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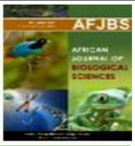

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GeoGebra teaching methodology" program to improve mathematical competence in an educational institution, Cusco 2023

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Abstract
The general objective of this research was to establish the effect of the application of the GeoGebra teaching methodology program on mathematical competence in an educational institution, Cuzco 2023. In order to carry it out, a quantitative approach, basic typology and quasi-experimental design were used. For this purpose, two groups (control and experimental) were selected, each comprising 28 students. A test was carried out in 2 moments: a pretest and a posttest after a total of 10 sessions where the main mathematical competences were strengthened through the use of GeoGebra software. After applying the tests, since the data were parametric, Student's t statistical analysis was used. The results showed that the application of the program significantly improved mathematical competence, since the p-value was less than 0.05. In the case of the specific results, the application of the software did not have an impact on the improvement of the ability to solve problems of regularity, equivalence and change (p value= 0.648). On the other hand, GeoGebra did have a positive impact on the improvement of the dimension solves problems of shape, motion and location (p value= 0.000).
Key words: software, GeoGebra, competency, mathematics.

INTRODUCTION

Education plays a vital role in creating citizens who can change the world. This requires going beyond simply imparting knowledge and focusing on the holistic development of individuals, promoting the skills, values and attitudes that will enable them to become agents of positive change in society, as well as focusing on students being the actors of their own learning, promoting positive, meaningful and relevant learning experiences that are appropriate to the context and needs of the learner, Therefore, emphasis should be placed on the development of important 21st century skills, such as critical thinking, creativity, effective communication, collaborative work, problem solving based on mathematical thinking, responsible use of technology and its applicability in mathematics (UNESCO, 2020).

Therefore, within the international context, the work done by teachers must be addressed immediately, which requires improvements in educational policies in several countries, in order to ensure trained and exempt teachers in their work responding with relevance to the nature and diversity of students, coexisting at present, various investigations that have focused on determining the best strategies, methodologies and technological resources that impact significantly on student learning in the world. This search is related to Sustainable Development Goal number four, which seeks to ensure quality education. Therefore, this goal, as well as the present research, wishes to enhance the talents and skills of students, since a quality education is the best tool to access a desirable quality of life (UNESCO, 2020).

On the other hand, high quality mathematics education is fundamental for personal and social development because it enables critical thinking, problem solving and informed decision making. UNICEF is aware of the importance of this field and has proposed various initiatives such as continuous and in-depth training of teachers to teach mathematics effectively, using innovative methods (ICT), taking into account the individual needs of students and introducing the use of educational tools. resources and technology. At the same time, it calls on teachers, families and communities to work together to ensure that all students have access to a high quality mathematics education that helps them develop the skills and knowledge necessary to maximize their potential and contribute to a better world (UNICEF, 2021).

On the other hand, teaching and learning mathematics is easy for teachers committed to involving students in mathematics, since the idea is not to overwhelm them with problems that they cannot solve, but to motivate them to explore so that they seek the solution to the problem (Bacher-Hicks et al. 2021; UNESCO, 2022). In this case, there has always been the question of how to make children and students take interest in mathematics, since some teachers have concluded that the best way is to do essays and projects that promote the attraction of children and not take it as just another qualifying subject, since knowledge is much more important than an evaluation, because they will carry this knowledge throughout their lives and will put it into practice in the future (Castro et al., 2020; UNESCO, 2022).

On the other hand, The Organization for Economic Cooperation and Development (2018) recognizes the importance of mathematics education for personal and social development and therefore recommends the use of GeoGebra, an interactive and dynamic software to improve mathematics learning. Therefore, it is necessary to train teachers to integrate this software. in their classroom, design appropriate learning activities, provide students with adequate support, and encourage collaboration and sharing of experiences among teachers using GeoGebra. This can be done through online communities, social networks and educational events that allow sharing best practices and effective strategies (UN, 2022).

On the other hand; the Ministry of Education (2023), indicated that the low performance of students in both international and national evaluation contests revealed that, regarding competencies in mathematics, at the reading comprehension and science level, Peru ranked 64th overall for 15-year-old students. A total of 77 countries participated, the same as in the 2015 assessment. It is worth noting that in 2015, the average score in reading was 398, the average score in the math assessment was 387 and the average score in science was 397. In the previous exam conducted in 2018, the results ranged from 400 to 404 points, with the highest in science. Although there has been a slight improvement in math and science, this score is still below that of other South American countries such as Chile. Chile's world average score is 452 points. Therefore, Colombia, which achieved an overall average of 412, or Brazil, which achieved an average of 413, are still the last countries in the region (Ministry of Education of Peru, 2019).

On the other hand, in the Peruvian case, it can be mentioned that more than 40% of students from different public schools in Lima have benefited in the learning and practice of mathematics through a digital platform to which they can access videos, practical exercises and reviews in a personal way for students at any time or place. Teachers can review all the progress students have made as they practice and execute math problem solving (Ministry of Education, 2018).

Similarly, Minedu (2016) states that, to better understand geometry, it is essential to mobilize the structure. In this way, it is possible to be in everything, to know which properties are treasured despite change. Therefore, it is necessary to abolish the traditional methods of teaching geometry using pencil and paper or slate and chalk as excellent teaching materials. Likewise, in Peru, there are 74% of students with mathematical inefficiencies so the SINEACE (2016), made the publication of the book “Standards of learning mathematics”, where science is taught in a pedagogical and attractive way from the beginning of educational teaching and all the following steps (Ministry of Education, 2016).

Therefore, these mathematical competencies are fundamental for the day-to-day life of citizens, since, through these, logical and coherent thinking is built through abstraction, but to achieve this affirmation must be had from the beginning of education (Ishartono et al., 2022).

In addition, Alvarez et al. (2019), who confirmed that GeoGebra's automaticity makes mathematics lessons articulated, connected, collaborative learning and logical thinking are practiced. In doing so, schoolchildren will appreciate the discipline of mathematics because they will see how to apply what they have learned in class to their daily lives (Weinhandl et al., 2020). In addition, he states that GeoGebra can be used to suggest, evaluate and dissipate mathematical problems in alliance with the performance of each schoolchild. Similarly, Poveda and García (2020) affirms that technological resources enable innovation in methodological skills. Poveda rejects involuntary processes and originates the discovery, or trial-and-error learning, which makes GeoGebra perfect to achieve this goal.

In this sense, from a local context, this national problem is a reflection of what is happening in an educational institution in Cusco, because in recent years, it is evident that teachers, especially those who belong to the area of mathematics, do not use continuously or efficiently some kind of learning software to teach their lessons. This results in students being limited in using strategies that allow them to solve the problems posed, especially considering that basic education is the best stage for the person to strengthen their skills and acuity to solve problems that arise in daily life. Otherwise, in adulthood, it will be more complex to put into practice their mathematical skills and allow them to solve everyday problems. Likewise, the absence of the use of these technological resources comes mainly from teachers who are still rooted in the traditional teaching model. If this reality does not improve, the inequality gap in the path to strengthen their mathematical competencies will be more notable in comparison with students who use various technological programs, one example being GeoGebra.

In this context and from the problematic reality exposed, the following general problem was formulated: What is the effect of the application of the program “Geogebra Teaching Methodology” on mathematical competence in an educational institution, Cuzco

2023? Regarding the specific problems, these were focused on answering: What is the effect of the application of the GeoGebra teaching methodology program in the dimensions of ability to solve problems of change and equivalence, regularity, as well as the ability to solve problems of location, movement and shape in an educational institution, Cusco, 2023?

The present work was justified theoretically because significant information was collected as theories, concepts, approaches and other areas of research prior to this study, at the same time a systematic search was made of platforms and repositories that give support to this research, in addition the report will expand the knowledge about mathematical competencies, here lies the importance of using the GeoGebra program (free software for dynamic mathematics), designed for any level of education. It brings together the fields of geometry, algebra, mathematical analysis, a program that combines graphics and statistics in a single tool to help you gain introductory theoretical knowledge.

Likewise, the practical justification is given in such a way that the academic community will benefit from the findings of this study. Advances in technological education, the applicability of mathematical competencies and using GeoGebra software, students can now also develop skills and competencies in education to more meaningfully process exercises based on real situations, even more so as mathematics education strives to go beyond the mere transfer of knowledge, focusing on the development of students' skills and critical thinking, The use of technological tools such as GeoGebra has become a worthy source to achieve this goal, providing more dynamic, interactive and effective learning at the secondary level, while promoting the exploration of mathematical models, making assumptions, manipulating objects, verifying results and, above all, simulating real life situations with functions that allow students to analyze and predict behaviors.

A valuable methodological contribution consisted in providing a useful tool that allows the teacher to objectively evaluate mathematics competencies. This is because the tool is well established and empirically validated, which ensures that the information collected and processed can help improve the formula, design or aspects used; furthermore, the use of GeoGebra in secondary mathematics education is based on a constructive and experiential methodological approach that promotes active learning as students construct knowledge, facilitating group work, allowing students to exchange ideas, discuss solutions, learn from each other, promote cooperation and develop social skills; In addition, GeoGebra can be used to pose contextual and relevant problems, allowing students to reflect on their learning, analyze error-strategies and improve schoolchildren's understanding of mathematical concepts.

Similarly, the use of GeoGebra in secondary mathematics education is based on a solid epistemological foundation, consistent with constructivist theories of multi-experiential representation and sociocultural learning theory, providing a solid foundation to develop mathematical skills seeking to promote conceptual understanding, mathematical reasoning, creativity and communication, and GeoGebra becomes a valuable tool to transform mathematics education into a dynamic, meaningful and effective learning experience.

As technological justification, the research addressed the need to highlight the benefits of GeoGebra software to improve the mathematical skills and abilities of schoolchildren as part of the strengthening that current education requires in terms of being a digital alphabet and all this will have an impact on the significance of solid learning for students and teachers. Finally, it is justified from a legal criterion, since it is based on different norms and laws (law number 28044 and 094-2020 among others) that seek to optimize the processes at the time of evaluating the degree of mathematical competence in basic education.

Based on these justifications, the general objective of the study was to establish the effect of the application of the GeoGebra teaching methodology program on mathematical competence in an educational institution, Cusco 2023. The specific objectives were to demonstrate the effect of the application of the GeoGebra teaching methodology program on the dimensions of the ability to solve problems of change and equivalence, regularity, as well as the ability to solve problems of location, movement and shape in an educational institution, Cusco, 2023.

Likewise, the research reviewed several precedents, among the international precedents, we have Aules (2022) who explained how GeoGebra software was used in primary schools in the DR in order to optimize the teaching and learning of mathematics in Ecuador. The main objective was to create a training plan for teachers in mathematics, using GeoGebra as a tool. Surveys were conducted with teachers, students and relevant population, with a total of 164 students from grades 8, 9 and 10, in addition to 4 participants from the mathematics subject. After carrying out the training program, teachers positively evaluated the training, the contents and the process, highlighting the ease of use of the software, concluding that the application of the program significantly improved the performance of teachers.

Similarly, in the article by Torres and Iriarte (2022), they sought to contribute to the improvement of learning the contents of derivatives and differential calculus through GeoGebra software in students of a national university in Paraguay. The work was based on a quantitative approach and a quasi-experimental design where each group (control and experimental) had a total of 27 students as a selected sample. The results showed that in the learning of derivatives and derivative rules dimension, the experimental group obtained an average of 2.33; on the other hand, the control group obtained 1.38, so a significant difference is assumed. However, in the dimensions application of optimization derivatives and function analysis, no significant statistical differences were observed. In sum, it was evident that the appropriate use of GeoGebra allows improving the levels of comprehension in these mathematical skills.

Similarly, Galarza et al. (2021) presented a research article with the objective of determining that the use of GeoGebra has a beneficial effect on the learning of mathematics; the study was conducted using a quasi-experimental design with variable control, and non-random sampling was used with the application of pretest and posttest. The sample was made up of 2 teams, each consisting of 40 students (experimental - control). The effects revealed that a significant sector of the students in both guilds had a low level of mathematics education before the implementation of the GeoGebra program. However, after the implementation of the program, a remarkable progress was observed in the experimental group, which shows that the use of GeoGebra benefits in the development of skills in a positive way and in the ability to learn to solve the mathematical problem in students of the secondary level (first grade) of the district Guayaquil 09D06.

On the other hand, Montaño and Valarezo (2023), in their article, aimed to evaluate how GeoGebra software impacts learning levels in a high school in Loja, Ecuador. The research was based on a quasi-experimental and cross-sectional approach. The survey was used as a technique and the pretest and posttest were used as instruments. From the Wilcoxon's W statistical test, it was determined that the GeoGebra educational intervention had a significant impact on the dependent variable. This incidence highlights the effectiveness of the program in promoting meaningful learning.

Similarly, Carvajal (2020) who carried out his research where he raises as main objective to enhance applied research, this study was conducted with the participation of schoolchildren, in order to optimize the process of teaching mathematics of 25 people, using questionnaires as a method of collecting information in it compared the diagnostic surveys (initial) with the final surveys, A quasi-experimental design was used. In this study, the automatism of GeoGebra software was considered as a methodological instrument that provides valuable support to the development of mathematical reasoning, assists students in their education, promoting the mastery of important learning contents and improving their school performance in the subject. In conclusion, it can be stated that this tool improves learning judgment and enhances students' development. In addition, GeoGebra in mathematics education has revealed inventions, increasing students' commitment and dedication in applying the skills learned to solve everyday problems.

Finally, Valderrama et al. (2020), presented the research paper “The impact of GeoGebra software on student learning outcomes” with the objective of evaluating and implementing the use of GeoGebra software for mathematics education and concluded that this is one of the most powerful resources that technology has provided to mathematical science. The study was designed to help teachers and students and to contribute positively to student learning. This study is based specifically on the use of GeoGebra, a dynamic computer program for teaching and learning mathematics that students use without much difficulty.

In the national context we have the following precedents: in the doctoral thesis of Bermeo (2017), he used a pre-experimental design with a pre- and post-test; that is why the design was quasi-experimental. It was conducted with a sample of 127 students from four classrooms of the first cycle, a questionnaire was used to collect information consisting of 27 dichotomous items. In order to evaluate the reliability of the study, a pilot test was carried out with 40 students and the KR-20 statistic was used, obtaining a reliability of 0.93. A Wilcoxon test was used to contrast this hypothesis. The results concluded that the training for graphing real functions was significantly influenced by the use of GeoGebra software in cycle I of the Department of Mechanical Engineering of a national university.

Likewise, in the article by the authors Ortega et al. (2024), they sought to identify the incidence of the GeoGebra program in the learning of integral calculus in a professional school of a university in Huancavelica. The design to work was quasi-experimental; 52 students were chosen as a sample to solve a written test, which was divided into a control group and an experimental group. As a result of the test, it was pointed out that the use of the software promotes a slight increase in the levels of learning performance of integral calculus. In addition, the use led to the effectiveness of the abilities to perform the calculation of volumes and moments. Therefore, it is affirmed that this program produces a significant impact in the learning process of a mathematical area.

In the same way Aldazabal et al. (2021), in their research “GeoGebra software in the improvement of problem solving capabilities of two-dimensional geometric figures in university students. Purposes and Representations”, aimed to evaluate the impact of GeoGebra applications on the ability to solve problems related to two-dimensional figures. The approach was quantitative, with a quasi-experimental design, since the sample was divided into 2 groups (experimental and control) to which a pre-test and post-test were applied. From the use of the software in different exercises, the performance indexes of the experimental group increased significantly. This was demonstrated when solving more effective mathematical problems; likewise, other factors such as student integration, collaborative work and the promotion of a better classroom climate were also observed. Therefore, it was concluded that the use of this software is a great option to improve solving skills related to two-dimensional geometric figures.

Finally, Calderón (2024) sought to establish the degree to which the use of GeoGebra software improves learning with respect to area exercises of flat regions in a national school in Sócota, Cajamarca. As a method, a quantitative and applied approach was used. As the sample of 46 was divided into 2 groups (22 for the control and 24 for the experimental), a quasi-experimental design was assumed. From the results obtained from the pretest and posttest, it was obtained that the exercises developed by the students through the application did not indicate significant improvements in learning about planar regions, but improvements were noted in the understanding of geometric relations and figures. This result was obtained from the application of the Mann-Whitney U test whose value was 0.028, which was less than 0.05. With this, it was concluded that the use of such software does not improve mathematical learning.

Next, as part of the research, it is relevant to deepen the theoretical bases of each of the phenomena or variables. Regarding the independent variable, GeoGebra didactic methodology, Hohenwarter (cited in Paiva, 2021) described GeoGebra as an interactive mathematical software, the program is ideal, practical and has an extremely dynamic approach to the elucidation of mathematics at all stages, from the most basic to the most complex. In addition, it facilitates collaboration in solving conflicts in various arguments, creating geometric drawings, performing symbolic and algebraic calculations, and comparing data without requiring extensive knowledge of the software (Zilinskiene&Demirbilek, 2015).

On the other hand, Lainoufar et al. (2021) conceptualize GeoGebra as a technology-based digital educational resource, which makes it accessible to all by helping to solve awkward situations with numbers. According to De la Cruz (2017), GeoGebra is defined as a widely used technological tool for numerical purposes due to its clear design in terms of data application, graphics and evaluation content.

On the other hand, Gagne's theory, which is based on processing data, is changeable according to the type of learning sought. The teaching staff must adjust the environment in which the knowledge acquisition procedure will be developed. According to (Gagné, 1987), cited in (De la Cruz, 2017), the type of learning will depend on different capacities, abilities, skills and attitudes. Achieving mathematical skills in RPFML requires the integration of several skills. When using GeoGebra software what matters are intellectual abilities, cognitive strategies and the approach to the problem to be solved. Gagne's most notable achievement was to consider reinforcement as an intrinsic motivator in the program, whereas in a behavioral program reinforcement is extrinsic in nature. Therefore, feedback is intended to guide future responses, providing information without punishment. This theory is fundamental to understand the design of educational software. That is why Gagñé's theory has been the basis for the creation of several courses where educational programs or applications are used. Therefore, the main contribution of the theory focuses on the concrete and specific guidelines for the design of these softwares. Undoubtedly, GeoGebra software motivates the student both intrinsically and extrinsically, In this way, the student is motivated to build his own method to employ tools or technological platforms, thus avoiding falling into monotony during the educational session (Korenova, 2017). Geometric constructions are impressive when executed through the GeoGebra application. In addition, this study is based on Connectivism and Discovery Learning Theory.

Similarly according to Vitavar (2014), cited by Bayes et al. (2018), in the field of mathematics education, the free GeoGebra software allows teachers, among other things, to create interactive teaching materials of their own. This means that it can be used as an authoring tool. GeoGebra has a platform that provides thousands of resources on a variety of topics in mathematics created and shared by a global entity of GeoGebra users (Zengin& Tatar, 2017). An example of the use of this application in the educational field is the study by Arteaga et al. (2019) that explains how using this software has the ability to recognize, identify and discover new connections and relationships. between exact elements in secondary subjects at this educational level. They also provide didactic considerations based on geometry problems in terms of fundamental concepts and level of demands, aspects that are of great hierarchy for the differentiation of illustration and instruction processes in secondary schools.

In contrast, Arnal and Oller (2020) explore the use of GeoGebra is used in geometric constructions that are carried out in the traditional way with ruler and compass highlight that the use of GeoGebra to perform this type of constructions is necessary to carry out a reevaluation or adjustment of the steps mentioned in the classic texts, which goes beyond simply transferring the procedure. This task of adaptation should be carried out by teachers When planning and organizing their classes, as well as when creating materials or activities for their students in relation to these topics, moreover, when planning and organizing their classes, as well as when creating materials or activities for their students in relation to these topics (Alcívar et al., 2019; Kim et al., 2017).

Likewise, Ruiz (2018) identified these difficulties in the instrumental creation process using GeoGebra. The products of this study reveal that one of the operations that corresponds to the teacher in pedagogical terms, it is sought to instruct students in the management of GeoGebra. Because of this, through proper use thanks to technology, students can. acquire a deeper understanding of mathematics (Alabdulaziz et al., 2021; Bakar et al., 2015). Technology motivates children to experiment and gives them the opportunity to reflect and meditate. The flexibility of technology allows school children to learn mathematics more effectively. According to Van Vorst (1999), technology is beneficial for students to approach mathematics in a more active and participatory way, as it allows them to actively interact with mathematics rather than simply following simple procedures or algorithms. It allows them to reason, investigate, solve problems, generate fresh information, and formulate new questions (Hegedus& Moreno-Armella, 2020). Furthermore, it is stated that technology "is a tool that facilitates the visualization of certain mathematical concepts for students and brings a new approach to mathematics education" (cited by Hohenwarter, Hohenwarter and Luvice, 2009, p. 136). Consequently, the use of ICT as an educational resource in the classroom will boost collaboration and instruction, encourage experimentation and discovery during the educational process, enhance didacticians' strategies, and foster students' enjoyment, motivation, excitement, inventiveness, and fantasy (Albano &Dello, 2019).

On the other hand, regarding the object of study of the dependent variable, mathematical competence, it is necessary to determine its concept. According to the Minedu (2018), competence is conceptualized as the ability of a person to conglomerate diverse knowledge, skills and dispositions. with the objective of achieving a specific goal, acting appropriately and ethically in a given situation. In the same document it is mentioned that within the competence is considered the determination of knowing what skills and what knowledge can work together to resolve a specific situation. Likewise, competence includes the management of socioemotional skills so that recommendations or decisions are not influenced by subjective issues or personal emotions. The fostering of students' skills is carried out intentionally, since in all educational institutions there is a pedagogical plan designed by teachers. This plan is built throughout all learning cycles (Peruvian Ministry of Education, 2018).

Likewise, if we wish to specify the concept of mathematical competencies, these are understood as hard skills that people use to solve problems and carry out activities that contribute to the construction and innovation of the situation. These skills include spontaneity, initiative and cooperation with others, as well as the ability to look, describe, understand and examine. It also involves being aware of, acting in consideration of procedures and strategies. the specific demands of the circumstances and individual requirements. Competency-based performance involves a process of uncertainty in which intellectual autonomy, critical awareness, creativity and spirit are fundamental elements for challenging personal and professional development. In addition, it involves accepting the consequences of actions and striving for human well-being. According to Tobón (2015), competencies are fundamental processes that activate logical thinking and creativity in conflict resolution.

On the other hand, in the field of mathematics, skills are based on the expected achievement of the student in the development of education and learning. These skills translate into applied knowledge and require the mastery, understanding and correct application of such knowledge. Therefore, this study focuses on the skills posed in basic education programs in the field of mathematics.

Similarly, the Ministry of Education (2016) considers the development of four skills in the field of mathematics that contribute to the comprehensive education of students. In addition, each of these skills is achieved through four competencies; these skills refer to the ability to solve different typologies of problems (change, movement, quantity, location, among others).

The approach or theoretical model of Social Mathematics is characterized by being interdisciplinary when proposing methods and concepts which are related to various social phenomena. It is here where the need appears that research oriented to educational theories must start from the need to solve certain problems that arise in the educational system, as is the case of the problems that arise in education and the process of acquiring knowledge of mathematics at each school level. The transcendental case of study direction described here is the higher level, also known as the university level. Therefore, this line of research began as a response to the mismanagement of mathematical concepts; it was also created to address the challenges associated with the evolution of mathematical ability in the profession (Camarena, 1999). Consequently, Social Mathematics, like mathematical theory in the framework of science, considers the connection of mathematics with other sciences, with professional situations and net activities of daily life in order for the calculations to prevail in the student for life.

Thus, the main fields of knowledge involved in socio-mathematical research are: social sciences, natural sciences and humanities, taking into account for the research practice the following types of knowledge: education, psychology, sociology, anthropology, philosophy and mathematics. In this sense, the “Theory of Mathematics in the Context of Science” and other theories included in the research aim to analyze the phenomena that need to be studied, starting from real problems of education and illustration of mathematics, as well as to develop mathematical skills. Moreover, it is a profession that is aligned with the concept of sociomathematical design. This study of social mathematics is framed in its fascinating educational theoretical framework “Mathematics in a scientific context”, which allows us to explain the two identifying features of the semantic concept of structure: theoretical architecture. Thanks to this, the theoretical structure of social mathematics is determined.

Consequently, from Bachelard's (1971) perspective, social mathematics can be described epistemologically as a field of thought that clearly breaks with conventional views on learning and teaching mathematics, as well as the growth and development in this area of mathematical competence in the professions, where mathematics is not an end in itself.

Likewise, with respect to the historical evolution of mathematics, over time, the development of mathematics has been associated with different phenomena and needs, which has given rise to its diverse and constantly evolving nature. Since thousands of years before Christ, human beings used mathematics as a tool to quantify the universe around them. Although it was a basic tool, it was not without logic and imagination. Later, even before Christ, the geometry of Pythagoras and other mathematicians became the main driving force and development of mathematics, being applied in various ways to real-world problems.

However, it was not until modern times, from the beginning of the 15th century to the end of the 18th century, that a large-scale scientific revolution took place, with a list of great scientists contributing to the advancement of knowledge in all possible fields. It was in this context that mathematics reached a high level, developing in an extraordinary way and playing an essential role as a powerful modeling tool in the sciences. It was in this context that Newton, one of the three great mathematicians of all time, achieved one of the greatest discoveries by creating differential calculus and laying the theoretical foundations necessary to understand the laws of gravity that govern the universe at the macroscopic level. Mathematics is the basis of science and technology, and is fundamental to human development. However, one of the greatest and most exciting challenges of modern mathematics is its role as a central tool in predictive processes, both in the past and in the future (Arbain&Shukor, 2015).

In order to fulfill the objective of the report, the mathematical competence test was used as an instrument. The test was elaborated by the author of the thesis, David SoncoJara, based on the two dimensions of the variable. The test was applied in two moments: before and after the application of the "GeoGebra Teaching Methodology" program (pretest and posttest). The results of the tests helped to corroborate the following general hypothesis: The application of the GeoGebra teaching methodology program significantly improves mathematical competence in an educational institution, Cusco 2023? Likewise the specific hypothesis, the application of the GeoGebra teaching methodology program significantly improves in the dimensions ability to solve problems of change and equivalence, regularity, as well as the ability to solve problems of location, movement and shape in an educational institution, Cusco, 2023.

METHODOLOGY

Regarding the type of research, this was applied, since the independent was manipulated to measure the dependent variable (Ñaupas et al., 2018). According to the thesis report sought to demonstrate the effect of the program "Geogebra Teaching Methodology", to improve mathematical competencies, the results obtained provided a more updated knowledge whose benefit is aimed at teachers and scientific community.

The study started from a quantitative approach, because it aims to analyze the information using statistical data to deepen and produce an analysis based on descriptive statistics (Hernández-Sampieri and Mendoza, 2018). That is why the data collected were represented numerically. In addition, the results of the statistical analysis were reflected through coefficients and numbers.

Likewise, the design worked was the quasi-experimental, because it aims to test the causal hypothesis through the manipulation of an independent variable where ethical and logistical reasons may not be assigned to the research unit (Hernández- Sampieri and Mendoza, 2018). Therefore, the work applied a quasi-experimental design so that the independent variable ("GeoGebra didactic methodology") is controlled or modified with the intention of seeing improvements in the study of mathematics in students.

The design for the quasi-experimental work was as follows:

(GE): 01 x 02
(GC): 03 - 04
Pretest Postest

Regarding the depth of the study, it had an explanatory scope, since a cause-effect relationship was established. In addition, it sought to understand more meticulously the structure of both variables, as well as the manipulation of one of these (Ñaupas et al., 2018). That is why the thesis sought to improve mathematical competencies in students belonging to the fifth year of secondary level of an educational institution in the district of URCOS. As a way to know in depth the phenomena, a previous evaluation was carried out simultaneously in each group, in the same environmental conditions, in order to measure the mathematical skills they possessed before the experiment. Afterwards, the "Experimental Group" gave mathematics lessons using GeoGebra educational software, previously installed on the XO laptops, while the "Control Group" gave similar lessons without the use of software. Finally, a post-test was performed on both groups to compare the average scores and thus confirm or refute the hypotheses of the study.

On the other hand, regarding the operationalization of the variables, it was necessary to determine the conceptual and operational definitions. Regarding the independent variable, the program related to the didactic methodology of GeoGebra is a teaching strategy that allows the evaluation of the cognitive, procedural and attitudinal aspects. The combination during the process causes the effect of evocation, organization, reflection, construction, apprehension, application, and resolution; at the level of mathematics (Akcay. and Cil, 2021). Furthermore, for Hohenwarter (according to Paiva, 2021), GeoGebra interactive mathematical software has been described as an excellent, useful and highly dynamic approach to learning mathematics from basic to advanced levels. This program supported problem solving in various scenarios, creating geometric representations, performing symbolic and algebraic calculations, as well as comparing the information collected without the need to master the software. A program was designed consisting of 10 sessions, which were carried out 2 per week. Sessions 1, 2, 3, 4, 6 and 10 focused on activities related to the dimension of graphical representation of linear and quadratic functions. In the case of sessions 5, 7, 8 and 9, the exercises were aimed at strengthening dimension 2, which consisted of the construction of geometric solids. The first part of the session was explained in the respective classroom; in the execution stage, students went to the laboratory side.

Regarding the dependent variable, with respect to the conceptual definition, mathematical competence is defined as the set of mathematical abilities in which students possess the knowledge to solve challenges of regularity, equality, configuration and movement, and moving temporal-spatial situations. To carry it out, it is relevant the existence of a dynamic interaction between teacher-students-environment that makes the student interconnect their mathematical skills and critical thinking (Huda and Mukminin, 2022). Regarding the operational definition, the focus of this work was on two dimensions: a) solving problems of regularity, equivalence and change; b) solving problems of shape, motion and location. Regarding indicators, dimension 1 presents the following: translates data and conditions into algebraic expressions, communicates understanding of algebraic relationships, uses strategies and procedures to find general rules, and argues statements about change and equivalence relationships. In the case of dimension 2, the indicators were: models objects with geometric shapes and their transformations, communicates understanding of geometric shapes and relationships, uses strategies and procedures to orient in space, and argues statements about geometric relationships.

Another relevant point of the methodology was to determine the population and sample. Regarding the first term, this is understood as the totality of objects, agents or persons that are investigated and that are within a given context or reality (Hernández & Mendoza, 2018). For the thesis, the population had as a criterion to include all students enrolled in the academic year 2023 at the secondary level, which was 567 students.

The sample was obtained from this population. This was defined as the subset of the population, whose elements were evaluated and observed, since they significantly reflect the results in the population, according to Hernández-Sampieri and Mendoza (2018). Non-probability and convenience sampling was used to determine the sample. With this, each group, experimental and control, had a total of 28 students. The entire sample belongs to the fifth grade, whose ages range from 15 to 16 years old.

For the measurement of this phenomenon, the study resorted to the test technique. Delgado (2010) pointed out that this technique consists of collecting direct information from a person with the intention of identifying cognitive skills. For the purposes of this thesis, as part of the quasi-experimental design, only the dependent variable was measured: mathematical competence. This technique will be fundamental to know the degree or level of mathematical competence possessed by the students in both groups (control and experimental).

Within this technique, the study resorted as an instrument to the written test (pretest and posttest) in the dependent variable. Regarding the written test, it is an evaluation tool that allowed the researcher to know the learning level of quadratic functions on the chosen sample (Baena, 2017). To collect data on the dependent variable, a 20-question mathematical ability test was developed and administered, in which the students solved the proposed exercises.

In the written test instrument, which belongs to the dependent variable, it was necessary to describe the data sheet. The mathematical competence test is proposed by the National Curriculum at the secondary level of the Ministry of Education. The test consists of several components:

Title: Evaluación de la competenciamatemática.

Author and year: Margen David SoncoJara, (2023).

Objectives: To evaluate mathematical competencies and abilities.

Scope: Secondary school students.

The duration of the event is 120 minutes.

Material: paper and pen.

Description: Among the six contextual problems, there are three that assess competency of Regularity, Equivalence and Change with 10 questions each, while the remaining three assess competency: Shape; Motion; and Location.

A scorecard is created by dividing the correct answer by 1 point and the incorrect answer by 0.

Prior to the application of the aforementioned instrument, it met the validation and reliability standards. Regarding validation, it focused on the evaluation of contents. For this purpose, a total of 5 expert teachers, both in the methodological area and belonging to the mathematics specialty, were consulted and reviewed the coherence and relevance of the indicators to be evaluated; this process is called “expert judgment”. The judges evaluated the content of the items through a form where they provided comments for improvement.

La investigación fue llevada a cabo en el centro educativo mencionado, se pidió la autorización al coordinador encargado de tomar la decisión de aceptar el estudio. Una vez aprobada la solicitud, se aplicó la encuesta a los estudiantes, quienes completaron el cuestionario digital enviado y se procesó la información recibida.

After validation of the instrument, a statistical analysis was carried out to measure the level of reliability. For this purpose, the analysis was applied to obtain the Kunder Richardson coefficient (KR 20), since the alternatives are dichotomous: right (1) and wrong (0). The result yielded a reliability coefficient of 0.892, which means that the instrument is reliable for collecting objective data.

As part of the data analysis techniques, once the validation and reliability were confirmed, the test was applied to the 2 respective groups (pretest). After 5 weeks where the 10 sessions were applied, the instrument was applied again (posttest). The results were exported to the SPSS statistical package where the data were analyzed from an inferential and descriptive criterion. These results were represented in tables and figures for their interpretation. As a central technique for data analysis, since the data were parametric or normal, Student's t-test was used to determine whether the impact or incidence on the dependent variable was significant.

As part of the ethical considerations, it is stated that this report complies with the provisions of the resolution issued by Universidad César Vallejo on April 1, 2024. Among the main criteria, it complies with the laws that protect copyrights. To this end, all quotations and references mentioned in the work adhere to the APA norms, seventh edition. Whether the quotation is textual or paraphrased, the intellectual origin is indicated. Likewise, the work complies with the percentages of similarity accepted by the university, since the institution has access to turnitin to verify the levels of similarity in terms of written ideas. Finally, the confidentiality of the students was respected, since participation in the tests was anonymous.

RESULTS

In this section of the report, statistical data were analyzed to establish the achievement of the stated objectives. As part of the general objective, we sought to establish the effect of the application of the geogebra teaching methodology program on mathematical competence in an educational institution, Cuzco 2023. To determine this, the results of the application of the test in the pretest and posttest stages were compared, as well as the statistical analysis to corroborate whether the application of geogebra improved the dependent variable.

Table 3
Level of mathematical competencies of the control and experimental groups before applying the "Geogebra Teaching Methodology" program.

	Grupo control		**Grupo experimental**	
	N	%	N	%
En inicio	28	100,0	28	100,0
En proceso	0	0	0	0
Logrado	0	0	0	0
Destacado	0	0	0	0
Total	28	100,0	28	100,0

Table 3 compares the frequency and percentage data of the control and experimental groups before developing the sessions referred to the "Geogebra Teaching Methodology" program. In this table it is observed that each group has 28 students; in addition, when the test was applied to them, the grades varied between 2 and 10, so it was designated that their level of mathematical competences, for both groups, was "in the beginning". This means that no student was able to obtain a passing grade. Therefore, it can be interpreted that before implementing the program, there is no difference in terms of the levels of management weaknesses and mathematical abilities in the students. This reaffirms the problematic situation that the students are going through in this layer that is so important for the labor and social development, which is mathematics.

Table 4
Level of mathematical competencies of the control and experimental groups after applying the "Geogebra Teaching Methodology" program.

	Control group		**Experimental group**	
	N	%	N	%
In process	16	57,1	0	0
In process	11	39,3	5	17,9

Achieved	1	3,6	21	75,0
Outstanding	0	0	2	7,1
Total	28	100,0	28	100,0

The table above compares the results of the grades obtained by the students in the control group with those obtained by the experimental group after the 10 sessions of the "Geogebra Teaching Methodology" program. Significant evidence can be seen at the time of comparison. In the case of the control group, a little more than 50% were "at the beginning"; this means that the grades varied between 0 and 10. 39.3% were at a level of "in process", which reflects that they had grades between 11 and 13 and only one student had a grade between 14 and 17 ("achieved" level). On the other hand, among the students who were recipients of the program, the vast majority were at the "achieved" level, which is represented by 75% of the students. In addition, 17.9% were in the "in process" level, while 2 students achieved a grade in the "outstanding" level, which indicates that they obtained a grade between 18 and 20.

Therefore, it can be inferred that there is a difference in the results of both groups after carrying out the sessions that strengthen mathematical competencies through the "Geogebra Teaching Methodology" program. It should be noted that the control group had improvements compared to the pretest, since in the second evaluation 12 of the 28 students did obtain passing grades. In the case of the experimental group, the improvement was consistent, since 100% of the students obtained passing grades, which evidences the positive impact of the Geogebra program to improve the mentioned competency.

In order to corroborate the hypotheses, it is necessary to determine whether the data yielded by the tests are normally or non-normally distributed. To find out, the normality test was applied, the results of which are shown in the following table:

Table 5

Analysis to determine the normality of the data

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Estadístico	gl	Sig.	Estadístico	gl	Sig.
GrupoexperimentalPRETEST	,188	28	,012	,916	28	,028
GrupoexperientalPOSTEST	,163	28	,056	,935	28	,084
CompetenciaMatemáticaDIM1Pretest	,223	28	,001	,933	28	,075
CompetenciaMatemáticaDIM1Postest	,243	28	,000	,865	28	,002
CompetenciaMatemáticaDIM2Pretest	,141	28	,160	,917	28	,030
CompetenciaMatemáticaDIM2Postest	,198	28	,007	,912	28	,022

a. Corrección de significación de Lilliefors

In order to know how the collected data are distributed, a normality test was performed. Since the sample was a total of 28 students, which represents a number less than 50, the Shapiro-Wilk test was considered. As evidenced in the table above, the significance value (Sig.), in almost all cases, was greater than 0.05 which reflects that the data are parametric, in other words, the numbers collected follow a normal distribution. In this case, to corroborate the alternative hypothesis, the Student's t-test, which is a statistical analysis for parametric tests, was used.

The general hypothesis test was as follows:

As a decision rule, for the alternative hypothesis to be accepted, the $p< 0.05$; with this, the effectiveness of the applied program will be evidenced. In case the $p> 0.05$, it will be determined that the program is not effective and the null hypothesis will be accepted.

Table 6
Parametric Student's t-test to corroborate the general hypothesis

		Diferencias emparejadas					t	gl	Sig. (bilateral)
		Media	Desviación estándar	Media de error estándar	95% de intervalo de confianza de la diferencia Inferior	Superior			
Par 1	Grupoexperimental PRETEST - GrupoexperientalPOSTEST	-9,571	2,659	,502	-10,602	-8,540	-19,049	27	,000

Through the statistical analysis that seeks to determine the impact on normal or parametric data (Student's t-test), it was possible to determine the degree to which the “Geogebra Teaching Methodology” program in the experimental group improved their grades in the posttest as opposed to the pretest. As shown in the table above, the degree of significance was 0.000, which is less than the standardized significance of 5% (0.05). Thus, it is determined that the experimental groups did have a significant improvement in their mathematical competencies after the development of the aforementioned program. In sum, it is proved that the hypothesis proposed by the researcher is acceptable as opposed to the null hypothesis.

As part of the first specific objective, we sought to demonstrate the effect of the application of the geogebra teaching methodology program in the dimension of solving problems of change and equivalence, regularity in an educational institution, Cuzco, 2023. For this purpose, the first specific hypothesis was tested.

Table 7
Parametric Student's t-test for corroboration of the first specific hypothesis

		Diferencias emparejadas							
		Media	Desviación estándar	Media de error estándar	95% de intervalo de confianza de la diferencia Inferior	Superior	t	gl	Sig. (bilateral)
Par 1	GrupoexperimentalPRETEST - CompetenciaMatemáticaDIM1Postest	-,214	2,455	,464	-1,166	,738	-,462	27	,648

Through the statistical test that seeks to know the impact or association in normal data, it was established the idea that the use of the program “Geogebra Teaching Methodology” the experimental group had improvements in their grades in the posttest as opposed to the pretest in terms of the student's ability or competence in solving mathematical problems related to equivalence, making changes and establishing regulations. The table above shows that the degree of significance was 0.648, which is greater than the standardized significance of 5% (0.05). With this, it is determined that the experimental group did not have significant improvements in the mentioned dimension after the development of the mentioned program. This resulted in the consequence that the researcher's assumption is not acceptable due to the high coefficient of the margin of error.

As part of the second specific objective, we sought to demonstrate the effect of the application of the geogebra teaching methodology program in the dimension of solving problems of location, movement and shape in an educational institution, Cuzco, 2023. In order to do so, the second specific hypothesis was analyzed.

Table 8

Parametric Student's t-test for corroboration of the second specific hypothesis

		Diferencias emparejadas							
					95% de intervalo de confianza de la diferencia				
		Media	Desviación estándar	Media de error estándar	Inferior	Superior	t	gl	Sig. (bilateral)
Par 1	GrupoexperimentalPRETEST - CompetenciaMatemáticaDIM2Postest	-4,000	2,625	,496	-5,018	-2,982	-8,064	27	,000

The Student's t test used was the centered statistical analysis for parametric or normal data, which was used to determine whether the use of the "Geogebra Teaching Methodology" program resulted in improvements in the experimental group's grades in the posttest as opposed to the pretest in terms of mathematical competence capable of solving problems related to space or geography. Based on the table above, it was reflected that the degree of significance was 0.000, which indicates that it was less than the standardized significance of 5% (0.05). Thus, it is determined that the experimental group did have significant improvements in the aforementioned dimension after the development of the aforementioned program. Therefore, the researcher's proposal that the application of the program does improve this dimension is acceptable.

DISCUSSION

Regarding the general objective, after applying the Student's t-test, regarding the effect of the "Geogebra Teaching Methodology" program on mathematical competence, a significance level of 0.000, which is less than 0.05, was found. Therefore, it was established that the application of the aforementioned program significantly improves the mathematical competence of students in an educational institution in Cusco. This result is congruent with the research of Galarza et al. (2021) who seek to determine whether the use of GeoGebra has a beneficial effect on the learning of mathematics. When comparing the control and experimental groups, it was found that thanks to the implementation of the GeoGebra program, a significant improvement was observed, which was reflected in higher levels of mathematics learning.

Both the results of the study and the research by Galarza et al. agree that the program helps students to manipulate mathematical objects in real time, fostering discovery learning. It should be noted that the program, within its content, helps to understand the connection between representations. This is why this application is of great help in different areas of mathematics such as algebra, geometry and calculus, helping students to establish connections between different mathematical areas. In addition, both works highlight that the use of interactive technology increases the interest and participation of students in learning mathematics.

However, a criterion that makes it difficult for the teacher to help the student obtain the facility to solve mathematical problems is to employ strategies that facilitate the exploration of multiple approaches to solve problems, developing critical thinking. This is where the teacher must guide the student to work at his or her own pace and explore concepts independently. In short, thanks to the program, students can instantly see the results of their actions, which facilitates self-correction and autonomous learning.

By way of commentary, GeoGebra software has become a valuable tool for teaching and learning mathematics in the digital age. Its ability to provide dynamic visual representations and enable interactive manipulation of mathematical objects has revolutionized the way students approach complex concepts. By encouraging experimentation and discovery, GeoGebra not only improves students' understanding, but also increases their motivation and confidence in mathematics. However, it is important to remember that GeoGebra is a supplementary tool and its effectiveness depends largely on how it is integrated into the curriculum and proper guidance from the teacher.

Regarding the first specific objective, after applying the Student's t-test, regarding the effect of the "Geogebra Teaching Methodology" program in the dimension referred to solving regularity, equivalence and change problems, it was pointed out that there is a significance level of 0.648, which is greater than 0.05. Therefore, it was demonstrated that the application of the aforementioned program does not significantly improve the student's ability to respond to problems of regularity, equivalence and change. This result is related to that of Ortega et al. (2024) who sought to identify the incidence of the geogebra program in the learning of integral calculus in a professional school of a university in Huancavelica. The study determined that the use of the software slightly increased the students' learning performance levels in the subject of integral calculus, which focused on the calculation of volumes and moments; in short, the application of the software produces a positive impact on the learning process in the area of mathematics.

It should be noted that the dimension of problems of regularity, equivalence and change bears a certain resemblance to integral calculus, since both use methods that allow them to find relationships between magnitudes based on the respect of certain rules. However, a point that does not coincide between the result of the work with the antecedent is the educational level at which it is presented. The antecedent belongs to the context of higher education, where students, due to the entrance requirements, have greater mathematical skills.

From an analysis between the results and the antecedent, it is unquestionable to assume that GeoGebra software helps students to solve regularity, equivalence and change problems in the following ways: (a) visualization of patterns, as it allows students to graphically represent sequences and patterns, facilitating the identification of regularities; (b) dynamic manipulation, as students can modify parameters in real time, observing how changes affect mathematical functions and relationships; (c) exploration of equivalences, as it facilitates the visual comparison of different algebraic or geometric expressions, helping to understand equivalence.

However, a factor that teachers should know how to guide when applying the software is that of multiple representation. This consists of showing, simultaneously, algebraic and graphic representations, allowing students to establish connections between them, but there are many students who are still confused. It is precisely for this reason that in the thesis report it was not possible to notice a significant improvement in this dimension, since students find it difficult to model situations of continuous change, such as exponential growth or motion, improving the understanding of variable functions, as well as applying and visualizing geometric transformations, better understanding how they affect figures and functions.

By way of commentary, the GeoGebra program has become a fundamental tool for addressing problems of regularity, equivalence and change in mathematics. Its ability to provide dynamic and interactive representations allows students to explore these concepts more intuitively and deeply. By facilitating the visualization of patterns, manipulation of variables, and exploration of relationships, GeoGebra not only enhances understanding of these topics, but also develops algebraic and functional thinking skills. However, it is crucial that educators design structured and meaningful activities to take full advantage of GeoGebra's potential, ensuring that its use leads to effective learning and not just superficial manipulation.

Regarding the second specific objective, after applying the Student's t-test, regarding the effect of the “Geogebra Teaching Methodology” program in the dimension referred to solving problems of shape, movement and location, it was pointed out that there is a significance level of 0.000, which is less than 0.05. Therefore, it was demonstrated that the application of the mentioned program significantly improves mathematical competence in terms of the ability to solve problems of shape, movement and location in students in an educational institution in Cusco. This result is congruent with that of Bermeo (2017) who, through a quasi-experimental work, concluded that thanks to the geogebra software, first cycle students of an engineering faculty had a better management to graph real functions.

Both studies agree that the geogebra software was of great help for students to graphically represent a function, as well as a table of values or points in a Cartesian plane, especially in the study of Bermeo. In the case of the present study, the software helped students to solve problems of shape, movement and location in the following ways: to perform precise geometric constructions, since it allowed them to manipulate and create geometric figures with accuracy, facilitating the study of their properties; to visualize shapes and spatial relationships in 3D so that the interactive three-dimensional representations were better understood.

As can be seen, one factor by which the software did have a significant impact on the ability to solve shape, motion and location problems. This is because the software allows to apply and observe in real time rotations, translations and reflections, understanding better these concepts. Likewise, the program favors the integration of 2D and 3D coordinate systems, helping students to locate points and objects in space. However, a criterion that does not coincide is the difference in the academic levels of the works, since the results of Bermeo are in a university context, while the present study is in the regular basic level. Despite this difference, the impact of the software application was equally favorable.

As a final comment, GeoGebra software has revolutionized the teaching and learning of geometry and the study of space. Its ability to create dynamic, interactive representations allows students to explore concepts of shape, motion, and location in a more intuitive and in-depth way than traditional methods. By providing a virtual environment where students can experiment, conjecture, and verify geometric ideas, GeoGebra fosters active and meaningful learning. However, it is essential that educators design well-structured activities and guide students in their use, ensuring that the tool is a means to develop geometric reasoning and not just a visual aid.

CONCLUSIONS

In the Student's t-test, regarding the effect of the “Geogebra Teaching Methodology” program on mathematical competence, it was noted that the significance side was lower than the established 0.05 (0.000). With this, it was possible to assume that thanks to the different sessions regarding the use of the Geogebra application, the level of mathematical competence of the students in the mentioned institution could be significantly improved.

In the Student's t-test, regarding the effect of the “Geogebra Teaching Methodology” program in the dimension referred to solving problems of regularity, equivalence and change, it was noted that the degree of significance exceeded the established 0.05 (0.648). With this, it is evident that the use of Geogebra and its respective handling did not have a positive differentiator compared to the results of the pretest. Consequently, it was determined that the use of the program did not significantly improve the ability to solve algebraic problems (change, regularity and equivalence).

In the Student's t-test, regarding the effect of the “Geogebra Teaching Methodology” program on the component referring to the ability to solve geographic or spatial problems, the statistical test yielded a 0.000 in terms of the significance level, which was less than the established margin of error of 0.05. In sum, it was determined that thanks to the application of the geogebra program, the dimension referred to solving mathematical problems of location, shape and movement was significantly improved.

RECOMMENDATIONS

Based on the results obtained, it is highly relevant to recommend to the selected institution to implement and design plans that seek to strengthen the mathematical competence of students, in coordination with teachers, through GeoGebra. For this, the first step to implement is to strengthen teacher training, which should be accompanied by a continuous training plan for teachers on the effective use of GeoGebra in the teaching of mathematics. Likewise, the use of the software should be systematically incorporated into the curriculum, aligning it with the learning objectives.

Teachers are encouraged to design and create meaningful tasks and projects that take advantage of GeoGebra's interactive and dynamic capabilities. Likewise, with respect to the ability to solve problems where equivalence, change or irregularity criteria can be established. That is, they should be focused as an exercise capable of being applied in the real world, thus encouraging critical thinking. In addition, if these activities are complemented by collaborative learning, discussion and exchange of ideas will be encouraged.

Teachers are encouraged to implement GeoGebra-based assessments that allow for continuous monitoring of student progress. To strengthen the ability to solve geographic or spatial problems, it is necessary that students have access to GeoGebra both at school and at home to encourage independent practice; this will be of great help, as they will be able to adapt to teaching at different levels and learning styles. In short, through the use of the software, students will be able to integrate projects that connect mathematics with other disciplines.

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