The use of GeoGebra and its impact on the academic performance of Mathematics in high school students

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Abstract

This research aims to analyze the impact of GeoGebra use on high school students' academic performance in mathematics. It was conducted using a mixed-methods research approach, based on an experimental design at the correlational-explanatory level, with instruments including a pre-test, a post-test, and a survey. The pedagogical intervention focused on using GeoGebra to teach functions in mathematics. The results showed significant progress in academic performance, as reflected in the pre-test-post-test comparison, as well as a positive perception among students of the application's use. Likewise, an increase in participation was observed as critical thinking developed, especially in resolving contextualized problems. It was concluded that GeoGebra is an effective tool for reinforcing the teaching-learning process in mathematics, facilitating the understanding of concepts through dynamic visualization and interaction with reality.

Keywords: *GeoGebra, Academic Performance, Mathematics, Functions, Critical Thinking.*

INTRODUCTION

The implementation of educational technologies in mathematics teaching and learning has become a crucial topic, as various applications have been introduced to facilitate visualization, exploration, and critical thinking. At the high school level, the content covered, such as functions, limits, and geometry, requires integrating concepts based on exploration.

The main problem identified at the Unidad Educativa "Academia Militar San Diego" (Academia Militar San Diego Educational Unit) is that its high school students showed significant difficulties in the academic performance of Mathematics, specifically in solving function problems, interpreting graphs, and applying algebraic procedures. These weaknesses were also reflected in the limited development of critical thinking, as many students had difficulty analyzing results, proposing alternative solutions, and establishing clear relationships between variables in problem-solving situations. Similarly, a reduced ability to teach mathematical concepts through real-life problems was observed, affecting students' understanding of the practical usefulness of mathematical functions in real-world contexts.

In the same way, it was found that the institution has not implemented innovative educational methodologies based on the GeoGebra Software, thereby failing to take advantage of its potential for dynamic visualization, mathematical experimentation, and interactive learning. The lack of strategies supported by technological tools limited students' motivation and reduced opportunities to strengthen higher-order cognitive skills in analysis, interpretation, and problem-solving.

As mentioned above, according to Salas et al. (2025), who clarify: "The use of GeoGebra facilitated the learning process regarding constant, linear, quadratic, reciprocal, and cubic functions." (p. 95). Therefore, the use of GeoGebra increases active participation, graphing, and meaningful understanding of functions, all of which are associated with higher-quality student work.

This research aims to evaluate the impact of GeoGebra use on high school students' academic performance in Mathematics, particularly in terms of interactivity and classroom work, by measuring its effect on grades for the content unit, while maintaining consistency with the graduation profile established for the educational institution. Based on the above, the following research question was formulated: Is the use of GeoGebra associated with significant improvements in high school mathematics grades compared with traditional methods?

Open-Source Software in Education

GeoGebra is classified as free and open-source software; therefore, it is an essential tool for educational settings. Its characterization helps ensure that it can be implemented within educational institutions without restrictions on access or cost. Therefore, in accordance with the authors Morales et al. (2023), who clarify: "… it lets you effectively graph the mathematical concepts and procedures through images and graphs, which greatly helps students to master and understand concepts and procedures related to functions" (p. 10).

GeoGebra functionalities

Among the features available in the GeoGebra application, there are numerous mathematical representations ranging from simple graphs to three -dimensional vector simulations; as specified by the authors Cevallos and Mestre (2023): "…creating simulators with GeoGebra strengthens collaboration between teachers and students, fostering responsibility, commitment and mutual care." (p. 5).

Dynamic Graphing of Functions

According to the authors Dávila et al. (2024), who contrast: "… used GeoGebra as a teaching strategy to collect data and demonstrated that the experimental group that received classes with GeoGebra obtained a higher academic performance than the control group" (p. 6). That is, the use of the GeoGebra digital tool significantly enhances the student's academic performance by fostering understanding and critical thinking.

As mentioned before, the interaction with the GeoGebra tool promotes critical reasoning and decision-making, as students can experiment, interact, and verify results through the application's graphical interface, thereby reinforcing meaningful learning.

Active participation

The use of GeoGebra, supported by the flipped classroom learning methodology, is a fundamental pillar, as students interact with the digital tool only under the teacher's guidance, making them active participants in the learning process in the classroom. This, according to the authors Salas et al. (2025), who clarify: "Outside the classroom, students used the tool to solve problems. In face-to-face classes, the teacher promoted collaborative work and the exchange of ideas based on the results generated with GeoGebra." (p. 87). Therefore, the use of the flipped classroom methodology in GeoGebra promotes motivation, autonomy, and commitment among students as they develop mathematical competencies, thereby enhancing classroom dynamics.

Development of critical thinking

In accordance with the authors Salas et al. (2025), it is established: "In the field of mathematics, the flipped classroom and digital tools have improved academic performance, motivation, participation, learning, critical thinking, …" (p. 87). Considering the above, the use of the GeoGebra tool is an academic boost for students, since it promotes critical thinking, and for the teacher, who becomes a facilitator and guide in learning, so that students create their own criteria for solving problems in mathematical exercises in everyday life.

Consequently, regular work with GeoGebra enables students to compare strategies, identify errors in math exercises, and explore alternatives that lead to solutions through an analytical approach, thereby strengthening their mathematical reasoning.

METHODOLOGY

The present research was conducted at the "Academia Militar San Diego" Educational Unit in the city of Ibarra and included its high school students as participants. Its purpose was to evaluate the use of GeoGebra and its impact on academic performance in Mathematics. For this study, a mixed-methods approach was employed to integrate quantitative and qualitative data, providing a comprehensive view of the problem under study. According to Prado and Sánchez (2021), who specify: “this methodology involves collecting, analyzing, and linking quantitative and qualitative data. It also employs various types of research techniques and instruments” (p. 262).

The paradigm used was positivist, as objective measurements were taken to quantify the procedures performed in the GeoGebra application; an experimental design was developed to assess the effect of using the digital application on student performance compared to traditional methodologies. The study was correlational, as it sought to evaluate the relationship between performance and mathematical learning. According to the authors, Youtibug et al. (2025) clarify: “A positive perception of GeoGebra correlates with better academic performance and a greater interest in mathematics” (p. 17). This was field research, so data were collected in the students' actual environment, without altering the educational setting. The intervention was carried out in real classrooms, allowing researchers to observe the impact in authentic conditions. This approach facilitated the direct collection of results, thereby increasing the study’s validity; consequently, it was essential for evaluating the actual impact of the GeoGebra application on high school students.

Population and sample

The sample was selected using purposive, non-probabilistic sampling. This decision was made because the classes had already been formed by the school, making it impossible to select participants at random.

Data collection instruments

Surveys and academic achievement tests were used as data-collection instruments in this research. First, a diagnostic test was administered to the students to assess their knowledge of mathematical functions and their prior experience using digital and technological tools in learning mathematics.

Subsequently, after the GeoGebra-mediated instructional activities were completed, a post-test with characteristics similar to the initial assessment was administered. This instrument enabled the collection of information on changes in students' academic performance and the analysis of the effect of using GeoGebra as a teaching tool in the teaching-learning process.

As a complement, the survey was administered to students in the experimental group to assess their perceptions of GeoGebra's use in teaching functions in mathematics classes. The survey had aspects related to content understanding, class participation, and the level of motivation generated by the use of this technological tool.

Survey: This survey was conducted on a non-probabilistic sample of 159 high school students (BGU -acronyms in Spanish) with closed-ended questions to obtain quantitative data on student performance and participation.

Performance test: An experimental group was formed to carry out activities without a digital application, and a control group was established to evaluate, by group, the impact of using GeoGebra with students in computer labs and of using traditional methodologies in classrooms without computers.

Validation of Research Instruments

The research instruments underwent a validation process based on expert judgment to ensure their relevance, clarity, coherence, and alignment with the study variables, as stated by Balderas et al. (2022): "…they suggest that the number of experts to be considered in a judgment depends on their level of experience and level of knowledge" (p. 10). Two specialists in research methodology and mathematics with a focus on educational technology participated in the process and reviewed the Likert-scale survey. The evaluation made it easier to verify that each item was designed to measure aspects related to the use of the GeoGebra application and its impact on the academic performance of high school students.

Table 1

Research Instruments Validation Matrix

Validator	Profession	Analysis
Efraín Velastegui López	Doctor in Educational Research – Universidad Bolivariana del Ecuador	The instrument contains clear and precise instructions so that surveyed individuals can

		answer the questions appropriately.
Iza Yugsi Pablo Gabriel	Master's in Pedagogy for Digital Environments– ACMIL Teacher – San Diego	The instrument does not contain an excessive number of questions; therefore, it is deemed suitable for the research being conducted.
Hamilton Omar Pérez Narváez	Doctorate in Educational Research – Central University of Ecuador	The collection instrument meets the requirements stipulated in the submitted heading.

Note: The validation performed on the survey before its administration is shown.

RESULTS AND DISCUSSION

The results from the Google Forms survey conducted during the pretest showed that, overall, students performed at an average level on the math tasks, in accordance with the established performance rubric. In descriptive terms, the study found that students had difficulty interpreting mathematical functions and solving real-life problems. These preliminary results provided a clear baseline for measuring students' prior knowledge before the GeoGebra app intervention.

Table 2

Pre-test Performance Rubric

Score	Level	Description
0 – 4	Low	The group had significant difficulty identifying and understanding mathematical functions and their applications.
5 – 7	Medium	The group demonstrated a partial understanding of basic function concepts and managed to solve simple exercises.
8 – 10	High	The group demonstrated conceptual domain knowledge, analytical ability, and critical reasoning in everyday life situations.

Note: Developed by the authors

For the quantitative analysis, descriptive statistics—specifically the mean, median, and standard deviation—were used to characterize the group’s performance as a starting point. Similarly, the Test of Normality (Kolmogorov-Smirnov) was applied to determine the correct distribution of the data ($p<0.05$), and later, the application of the Student’s T-test for paired samples as an inferential strategy in the comparison with the post-test. This, in accordance with the authors Asqui et al. (2025), who specify: “The diagnostic survey (pretest) was administered to identify the teachers’ prior practices …” (p. 615).

Table 3

Pre-test Rubric Performance Results

	Frequency	Percentage
Low level	18	11.3%
Middle Level	50	31.4%
High level	91	57.2%
Total	159	100%

Note: Analysis of Pre-test Performance Levels Using SPSS Software

According to the results, it was evident that the students had a medium Level with a tendency toward high; therefore, the intervention using GeoGebra is ideal, as the students reported feedback indicating that their academic performance can be significantly improved with the help of the GeoGebra software.

Table 4

Kolmogorov-Smirnov Test of Normality

	Statistic	df	p-value
Performance	0.176	159	<0,001

Note: Normality test performed using SPSS software

Based on the discussion, these results were consistent with various studies in which students initially experienced difficulties solving math problems using traditional methods. As stated by the authors Tocto et al. (2023), who state: “… at the national level, there has been a shift in how teaching methodologies are approached, with a current emphasis on Information and Communication Technologies (ICT); this is how we can see a difference in teaching compared to traditional methods” (p. 7232).

Taking into account what has been stated and elaborated upon using the Kolmogorov-Smirnov test, which, according to Molina and Molina (2025), “…is its ability to evaluate the fit of data to a variety of theoretical distributions, not limited solely to the normal distribution. This makes it particularly useful in areas where data distributions may display various patterns…” (p. 160). Therefore, taking into consideration the null hypothesis that specifies: “Students perform well in mathematics”; and the alternative hypothesis: “Students perform poorly in mathematics.” Upon contrasting, the resulting p-value ($p<0.05$) supported the alternative hypothesis; therefore, the baseline level of knowledge for the GeoGebra application was established.

Table 5

Post-test Performance Rubric Results

	Frequency	Percentage
Low level	0	0 %
Middle Level	0	0 %
High level	159	100 %
Total	159	100 %

Note: Analysis results of post-test performance levels conducted using SPSS software

The post-test results showed significant progress in the students' academic performance, with a notable increase in high-level performance, according to the applied rubric.

Table 6

Kolmogorov-Smirnov Test of Normality

	Statistic	df	p-value
Performance	0.521	159	<0.001

Note: Normality test performed with SPSS software

To obtain inferential results, a Student's t-test for paired samples was used to compare pretest and posttest scores. Based on the above, the results showed statistically significant differences ($p < 0.05$), which supported the research hypothesis regarding the positive impact of using the GeoGebra application. Taking into account the author Sánchez (2015), who specifies: "…it was designed to examine differences between two independent, small samples that have normal distribution and homogeneity of variances…" (p. 59).

Table 7

Student's t-test performed on Pre-test and Post-test scores.

	Mean	N	Standard Deviation	Standard Error Mean
Pretest	7.48	159	2.201	0.175
Posttest	9.87	159	0.386	0.031

Note: Analysis and comparison of means and T-test deviation

Table 8

Student's t-Test considering the significance of Pre-test and Post-test

	t	df	p-value
Pretest - posttest	-13.706	158	<0.001

Note: Significance of the Student's t-test

As the discussion unfolded, these Findings were consistent with other studies on the capability of educational software to significantly improve mathematics performance, particularly in areas focused on the development of critical thinking—as GeoGebra facilitated conceptual understanding. This is in accordance with the authors Zambrano et al. (2024), who mention: “This is because these tools allow you to personalize learning, provide immediate feedback and make it easier to understand complex concepts…” (p. 53).

Table 9

Matrix of Results from Surveys

Questions		I totally disagree	I disagree	Neither agree nor disagree	I agree	I totally agree
Q1	GeoGebra was easy to access and use both inside and outside the classroom.	0 %	0 %	1.3 %	20.1 %	78.5 %
Q2	GeoGebra tools were easy to understand and use during classes.	0 %	0 %	5.7 %	21.4 %	73.0 %
Q3	GeoGebra offered useful features to solve mathematical problems efficiently.	0 %	0.6 %	2.5 %	20.8 %	76.1 %
Q4	GeoGebra helped me better understand the graphs of mathematical functions.	0 %	0 %	3.8 %	17.0 %	79.2 %

Q5	When I changed values in GeoGebra, I could see immediate changes in the graphs.	0 %	1.3 %	1.3 %	14.5 %	83.0 %
Q6	The activities carried out with GeoGebra made maths classes more dynamic	0 %	0 %	1.9 %	20.1 %	78.0 %
Q7	Using GeoGebra helped me engage more with the math content.	0 %	0.6 %	3.1 %	19.5 %	76.7 %
Q8	GeoGebra made it easier for me to solve problems that I had previously found difficult.	0 %	1.3 %	6.3 %	21.4 %	71.1 %
Q9	The use of GeoGebra helped me to develop greater autonomy in solving mathematical exercises.	0.6 %	1.9 %	6.3 %	16.4 %	74.8 %
Q10	Using GeoGebra allowed me to analyze different ways to solve the same	0 %	1.9 %	5.0 %	17.0 %	76.1 %

	mathematical problem.

Note: Analysis of Survey questions with SPSS software

In accordance with the data presented by the research tool—a Likert-scale survey—it was evident that students expressed a positive perception of the GeoGebra platform and its built-in resources, based on the responses submitted via Google Forms, a trend was observed toward the "agree" and "totally agree" categories, highlighting aspects such as ease of use, interactivity, and improved understanding of mathematical functions. These results reinforced the application's adaptation as a teaching tool.

Table 10

Reliability Statistics using Cronbach's Alpha

Cronbach's Alpha	N of items
0.929	10

Note: Reliability analysis of the surveys

To analyze the data statistically, descriptive statistics were used to evaluate the reliability of the investigative instrument using Cronbach's alpha coefficient, yielding values above 0.9, confirming that the research instrument is highly reliable. As a result, a direct analysis was conducted of the impact on students' academic performance in functions. This, according to the authors Toro et al. (2022), states: "…on scales with items that have multiple-choice responses, using the principles of correlation assumes that the proportion of variance is consistent with the participants' answer tendency." (p. 15).

The results indicated that the use of GeoGebra significantly improved the academic performance of high school students. The comparison between the pretest and posttest revealed a significant improvement in student performance, demonstrating the effectiveness of interactive technological tools in mathematics learning. These findings are consistent with research by Dávila et al. (2024), who found that students who used the GeoGebra app achieved better academic results than those who used traditional teaching methods. Similarly, Guerrero et al. (2025) explained that GeoGebra Classroom facilitated dynamic visualization and conceptual understanding of functions in mathematics, thereby strengthening students' active participation.

In contrast, the authors Medina et al. (2025) asserted that GeoGebra not only improves academic performance but also enhances motivation and fosters a positive attitude toward mathematics. In this research work, a favorable perception of the students regarding the use of the tool was evidenced by the interactivity, flexibility, and autonomy in the resolution of exercises.

According to critical thinking, the results showed that the students were able to analyze different solution strategies and correctly relate mathematical variables. This coincides with the authors Salas et al. (2025), who agreed that digital tools and the flipped classroom enhance analytical skills and active participation in the classroom.

Finally, the results obtained allow us to affirm that GeoGebra is an effective pedagogical tool to strengthen mathematical learning in high school educational contexts.

Proposal

The purpose of this educational proposal is to implement GeoGebra to support interactive activities that enhance students' academic performance, active participation, and creativity in the classroom. In today's society, educational apps are revolutionizing educational institutions by promoting innovation and driving positive, relevant changes in educational management in the countryside, with an emphasis on teaching practices. This approach fosters learning and the development of new knowledge through technological tools that feature digital content. The above findings are also corroborated by Guerrero et al. (2025), who explain: "GeoGebra enables students to construct and experiment with graphical representations of functions, observing in real time how their properties change when modifying parameters" (p. 4568).

In developing this research proposal, students are required to have access to electronic devices such as computers, laptops, cellphones, or tablets, or, if applicable, to a computer laboratory with a stable Internet connection. This section is essential because using all the application's features requires reliable network connectivity and up-to-date versions with graphics and dynamic tools. As demonstrated by the authors Gerrero et al. (2025): "However, there were also some limitations that could have influenced the results, such as occasional difficulties in accessing the Internet, immediate availability of technological devices for some students, and certain initial barriers in the use of the tool…" (p. 4579).

Validation of the proposal

The proposal, which was based on the use of GeoGebra, was validated through expert judgment and a structured evaluation rubric administered to specialists in research methodology and educational technology in mathematics. The purpose of this process was to assess the strategy's relevance and feasibility before its formal implementation. For this purpose, five quantitative evaluation criteria and one qualitative assessment criterion were established.

Table 11

Technological Proposal Validation Matrix

Validator	Profession	Quantitative valuation

Hamilton Omar Pérez Narváez	Doctor in Educational Research – Central University of Ecuador	4.5
James Alduber Taramuel Villacreces	Doctorate in Educational Research – Central University of Ecuador	5
Luis Alberto Zapata Villacís	Master in Mathematics Teaching – Central University of Ecuador	5

Note: This table shows that the proposal is viable for current research

The results obtained showed a favorable evaluation of the proposal assigning within each criterion the following: In terms of the proposal's relevance, it received an average score of 4.6, with particular emphasis on its logical structure, objectives, and methodology; regarding institutional feasibility, the score was 4.88, given that the educational institution has a computer lab and basic resources for implementation, although it was suggested that connectivity and the lab's available usage time be improved; In terms of relevance, the proposal received an average score of 5, as the specialists agreed that the pedagogical strategy directly addresses the problem at hand.

In summary, the average rating was 4.83 out of 5, indicating that the proposal is very viable and relevant. According to the observations issued, adjustments were incorporated to specify certain achievement indicators, extend GeoGebra practice time, and reinforce execution within GeoGebra. These results confirm that the proposed strategy has specific bases for implementation and provide evidence of improved academic performance.

Development of the proposal

As stipulated, an activity has been created in GeoGebra for the corresponding interaction and is accessible via the following link: https://www.geogebra.org/m/nxvqzmuj. According to the link provided, several days of training were scheduled to adapt the GeoGebra application to the topic of Functions in Mathematics.

Table 12

Implementation schedule

Phase	Week	Activity
Diagnosis	1	Pretest application
Training	2	Teaching workshop
Implementation	3-7	Strategy implementation

Evaluation	8	Posttest and Survey

Note: Specification of times for the development of the proposal

Specifically, during the diagnostic week, a pretest was carried out to assess high school students' level of knowledge regarding their academic performance; during the training week, training and planning workshops were held for students on the pedagogical use of the GeoGebra application; during the strategic implementation phase, activities were organized over five weeks and included interactive exploration of functions, manipulation and interaction with variables within the application, solving real-life contextualized problems, and collaborative work in the lab; Finally, during the evaluation phase, both the posttest and the survey were administered. Mean scores were compared using Student's t-test, as specified above, and descriptive statistics were derived from the survey results.

Among the strengths of the GeoGebra application is its ability to provide interactive visualizations of functions, which helps students understand how changes in different parameters affect both the shape and the behavior of each proposed exercise. According to the authors Villavicencio and García (2025), who specify: "By facilitating the visualization of abstract concepts and promoting a more interactive and collaborative approach, GeoGebra contributes to building a solid foundation of mathematical knowledge" (p. 197).

Another benefit of the app is that it makes it easy to verify results and test multiple solutions in real time immediately. This advantage motivates the student and their mathematical exploration, which causes active learning. This is in accordance with the authors Medina et al. (2025), who clarify: "… GeoGebra's impact transcends the cognitive realm, as it also fosters positive attitudes toward mathematics, stimulates active classroom participation and strengthens collaborative work." (p. 25).

The app includes exercises related to real-life situations, such as growth analysis, economic activities, variations, and connections to everyday contexts. According to the authors Villavicencio and García (2025), who establish: "The results obtained in this research, which include significant improvements in academic performance, active student participation, and general satisfaction, support the implementation of this methodology in the Ecuadorian educational context." (p. 196).

Analysis of the proposal

After the implementation of the GeoGebra-based proposal, significant improvements were observed in the academic performance of this institution's high school students; the pretest results showed several difficulties in understanding mathematical functions, particularly in real-life problem-solving contexts.

During the pedagogical intervention, it was found that the students participated actively, recognized the relationships between variables in each of the functions studied, quickly identified the types of functions, and had a better understanding of how to resolve contextualized problems in everyday life.

Following the activities described above, the post-test results showed a very positive increase in students' academic performance, far exceeding the expected improvement within the intervention.

Among the main results were:

- Greater understanding between algebraic and graphic representations.
- Increase in the active participation of students in learning activities.
- Improved ability to solve contextualized mathematical problems.

Key points highlighted in the proposal included that GeoGebra software facilitated understanding of abstract concepts by allowing interaction with variables in each function graph, which significantly aided visualization of exercises. The findings of the present research were consistent with other studies showing improvements in students' academic performance.

However, during the implementation of the proposal, several limitations were identified, including difficulty in using electronic devices and limited internet access at the educational institution, along with the need to strengthen learning within the institution; despite this, experience shows that the integration of educational technologies can bring about transformations in teaching and learning processes, thereby promoting improvements in students' academic performance.

Example of the proposal in GeoGebra

Application of pretest

Figure 1

Evidence of pretest application

Note: Photographic evidence of pretest application in Google Forms by authors.

To identify the strengths and weaknesses in the themes of Mathematics Functions, a pretest was developed as a starting point to improve knowledge through the implementation of the GeoGebra application.

Activity: GeoGebra Virtual Workshop

Figure 2

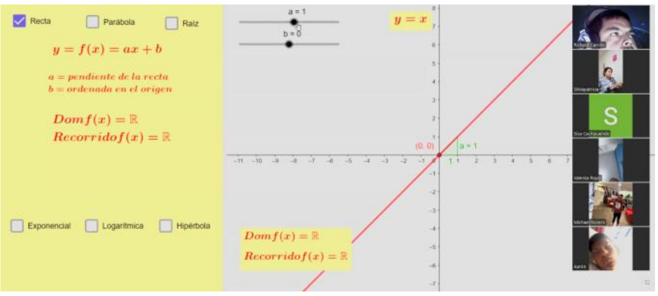
Evidence of the virtual workshop held during the workshop weeks.

Note: Photographic evidence of the workshop initiated in the GeoGebra application

It continued with a workshop on basic GeoGebra, explaining how to start the application and join the class, along with proposed activities.

Figure 3

Evidence of Strategic Implementation



Note: Photographic evidence of GeoGebra software implementation

Within the strategic implementation, implementation activities were taught through exercises on functions and interactive GeoGebra activities to improve their academic performance.

Figure 4

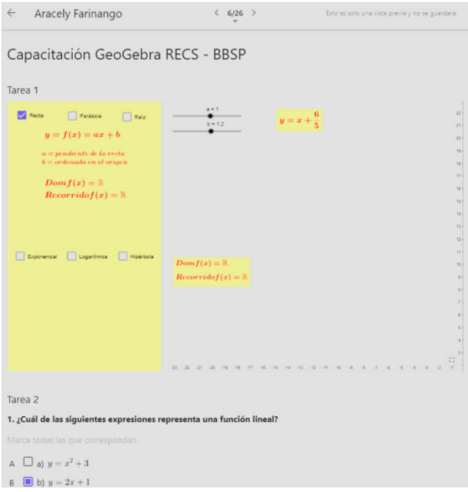
Evidence of Post-test application with GeoGebra software

Note: Photographic evidence of the application of the post-test with students, by the authors.

Once the activities were implemented, the students were provided with links to take the post-test in different ways, such as via a QR code, an invitation link, or a synchronous meeting chat.

Figure 5

Evidence of post-test application



Note: Review of activities in GeoGebra Classroom.

As an innovative initiative, this proposal outlines the structured implementation of GeoGebra as a teaching strategy to improve high school students' academic performance in mathematical functions, integrating digital resources, contextualized activities, and evidence-based assessment. Unlike traditional teaching methods, which focus solely on theoretical explanations and the mechanical solving of exercises, this approach incorporated interactive experiences in which students manipulated specific variables or elements of each function, observed real changes, and developed mathematical interpretations based on dynamic visualizations. This approach transformed the student's role from a passive recipient to an active learner, fostering the progressive development of analytical skills.

Similarly, the program takes an innovative approach by combining the teaching of functions with critical-thinking processes through the resolution of everyday problems, such as growth, variation, relationships, and the modeling of daily activities. Evidence shows that a structured methodological approach—comprising assessment, training, intervention, and validation of results—ensures the program's feasibility and scientific validity. As a result, it not only introduces an additional tool into the classroom but also establishes a replicable model of educational innovation that can be adapted to other areas of mathematics to improve students' academic performance.

CONCLUSIONS

In accordance with the general objective of analyzing the impact of GeoGebra use on academic performance in Mathematics, it was concluded that the GeoGebra application had a favorable impact on the academic performance of students at the institution: "San Diego Military Academy." A comparison of pretest and posttest results confirmed improvements in solving function problems, interpreting graphs, and applying mathematical procedures, demonstrating the positive effect of the instructional intervention implemented using the digital tool.

In line with the work, it was determined that the design and implementation of GeoGebra-based activities with guided interactivity strengthened understanding of function-related content. Activities focused on manipulating parameters, constructing graphs, and dynamic analysis helped students establish relationships between variables using Student's t-test; they recognized patterns of behavior and improved their academic performance in areas where they had previously struggled.

It was found that students who used GeoGebra performed better academically than those who received traditional instruction. The differences observed in the performance categories studied indicated that 100 percent of the students at this institution showed a very significant improvement in their understanding of mathematical functions.

A positive relationship was found between the use of the GeoGebra application and the academic performance of high school students. The data obtained through the research proposal showed very positive perceptions of the usefulness of Mathematics, participation levels, critical thinking, and academic performance.

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