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Geogebra Software And Playful Strategies In Mathematics Learning In Students Of A State Educational Entity Of Piura, 2023

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Abstract

The objective of the investigative study was to determine the effect of GeoGebra Software and playful strategies on mathematics learning in students of a state educational entity in Piura, 2023. The research was quantitative, applied and pre-experimental in design. The sample was 48 students, to whom a written test "I demonstrate my learning in mathematics" was administered, which has a KR-20 reliability of 0.823 and expert criterion validity with an Aiken V of 0.88. The results after the application of the program are positively evident in the achievement levels. Before the program, 85.42% of students were below expected achievement (Start and process) and after, 66.67% were in expected achievement and 8.33% in outstanding achievement. In the hypothesis testing, a significance of less than 5% ($p<0.05$) was obtained, determining the effect of the program in the four dimensions: solves problematic quantity situations; of regularity, equivalence and change; of form, movement and location; and data management and uncertainty, concluding that the use of GeoGebra software and playful strategies have a significant effect on mathematics learning.

Keywords: *GeoGebra software, playful strategies and mathematics learning*

I. INTRODUCTION

Obtaining favorable learning achievements in mathematics have always been primary objectives of every educational institution. However, the expected results have not yet been achieved in many countries. These are consequences of different factors such as the role of the teacher in the application of a traditionalist methodology, little use of technology as learning tools; It is also due to the lack of adequate environments and technological means.

This problem, at the international level, is reflected in the low results obtained through the PISA evaluations in 20[1]18 (Moreano et al., 2022). Also in Colombia, where since 2006 there have still been no favorable results. According to Bolaños et al. (2020) and Hernández et al. (2021), it is due to teacher traditionalism and the limited use of technology. Also, another important factor is the non-existent motivation for learning, due to out-of-context strategies or limited use of recreational activities (Tigrero, 2022).

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Thus, at the national level, the Office for the Measurement of the Quality of Learning (UMC, 2022), informs us of the not so convincing results obtained in 2022 compared to 2019, in the levels of achievements prior to the start, start and process that increased 2.7%, 4.7% and 2.8% respectively, however, In satisfactory, they had a decrease of 5.0%, being a negative trend. Montoya (2022) points out that the difficulties are reflected in resolving situations in the context, without exceeding basic standards, due to factors such as Zegarra (2020), Caballero (2022) and Valera (2021) in the scarce use of interactive didactics and limited use of ICTs.

Therefore, at the local level, it is not far removed from the national results, reflected in the low learning achievements obtained in the area of mathematics. According to the Ministry of Defense (MINDEF, 2018), the military educational institution in the city of Piura, with a boarding school system based on the military education system, whose academic and military activities are during the day, afternoon and part of the night, is part of this problem. And even more so because of the different activities carried out at the appointed times.

In this way, the use of technological strategies and resources to improve learning in mathematics is of great importance, which is why Villamizar et al. (2023) point out that there are different ways to deal with them, where it is necessary for the teacher to be professionally prepared in his or her field and permanent mastery of technology. Thus, Arteaga et al. (2019) and Collazos et al. (2023) give reason for this, recommending the use of educational applications such as GeoGebra, as a software for learning mathematics, awakening interest and developing critical thinking in the student.

In this context, the general problem arises : What is the effect of GeoGebra Software and playful strategies on mathematics learning in students of a state educational entity in Piura, 2023? And as specific problems we have: What is the effect of the GeoGebra software and playful strategies on the dimensions of solving problematic situations of quantity; regularity, equivalence and change; shape, movement, and location; and data management in uncertainty in students of a state educational entity in Piura, 2023?

From this perspective, the general objective is to determine the effect of GeoGebra Software and playful strategies on mathematics learning in students of a state educational entity of Piura, 2023; and as specific objectives are established in: To determine the effect of GeoGebra software and playful strategies in the solution of problematic situations of quantity; regularity, equivalence and change; shape, movement, and location; of data management and uncertainty in students of a state educational entity of Piura, 2023.

Within this framework, the research carried out is theoretically justified in the relationship between theory about technology, learning strategies and constructivist approach; methodological by the use of a program based on interactive strategies and the use of technological tools; social because it strengthens student learning and serves as a support to teachers in their innovations and convenient because it solves a problem identified in educational institutions.

Based on the above, research has been carried out on the learning of mathematics making use of interactive strategies and tools that have allowed to strengthen the learning of mathematics, this is how we have international and national precedents where the use of GeoGebra software and playful strategies have strengthened the learning of mathematics.

In international background, we have Tigrero (2021) and Arévalo et al. (2020) on their research carried out in Ecuador and Colombia respectively regarding the use of ICTs, demonstrating that through technology the learning of mathematics is strengthened. Thus, GeoGebra, as a mathematical software, gained strength in learning, where Ogbonnaya and Mushipe (2020), Mosquera (2023), Abdullah et al. (2020), Marion et al. (2023) and Misrom et al. (2020) with their research in South Africa, Colombia and Malaysia, the last three on GeoGebra, determining its positive effect on the learning of graphical representations and interpretations of linear functions, issues regarding the dimension of GeGebra, and the future of GeoGebra.

Regarding the dimension of solving problematic situations of quantity, we have Yerizon et al. (2022), in the effectiveness of software in the development of a spreadsheet for the improvement of learning, carried out in Indonesia. A Mosquera (2023) on the effectiveness of fraction learning carried out in Colombia. Also in the dimension of solving problematic situations of shape, movement and location, Defi and Qohar (2022) demonstrated in their research carried out in Indonesia the effectiveness of GeoGebra in the learning of trigonometric relationships, Ramírez et al. (2021) with their research carried out in Mexico, demonstrating the effectiveness of GeoGebra in the argumentation of the processes of dynamic geometry, to Chang et al. (2022) in South Korea on the effectiveness of software in Geometry.

Regarding the positive effects of playful strategies, we have López (2022) and Sánchez (2019) with their research in Ecuador, where they determined that by making use of interactive strategies such as playful strategies, students have the necessary motivations to strengthen learning in the area of mathematics.

At the national level, according to the GeoGebra software, Beltrán (2022), Morales (2022), Muñante (2021), Salcedo et al. (2021), Sevillanos (2022) and Ruiz (2022) with their research on mathematics learning, determined that the software strengthens reasoning, creativity and argumentation in problem solving, a focus of the mathematics area. And regarding playful strategies, we have Zegarra (2020) and Cotrina (2018), where they determined with their research the effectiveness of recreational activities that strengthen student interactivity for mathematics learning.

The learning of mathematics, from a constructivist approach, seeks since ancient times to apply processes and strategies that facilitate solving problematic situations of the context (Ortiz, 2005). It is currently being developed under the approach of competency-based learning (Minedu, 2016). Competencies, referred to in this research as Problem Quantity Problem Solving (SSPC); solves problematic situations of regularity, equivalence and exchange (SSPREC); solves problematic situations of shape, movement and localization (SSPFML) and solves problematic situations of data management and uncertainty (SSPGDE).

This learning must be of great significance, where the student interacts with life itself, with their environment, and has the skills to solve problems (Beltrán, 2022), allowing the student to freely express their ideas and have constant interaction in the learning processes (Lee, 2009; Aguerrondo, 2009). As a result, according to Judy (2010), a competent student with highly complex skills such as reasoning, abstraction, pattern recognition, prediction, estimation and making use of technology.

Achieving meaningful learning in mathematics involves making use of interactive strategies that motivate the student. This implies that the social and emotional conditions are favorable, with an appropriate learning environment, curriculum, strategies and tools (Haynes et al., 2003). GeoGebra software and playfulness, as a tool

and strategies, strengthen learning. Leal et al. (2021), Ruiz (2022) and Villaroel (2022) define GeoGebra as a mathematical software that facilitates learning in geometry, algebra, calculus and statistics, and is also a free software. In this way, Prieto and Arredondo (2022), Janampa et al. (2021), García and Martín (2022), Hernández et al. (2021), and Rojas (2020) point out that through this software it is possible to design learning environments, which facilitates and strengthens the learning of mathematics favoring both the teacher and the student.

Regarding playful strategies, Fernández and Gómez (2020) define it as a strategy that contributes to forming a favorable learning environment, due to the motivation it originates in learning. Zaieg (2018) points out that it is the necessary motivation for learning, due to the importance of play as a strategy in the learning processes of mathematics and the dynamism that it originates.

II. METHODOLOGY

The research was of an applied type, because through actions it allows the solution of real problems (Concytec, 2019) and with a quantitative approach, it makes use of statistics (Hernández et al., 2018). Pre-experimental design, single-group intervention (Hernández et al., 2018). The sample consisted of 42 students from a state institution in Piura, and the sample was non-probabilistic.

The technique used was the test, in this research the performance test, as an instrument the written test, which was validated by five doctors in education, and whose result of Aiken's V was 0.88, with a Kuder Richardson (KR-20) reliability of 0.823.

In its execution, it began with the request for permission to carry out the research, then the application of a pilot test in a different educational institution. A pre-test was applied with the validated data collection instrument with favorable reliability, to then develop the program based on GeoGebra software and playful strategies for learning mathematics. The duration of the program was two months, with 16 three-hour learning sessions. Finally, the post-test was applied, the data was processed and the final report was prepared.

III. RESULTS

The results were elaborated in response to the research hypothesis, for which descriptive statistics were applied to know the percentage results of the study variable and its dimensions, and then inferential statistics to know the behavior of the data and apply the non-parametric Willcoxon test in the hypothesis testing.

Table 1Levels of achievement of the dimensions of mathematics learning.

Achievement Levels	Quantity SSP				SSP of regularity, equivalence and change				SSP of Shape, Motion, and Localization				Data and Uncertainty Management SSP.			
	Pre-test		Post test		Pre-test		Post test		Pre-test		Post test		Pre-test		Post test	
	f_i	f%	f_i	f%	f_i	f%	f_i	f%	f_i	f%	f_i	f%	f_i	f%	f_i	f%
In the beginning	24	50.00	3	6.25	24	50.00	4	8.33	32	66.67	11	22.92	29	60.42	11	22.92
In process	21	43.75	7	14.58	16	33.33	15	31.25	12	25.00	18	37.50	10	20.83	16	33.33
In Expected Achievement	3	6.25	23	47.92	8	16.67	22	45.83	4	8.33	16	33.33	9	18.75	21	43.75
In Outstanding Achievement	0	0.00	15	31.25	0	0.00	7	14.58	0	0.00	3	6.25	0	0.00	0	0.00
Total	48	100.00	48	100.00	48	100.00	48	100.00	48	100.00	48	100.00	48	100.00	48	100.00

According to Table 1, in the pre-test we can see that the dimensions of mathematics learning: solve problematic situations of quantity; regularity, equivalence and change; shape, movement, and location; and data management and uncertainty that 93.75%, 83.33%, 91.67% and 81.25% respectively were at the lowest achievement levels such as "Start" and "Process".

After having applied the program based on "GeoGebra Software and playful strategies for the learning of mathematics" the students obtained in the post-test, in solving problematic situations, quantity in "expected achievement" 47.92%, in outstanding achievement 31.25%. In solving problematic situations of regularity, equivalence and change, in "expected achievement" 45.83%, in outstanding achievement 14.58%. In solving problematic situations of shape, movement and location, in "expected achievement" 33.33%, in outstanding achievement 6.25%. And in solving problematic situations of data management and uncertainty, in "expected achievement" 43.75%.

Table 2 Levels of Achievement in Mathematics Learning

Achievement Levels	Pre-test			Post test			Differences	
	f_i	f%	F%	f_i	f%	F%	f_i	%
In the beginning	22	45.83	45.83	1	2.08	2.08	-21	-43.75
In process	19	39.58	85.42	11	22.92	25.00	-8	-16.67
In Expected Achievement	7	14.58	100.00	32	66.67	91.67	+15	+31.25
In Outstanding Achievement	0	0.00		4	8.33	100.00	+4	+8.33
Total	48	100.00		48	100.00			

In Table 2, we can see that after the program based on the "Use of GeoGebra software and playful strategies for learning in mathematics", the students were placed in "Outstanding Achievement" 8.33%, in "Expected Achievement" 66.67%, "In Process" 22.992% and only at the beginning 2.08%.

And in the hypothesis contrast, first of all, the Shapiro Will test was performed, obtaining a significance of less than 0.05, which means that the data have a non-normal behavior, determining the application of Wilcoxon's non-parametric test. (Table 3)

Table 3 Shapiro Wilk test for data normality in each of the dimensions and mathematics learning

Dimensions/DV	Shapiro – Wilk Pre-test			Post Test			Difference between pre and post		
	Statistical	Gl	Gis.	Statistical	Gl	Gis.	Statistical	Gl	Gis.
Quantity SSP	.851	48	<,001	.828	48	<,001	0.926	48	0.005
SSP of regularity, equivalence and change	.874	48	<,001	.867	48	<,001	0.950	48	0.039

SSP of Shape, Motion, and Localization	.866	48	<,001	.901	48	<,001	0.886	48	<0.001
Data Management & Uncertainty SSP	.855	48	<,001	.799	48	<,001	0.922	48	0.004
Learning Math	.948	48	.033	.943	48	.021	0.926	48	0.005

By applying the non-parametric test in the testing of hypotheses, both specific and general, according to the following table.

Table 4 Effects of the Program on Mathematics Learning and Its Dimensions through the Wilcoxon Test for Related Samples

	N			Average Range	Sum of Ranks	Z	Sig.asin. (bilateral
Quantity SSP	1a	41b	6c	21.79	893.50	-5.599b	<0.001
SSP of regularity...	6a	35b	7c	22.26	779.00	-4.604B	<0.001
SSP of form, movement...	9a	33b	6c	23.41	772.50	-4.101b	<0.001
Data Management SSP...	6a	27b	15C	18.19	491.00	-3.819b	<0.001
Learning Math	4a	41b	3C	24.51	1005.00	-5.512b	<0.001

According to Table 4, it can be seen that the value of "p" is less than 0.05, determining the acceptance of the hypotheses and the rejection of the null hypothesis. Therefore, the effectiveness of the program is demonstrated.

IV. DISCUSSION

The study carried out on the effect of the program based on "GeoGebra Software and playful strategies for mathematics learning in students of a state educational entity of Piura, 2023" based on the results of the Wilcoxon non-parametric test, whose results show a difference of 5,512 points between the post-test and pre-test, with a significance of less than 0.05 ($p<0.05$), which demonstrates the effectiveness of the program in the mathematics learning of students in the 5th year of secondary education.

About the effectiveness of the program regarding the use of GeoGebra and playful strategies. First, we focus on technology, where, Aguerrondo (2009) points out that, when making use of technology, students use their abilities to understand and solve problematic situations in their context. In the same way, Arévalo et al. (2020) point out that ICTs promote interest and enthusiasm for learning and should also take advantage of the student's proactivity in the use of technology.

Regarding GeoGebra, Leal et al. (2021), Ruiz (2022) and Villaroel (2022) define it as a mathematical software for algebraic and geometric calculation, representation and symbolization. Thus, as Prieto and Arredondo (2022), García and Martín (2022), Janampa et al. (2021), Hernández et al. (2021), and Rojas (2020) point out that through the use of GeoGebra, learning environments can be designed, developing mathematics learning and strengthening the digital skills of the student and the teacher.

Taking into account the importance of GeoGebra, there are studies that have determined its effectiveness in strengthening learning capacities in mathematics. Bermúdez

and Higuera (2022), in their research on the effect of GeoGebra, determined its impact on improving modeling, representation, and communication when solving problematic situations in mathematics. In the same way, Samura and Darhim (2023) in their research on the impact of GeoGebra, determined that its use allows the development of complex thinking, improving their reasoning, creativity and argumentation skills.

In the improvement of mathematics learning, dynamic strategies such as playful strategies play an important role, which have led to improvements in the level of student achievement. Fernández and Gómez (2020) define it as a proposal that allows a very favorable space for learning. Zaieg (2018) characterizes it as a strategy that allows recreation in learning and plays an important role in the didactics of mathematics. In this way, research such as that of López (2022) determined the effect of playful strategies in solving problematic situations in the context, improving reasoning, communication and understanding of problems. Sanchez (2019) determining its impact on mathematics where students, after its use, were placed at a good and satisfactory level of achievement. And finally, Cotrina (2018) and Carbajo (2018) in their research determined positive results about its usefulness in the learning of mathematics.

According to the results of the pre-test, the students were mostly placed in the lowest achievement levels, due to causes that limit the learning of mathematics. One of them is inadequate didactics and limited use of technology, a factor that Tigrero (2021) agrees with in his research on the effect of technological tools, where they determine that although 87.5% teachers know the usefulness of technology, they are not used. Teacher traditionalism, another factor, according to Bolaños et al. (2020) and Hernández et al. (2021), the teacher does not make use of interactive didactics, technology and causes minimal student participation in classroom activities. According to the WBU (2022) in a comparison of results from 2022 to 2019, students in the levels of achievement in mathematics had a negative trend, which has caused our country to be at the bottom of the results of international assessments.

Regarding the positive results of the post-test. They show the effect of the GeoGebra software-based program and playful strategies on mathematics learning. Thus, in solving problematic situations of quantity, about 50.00% of students are in "Expected Achievement" and more than 30% in "Outstanding Achievement", where the student has strengthened the skills of competence, such as translating verbal expressions into numerics, communicating mathematically, making use of procedures and strategies, and arguing processes and results (Minedu, 2016). Mosquera's (2023) research on the effect of GeoGebra on fraction learning, students improved by 35.3%, demonstrating interaction between students, knowledge, and teacher. Yerizon et al. (2022) on the use of GeoGebra in the application of a spreadsheet (Quantity) for problem solving, strengthening critical thinking skills.

In solving problems of regularity, equivalence and change, and the positive results are related to the research of Misrom et al. (2020), the student using GeoGebra, had a minimal improvement of 10.00% in learning linear functions. Ogbonnaya and Mushipe (2020) in algebra, determined the improvement in symbolic and graphical representations of linear functions. Students have the ability to represent algebraic expressions and graphs, know how to communicate, make use of strategies and procedures, and know how to argue the processes and results of problematic situations (Minedu, 2016).

The research related to the positive results obtained at the end of the program solves problematic situations of shape, movement and location, we have Delfi and

Qohar (2022), in the use of GeoGebra in trigonometry, students obtained a significant improvement in learning. Added to this is Ramírez et al. (2022) whose results of improvement in the use of GeoGebra, students interacted with knowledge, with their classmates and teacher, improving in the solution of geometric problems. Sevillanos (2022), Salcedo et al. (2021) and Zapata (2021) where through GeoGebra, students elaborated and built their knowledge, determined the geometric properties of objects and solved problematic situations.

The dimension solves problematic situations of data management and uncertainty, its positive results are related to the research related to Morales (2022) where he reveals the impact of GeoGebra on Mathematics competencies in an effective way, improving the skills that allow solving problematic situations, being included this dimension.

The research was based on the theory of constructivism, where according to Beltrán (2022) it pointed out that, for meaningful learning, students must interact with their environment and solve their own problematic situations. The program allowed students to interact freely with their classmates, as stated by Lee (2009) that in a good learning process the student has to develop in a learning space freely, getting their ideas across, and knowing how to support their arguments. In socio-cultural, the student related to his environment, where the students supported each other and also the support of the teacher. Haynes et al. (2003) point out that a student depends on social and emotional conditions for good learning, which will allow him or her to develop cooperatively, organized, and positive at all times. In the same way, Sultan and Artz, (2011), the teacher must have qualities that allow motivating the student, that is, the teacher must be creative and innovative, adapting to the needs and demands of the student.

In mathematics, according to Minedu (2016), it has four competencies, where our program has been directed. In other words, as López (2020) points out, the student mobilizes cognitive and procedural skills; attitudinal skills and values that allow them to be applied in the context while respecting the person and society. Masciotra (2018) the student must know how to act, arrange, situate himself, and position himself, which allow him to improve his learning.

As mentioned above, the learning of mathematics, is related to didactics and technological resources that allow strengthening basic and complex learning skills. These will depend on the updating and training of the teacher, however, these will be subject to the teacher's decision to improve learning.

V. CONCLUSIONS

1) The application of the GeoGebra software-based program and playful strategies have significant effects on mathematics learning in students from a state entity in Piura, 2023; where the students had very significant results found in the difference between the pre-test and post-test ($Z = -5.512$ and a significance < 0.001)
2) The development of the program based on GeoGebra Software and playful strategies has positive effects on the dimension of solves problematic situations of quantity in the students of a state educational entity of Piura, 2023; in which the students had very significant improvement results due to the differences found in the pre and post test ($Z = -5.599$, and a significance < 0.001).
3) The development of the program based on GeoGebra Software and playful strategies has positive effects on the dimension of solves problematic situations of regularity, equivalence and change in the students of a state educational entity of Piura, 2023; in which the students had very significant improvement results due to the differences found in the pre and post test ($Z = -4.604$), and a significance < 0.001).

4) The development of the program based on GeoGebra Software and playful strategies has positive effects on the dimension of solves problematic situations of shape, movement and location in the students of a state educational entity of Piura, 2023; in which the students had very significant improvement results due to the differences found in the pre and post test (Z = -4.101), and a significance < 0.001).
5) The development of the program based on GeoGebra Software and playful strategies has positive effects on the dimension of solves problematic situations of data management and uncertainty in students of a state educational entity in Piura, 2023; in which the students had very significant improvement results due to the differences found in the pre and post test (Z = -3.819), and a significance < 0.001).

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