reached. This showed that in a diagnostic way there were similarities around the development of mathematical thinking, showing a high percentage of infants who were at an initial level.

Table 2. Pre-test results

	Experimental group		Control group	
Beginning	26	74,3%	28	80,0%
In process	7	20,0%	6	17,1%
Accomplished	2	5,7%	1	2,9%
Total	35	100%	35	100%

Source: own elaboration 2024

Recreational activities programme

As an intervention resource, the design of a program of recreational activities that would be applied progressively in the infants under study was determined. This program integrated a total of fifteen playful activities that were associated with different dimensions of mathematical thinking such as the understanding of relationships and functions, numerical understanding and geometric understanding.

The activities were framed within an active participatory approach aimed at promoting dynamism and interaction among children. Through this set of activities, the aim was to generate learning experiences that could be meaningful, thus achieving an improvement in the mathematical thinking of high school children. The implementation of the playful activities considered an organized process, making this process easy for the teacher. It is important to note that this program was only applied in the experimental group.

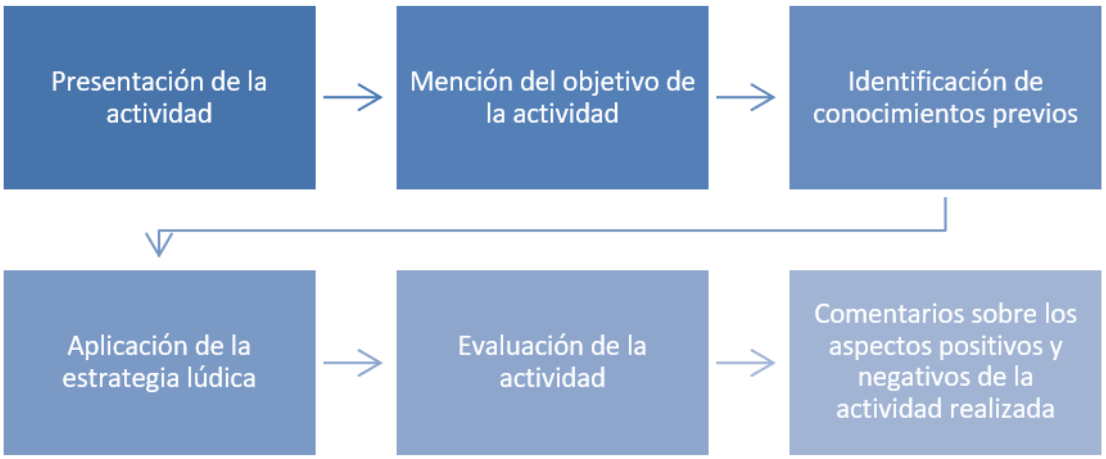

Fig. 1. Process of implementation of the playful activities in the experimental group

Source: own elaboration 2024. In original language Spanish

Post-test results

After the intervention carried out on the experimental group, the questionnaire already applied in the diagnosis was used for the second time. The data showed significant differences between the experimental group and the control group. Thus, 2.9% of the experimental group was at the baseline level, in contrast to 65.7% of the control group. On the other hand, at the level in process, the experimental group reached 22.9%, while the control group obtained 28.6%. Finally, at the level achieved, the experimental group showed a significant increase to 74.2%, compared to 5.7% in the control group.

Table 3. Post test results

	Experimental group		Control group	
Beginning	1	2,9%	26	74,3%
In process	8	22,9%	7	20,0%
Accomplished	26	74,3%	6	5,7%
Total	35	100%	35	100%

Source: own elaboration 2024

The data show that the implementation of the program of recreational activities had a significant impact on the experimental group. While before the intervention, this group showed a low proportion of students at the level achieved and a high proportion at the initial level, after applying the recreational activities, a notable improvement was observed. The increase to 74.2% in the level achieved shows that the playful activities not only facilitated the understanding and assimilation of concepts, but also promoted more effective learning compared to the control group, which remained with a low percentage at the level achieved.

Inferential results

In order to accept one of the hypotheses determined at the beginning of the study, an inferential analysis was carried out. Initially, the Shapiro Wilk normality test was applied, which determined the use of a parametric test. In this way, the Mann Whitney U statistic was used. The test results showed a U= 565,500; Z= -6.431; p value < 0.05 (.000 < 0.05) suggesting a statistically significant difference between the experimental group and the control group. The p-value of less than the expected .05 supports the robustness of these findings, confirming that the improvements in the experimental group are not due to chance and that the intervention produced a significant impact on the development of the skills evaluated. In this way, Ho was rejected, Hi was accepted and it was determined that play positively influences the mathematical thinking of infants.

Table 4. Mann Whitney U Test Results

Ranges				Test statisticians	
Groups	N	Average Range	Sum of ranks	Statistical	Values
Post control	35	51,13	1789,50	U de Mann-Whitney	65,500

Post experimental	35	19,87	695,50	With	-6,431
Total	70			Asymptotic Sig.	,000

Source: own elaboration 2024

4. Discussion

The results obtained from both the descriptive and inferential analysis allow us to accept the main hypothesis, discard the null hypothesis and determine the influence of the program of recreational activities on the development of mathematical thinking in infants. These results are similar to those proposed by Niu, who referred to teaching processes that integrate playful activities as a methodology that not only seeks to entertain students, but also to make the process of assimilating information easier. (2023)

The incorporation of activities adapted to the characteristics of the group within the program of playful activities had a positive impact on the mathematical thinking of the children by showing a notable improvement in their ability to solve logical and mathematical problems, reflecting the effectiveness of these activities. This is related to what Pyle and others indicated (2022) when they point out in their study that through playful processes students are able to be more attentive, which allows a more spontaneous introduction of content that may be complex in other contexts.

The effective implementation of playful activities promoted greater interaction and motivation among students, facilitating the development of critical and logical thinking skills, but also aroused a greater interest in mathematics, as evidenced by superior performance during activities and assessments related to this area. On this, Becerril determines that by implementing activities that are dynamic, the innate interest in children to participate in them is generated, generating a high level of satisfaction that facilitates the understanding of ideas. (2021)

It could be said then that the results became an empirical basis for the design of a proposal that could exercise a progressive improvement of this problem. The proposal consisted of applying different workshops aimed at high school teachers in order to enhance the knowledge and approach to recreational activities, especially in infants such as those analyzed in the research. Through these workshops, it is intended to train teachers in the use of methods based on games and gamification, promoting a pedagogical approach that promotes greater participation and enthusiasm among students. In this way, it is intended to enrich educational practices and improve learning, providing teachers with effective tools to capture and maintain the interest of their students while developing their mathematical thinking.

5. Conclusions

The program of playful activities applied to the experimental group had a significant impact on the development of mathematical thinking of the infants who make up the preparatory level of an Educational Institution in Guayaquil, which underlines the effectiveness of these activities in the promotion of mathematical skills, confirming that innovative pedagogical methods can overcome the limitations observed in traditional approaches.

The strengthening of mathematical thinking at the preparatory level constitutes a fundamental pillar for the cognitive and academic development of students in later stages. By providing children with educational experiences that allow them to explore mathematical concepts concretely and meaningfully from an early age, the foundation is laid for logical reasoning and problem-solving skills that will be crucial in their future education.

It is essential that in the early years of education, educational experiences are generated that not only introduce children to the basics, but also foster a stimulating learning environment adapted to their cognitive and emotional needs. By offering activities that integrate play and exploration, it facilitates the understanding of fundamental concepts and promotes a positive attitude towards learning.

It is important that teachers are continuously trained in the use of playful activities to ensure the effectiveness and relevance of their teaching methods. By mastering techniques that are appropriate for students, teachers can create more engaging and dynamic learning experiences that not only facilitate the understanding of complex concepts, but also motivate students and foster a positive and participatory educational environment. This continuous updating is key to optimizing the impact of teaching and adapting activities to the changing needs of students.

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